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Food Choice by a Free-ranging Antillean Manatee (Trichechus manatus manatus) in Tabasco, Mexico

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Abstract

Understanding foraging ecology is an important element of effective conservation strategies. While West Indian manatees (*Trichechus manatus*) have been documented to consume a wide variety of vascular plants and algae, little is known about the diet of the Endangered Antillean subspecies (*T. m. manatus*) at freshwater sites such as the wetlands of Tabasco, the largest manatee habitat in Mexico. Here we present the results of a study of wild manatee diet in a freshwater site in Mexico. Controlled food choice experiments were conducted on a wild adult manatee during the dry seasons of 2011 and 2012. Plant species tested were representative of the habitat and included 14 of the 15 most common species. A total of 54 plant species, representing 25 families and 43 genera, were systematically tested during seven days of experiments. The manatee selected 27 (from 11 families and 20 genera) of the 54 species. Ten of the 20 genera are new reports from the previously known freshwater genera consumed by West Indian manatees, an increase of 12.8%. Results from this study support the literature indicating that manatees are generalists (i.e. feed on a wide variety of plant species); however, this manatee was also very selective in the food items it consumed, both rejecting and selecting an equal amount of species. Both this large dietary breadth and selectivity must be taken into consideration when developing conservation strategies for wild manatees in freshwater habitats and protocols for captive rehabilitation of orphaned and stranded manatees that will be reintroduced into the wild in the region.
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Keywords: diet, West Indian manatee, Balancan, Sirenia, foraging ecology

Introduction

Manatees are tropical aquatic mammals that eat a variety of aquatic and terrestrial vegetation (8, 11, 23). There are three extant species of manatees, the Amazonian *Trichechus inunguis*, the West Indian *Trichechus manatus*, and the West African manatee *Trichechus senegalensis*. All are listed as Vulnerable by the International Union for Conservation of Nature primarily due to habitat loss, poaching, and other anthropogenic causes (19). The West Indian manatee has been further divided into two subspecies, the Florida *T. m. latirostris*, and the Antillean manatee *T. m. manatus*, both of which are currently listed as Endangered (13, 30). Of these, the Florida manatee has been the most studied, however the Antillean manatee occupies a wider geographical distribution (21, 29).

West Indian manatees utilize a variety of aquatic habitats that can be divided into four general environments. Shallow marine environments where they primarily consume marine algae and seagrasses (1, 10, 22, 24). Brackish estuarine habitats where they consume a variety of submerged and shore vegetation (1, 16, 31). Clear freshwater rivers and lakes, where they primarily consume submerged freshwater flowering plants (e.g. *Hydrilla*) (8, 14, 17). Finally, dark freshwater rivers and lakes where they primarily consume floating (natant) and shore vegetation (7, 11, 27). Food choice depends greatly on available foods and thus varies between locations. Information on local manatee diet is critical for conservation efforts because it can be used to determine habitat quality, carrying capacity, and to aid in rehabilitation efforts of orphaned and stranded manatees that will be released back into the wild.

There are several methods for determining manatee diet and food choice, all of which have certain advantages and limitations (6). Direct observation is the most straight-forward and has been successfully used in clear freshwater habitats and marine areas where water visibility allows observation (17). However, this method is less useful for manatees living in areas where water visibility is poor. In addition, direct observation can potentially bias towards food items that are easier to observe being consumed.

Another method is the analysis of digesta (18). While this method is arguably the best for providing information on food items eaten by manatees, it is limited to areas where digesta can be obtained either from carcasses or from fecal samples. Mouth and stomach samples provide the most information, but may be biased to locations where anthropogenic pressure is highest because they must be collected from carcasses. Fecal samples are easier to collect, but can also be biased because different food items are differentially digested. Therefore, fecal samples may be biased towards species that are least digested rather than those that are most consumed (23). In addition, this method is very time consuming and a micro-histological collection of reference plant material is needed, which can be very difficult to obtain in areas of high floral diversity. Near infra-red reflectance spectroscopy has been used to

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determine dugong diet from digesta (5). However, while this method is a great improvement over micro-histological analysis in terms of the time needed to analyze each sample, there still needs to be a reference of chemical signatures of plant samples in the local area.

Isotope analysis has been used to determine the relative importance of marine and freshwater plants in Florida and Antillean manatees (3, 4, 26). This method provides diet information from a longer time scale because it is measured from tissue or hair, which have a variable turnover rate (2). However, it does not provide detail as to which species are being consumed and is limited to areas where manatees utilize both marine and freshwater habitats so the isotopic ratios can be compared.

Finally, wild Florida manatees have been presented potential food items in controlled feeding experiments to determine food choice. Bengtson presented wild manatees in Florida with 23 potential food plants and observed which ones they consumed and which they avoided (7). While this type of experiment is best suited for locations where manatees can be observed (e.g. clear waters) and where manatees are habituated, it has the advantage of providing information on both selected and rejected food items (14). Other methods cannot exclude a food item only because it does not appear in the observed sample.

A substantial portion of the remaining habitat available to Antillean manatees in Central and South America is in dark freshwater rivers and lakes (9, 16, 20, 21, 31). This makes diet studies very difficult because of the inability to make direct observations and the large number of potential food items due to the rich floral biodiversity in some locations.

In Mexico, Antillean manatees inhabit three major areas: (a) the coastal rivers and lakes of Veracruz; (b) the extensive freshwater wetlands of the Usumacinta-Grijalva river basins; (c) the brackish and marine Caribbean coastal waters (3, 12, 25). Of these areas, manatee diet has only been studied in Chetumal Bay, which is located on the Caribbean coast and a study in an enclosed lake in the Grijalva River area (10, 27). Moreover, there is very little or no plant species overlap between the marine plant species in Chetumal Bay and the other manatee sites in Mexico, which are primarily in freshwater habitats.

Here we present the results of feeding experiments on a wild adult manatee in the wetlands of Tabasco, Mexico. Our study is the first to examine manatee diet in Mexico using food choice experiments and adds to the only other manatee diet study in the freshwater habitats of Mexico (27). This will greatly aid in the rehabilitation of orphaned and stranded manatees in the region by providing data on additional plant species consumed by wild manatees in these habitats.

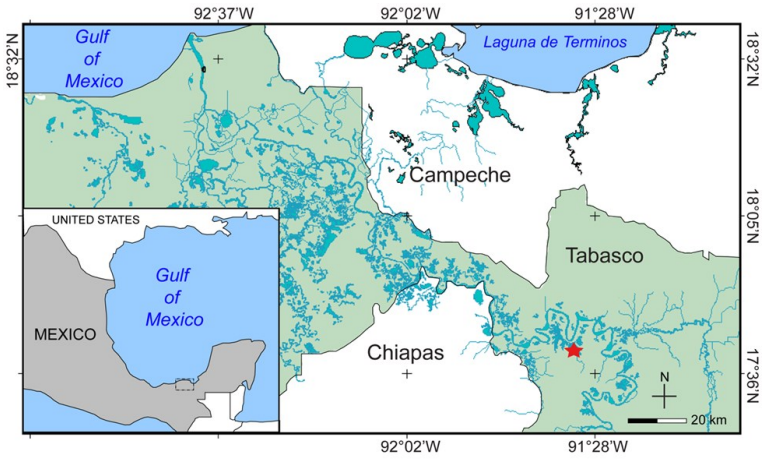

Figure 1: Location of the contact lake where the study was conducted (red star) within the state of Tabasco, Mexico.

Methods

Study site

Food choice experiments were conducted in Laguna Leona Vicario in Balancan, Tabasco, Mexico (17° 42' N, 91° 32' W) (Figure 1). This permanent contact lake swells and shrinks during the wet and dry season from water that overflows from the Rio Usumacinta, one of the largest rivers in Mexico. During a year-long study from August 2010 to July 2011, the water depth of this lake fluctuated 6.6 m between the peak dry season in June and the peak-wet season in September (15). Plant availability varied with season and was greatest in the wet season and lowest in the dry season (15). During several months in the dry season (April-June) food availability may be so restricted that manatees are forced to fast (15).

This study site was selected opportunistically while conducting other manatee research because of the ability to interact with an adult wild manatee (15). Manatees are found in this lake year round (Gonzalez-Socoloske and Olivera-Gomez pers. observ.).

Study subject and food choice experiment

Food choice experiments were conducted on a wild free-ranging adult manatee. All handling and interaction was done *in situ* at the will of the manatee, since water visibility was very poor. The manatee was physically examined in the water prior to the feeding experiments in both 2011 and 2012, where it was measured, skin and hair samples were collected for

future research, and the sex was determined (Table 1). At no time was the manatee restrained in any way during the experiments or the physical examination. This project was conducted under Mexican federal permit number SGPA/DGVS/04675/10 and SGPA/DGVS/02901/11 and approved by the Duke University IACUC A01-09-01.

	19 Jun 2011	14 April 2012
Body length (curved)	260	274
Girth (peduncle)	91	94
Girth (umbilicus)	160	175
Girth (axillae)	115	119
Tail width	66	66
Tail length	69	71

Table 1: Morphometrics of adult female manatee used in food choice experiments. All measurements are reported in cm.

All food choice experiments were conducted during the dry season in both 2011 (June-July) and 2012 (April), when this manatee had restricted access to vegetation due to the seasonally low water levels (15). The female manatee was determined to be in good health and all contact was voluntary as it was impossible to locate her without her approaching and interacting of her own free will. Health status was determined by the lack of any external scars or wounds and based on the overall body condition (i.e. not emaciated).

Food choice experiments were conducted with at least two people present: the primary author and at least one assistant. Before the food choice experiments began, the female manatee was encountered and time was spent interacting with her to make sure she was relaxed enough to breathe normally adjacent to us. Once this was accomplished, the assistant would remain in the water with her and the primary author would retreat to the shore where the vegetation that had been collected earlier was laid out. Only one plant species was presented at a time. A minimum of three minutes was given to allow the manatee to select or reject each food item. No additional submerged or floating vegetation was available to the manatee during the feeding experiments so the only plants available were those being held underwater in the assistant's hand. Experiments were conducted at a water depth between 25-50 cm.

Because of the low water visibility, feeding was determined by listening to the mastication sounds with a hydrophone (SQ26-H1, Cetacean Research Technology, Seattle WA), as was done in a previous feeding ecology study in Florida (14). The omnidirectional hydrophone was placed 10-20 cm below the surface of the water adjacent to where the manatee was offered the potential food items. Plant species characterized as "rejected" were not sampled by the manatee (no mastication sounds produced), while those characterized as "selected" were fed on continually for the three minutes offered until the entire sample was consumed or the assistant removed it from the water.

Manatee presence during food choice experiments was continually and independently determined by physical contact with the assistant in the water, vocalizations heard with the hydrophone, and visual observation by both the assistant and the primary author when the manatee surfaced to breathe. The primary author determined food choice in real-time by listening to the mastication sounds produced by the manatee. Feeding trials were also recorded and saved digitally (Zoom H1 solid state compact flash recorder, Cetacean Research Technology, Seattle WA) for confirmation and further analysis.

A Pearson's correlation coefficient was conducted using Excel (Microsoft Excel for Mac ver. 16.16.14) on the order the plant species was presented in each of the seven experimental days and the proportion of those species that were consumed to determine if the manatee was more likely to eat the first couple of items we presented and less likely to eat the last few items.

Plant identification

After the feeding experiments, a sample of each plant species used was pressed and dried for subsequent identification. Plant samples were identified with the assistance of personnel from the herbaria of the Universidad Juarez Autonoma de Tabasco, Colegio de Posgrados de Cardenas, and the Universidad Autonoma de Yucatan by comparing with voucher specimens.

Results

A total of 54 plant species were systematically tested during seven independent feeding experiments on as many days (Table 2). Between 7-9 species were tested each day during feeding experiments, which lasted between 80-120 min. Of the 54 species, the adult manatee selected 27 and rejected 27. All rejected plants were never sampled by the manatee (no mastication sounds were produced), while all selected plants were fed on continually for the 3+ minutes offered. The only exceptions were *Bacopa egensis*, in which the manatee

Date	Species Tested	Selected	Rejected	Exp. Duration (min)
19 June 2011	9	6	3	100
3 July 2011	7	7	0	80
6 July 2011	7	4	3	85
8 July 2011	9	2	7	110
10 July 2011	9	6	3	105
11 July 2011	8	1	7	95
14 April 2012	7	1	6	120
Total	54*	27	27*	695

*Table 2: Summary of feeding experiments conducted in Balancan, Tabasco, Mexico in 2011-12. *Two species were retested in 2012 and are not added to the unique species count. Both species were rejected the two years tested.*

fed for one minute and then abruptly stopped and did not feed for the remaining two minutes, and *Ludwigia peploides* in which the manatee appeared to ignore the plant material for the first two and a half minutes and then began feeding and continued to do so for the remaining 30 seconds. There was no correlation between plant order and proportion selected ($r(7)=0.304$, $R^2=0.092$, $p=0.425$).

Plant identification revealed that the 54 plant species represented at least 25 families and 43 genera (Table 3a & b). Poaceae (grasses) was the family that had the greatest representation with 10 species. Plant species represented all growth forms available to manatees in the area, with the exception of the one submerged species (*Utricularia* sp.), which is found in low abundance (15). Terrestrial herbaceous species were the growth form most represented in the 54 species tested.

Plants species, as well as the specific plant part selected and rejected are presented in Table 3a & b. Three *Cyperus* spp. were partially consumed; leaves and inflorescences were consumed, while the stems were rejected. The roots of *Eichhornia crassipes* were also rejected. Some families like Poaceae (10 species) and Cyperaceae (6 species) had all the tested species selected, while others like Mimosaceae (3 species), Fabaceae (6 species), Onagraceae (3 species), and Verbenaceae (3 species), had some species selected while others were rejected (Figure 2).

Family	Species	Date Tested	Part[1] Selected	Part[1] Rejected
Natant (floating)				
Menyanthaceae	*Nymphoides indica*	10 July 2011		S, B
Mimosaceae	*Neptunia natans*	10 July 2011	B, S, R	
Nelumbonaceae	*Nelumbo lutea*	10 July 2011		S, B
Onagraceae	*Ludwigia helminthorrhiza*	10 July 2011		S, B, I
	Ludwigia peploides	10 July 2011	B, S	
Plantaginaceae	*Bacopa egensis*	10 July 2011	B, S, I	
Pontederiaceae	*Eichhornia crassipes*	19 June 2011	B, S	R
Salviniaceae	*Salvinia auriculata* & *S. minima*	11 July 2011		B,R
Emergent herbaceous				
Alismataceae	*Sagittaria latifolia*	10 July 2011	B, S	
Euphorbiaceae	*Caperonia castaneifolia*	11 July 2011	B, S	
Marantaceae	*Thalia geniculata*	11 July 2011		S, B
Poaceae	*Echinochloa polystachya*	3 July 2011	B, I	S
	Paspalum repens	3 July 2011	B, S	
Pontederiaceae	*Pontenderia sagittata*	10 July 2011	B, S	
Typhaceae	*Typha domingensis*	14 April 2012	S, B	

Table 3a: Summary of freshwater plant natant and emergent herbaceous parts selected and rejected by an Antillean manatee - divided by plant growth form. [1]Plant parts are: leaf blade (B), stem (S), inflorescence (I), and root (R).

Family	Species	Date Tested	Part[1] Selected	Part[1] Rejected
Terrestrial herbaceous				
Asteraceae	*Ambrosia cumanesis*	6 July 2011		S, B, I
Asclepiadaceae	*Asclepias currassavica*	8 July 2011		S, B, I
Boraginaceae	*Heliotropium indicum*	11 July 2011		S, B, I
	Tournefortia sp.	11 July 2011		S, B, I
Capparaceae	*Cleome aculeata*	8 July 2011		S, B, I
Cyperaceae	*Cyperus aff. brevifolius*	19 June 2011	B, I	S
	Cyperus aff. haspan	19 June 2011	S, B, I	
	Cyperus digitatus	3 July 2011	B, I	S
	Cyperus imbricatus	3 July 2011	B, I	S
	Cyperus sp.	3 July 2011	B, S	
	Fimbristylis vahlii	3 July 2011	B, S, I	
Euphorbiaceae	*Croton punctatus*	8 July 2011		S, B, I
Fabaceae	*Aeschynomene rudis*	6 July 2011	B, S	R
	Aeschynomene sp.	14 April 2012		S, B, I
Malvaceae	*Malachra capitata*	8 July 2011		S, B, I
Onagraceae	*Ludwigia octovalvis*	19 June 2011		S, B, I
Poaceae	*Eragrostis contrerasii*	19 June 2011	B	
	Eriochloa punctata	19 June 2011	B	
	Leptochloa panicea subsp. *brachiata*	6 July 2011	S, B, I	R
	Leptochloa panicoides	6 July 2011	S, B, I	
	Panicum sp.	19 June 2011	B	
	Paspalum fasciculatum	8 July 2011	B	
	Paspalum sp.	10 July 2011	B	
	Setaria glauca	8 July 2011	B	
Solanaceae	*Solanum campechiense*	6 July 2011		S, B, I
Sphenocleaceae	*Sphenoclea zeylanica*	6 July 2011		S, B, I
Verbenaceae	*Lippia alba*	8 July 2011		S, B. I
	Phyla strigulosa	6 July 2011	S, B, I	
	Stachytarpheta angustifolia	11 July 2011		S, B, I
Unidentified #1		14 April 2012		S, B, I
Epiphyte or Vine				
Cucurbitaceae	*Momordica charandtia*	8 July 2011		S, B, I
Passifloraceae	*Passiflora foetida*	14 April 2012		S, B, I
Tree or Shrub (woody stem)				
Bignoniaceae	*Tabebuia rosea*	8 July 2011		B
Fabaceae	*Dalbergia glabra*	3 July 2011	B	
	Haematoxylum campechianum	19 June 2011		B
	Haematoxylum campechianum	14 April 2012		B
	Lonchocarpus hondurensis	11 July 2011		B
	Senna sp.	14 April 2012		B
Mimosaceae	*Mimosa pigra*	19 June 2011		B, I
	Mimosa pigra	14 April 2012		B, I
	Zygia recordii	11 July 2011		B

Table 3b: Summary of freshwater plant terrestrial herbaceous, epiphyte, and tree or shrub parts selected and rejected by an Antillean manatee - divided by plant growth form. [1]Plant parts are: leaf blade (B), stem (S), inflorescence (I), and root (R).

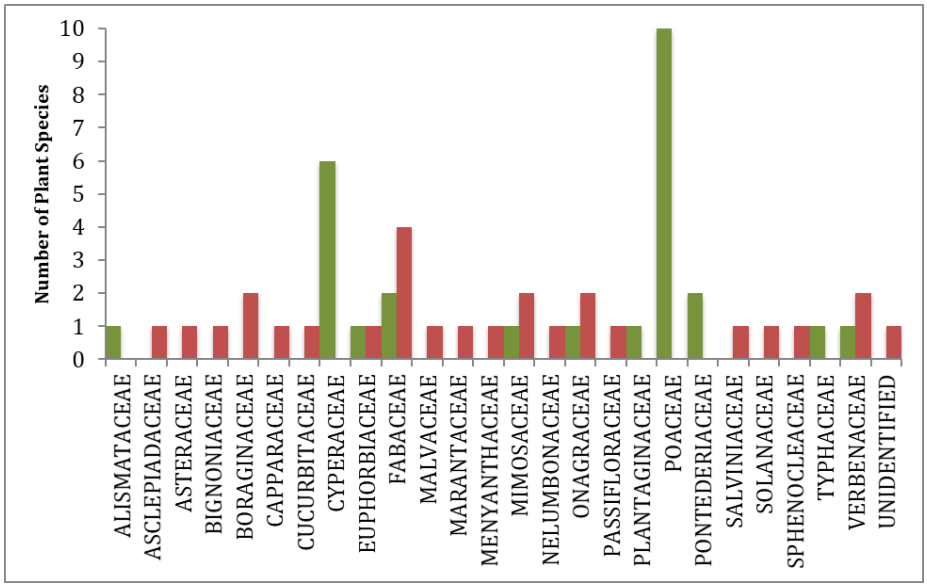

Figure 2: Number of plant species selected (green) and rejected (red) divided by plant family.

Discussion

Wild manatees tend to be very cryptic and reclusive, at times violently reacting to human approach or during attempts to capture them. With the exception of the adult female described above, this has been the observed and reported behavior of manatees in the wetlands of Tabasco (Olivera-Gomez pers. observ.). Such behavior has been suggested to occur in areas where hunting by humans is prevalent or has occurred historically, resulting in manatees modifying their behavior to avoid humans (28). Therefore, this evasive behavior observed in Tabasco and elsewhere may be explained as a historic adaptation to avoid human hunters, rather than a normal reaction to humans.

While rare, wild manatees interacting with humans is not without precedent. Hartman (1979) noted in Crystal River, Florida that some manatees become habituated to humans and would actually seek out petting and stroking with no apparent fear (17). This seems to be the case with the adult female manatee in Balancan, and is reinforced by the similar habituated behaviors observed in both 2011 and 2012, and subsequent visits in 2018 (Gonzalez-Socoloske pers. observ.). However, while humans can swim towards a manatee to interact with it in Crystal River, FL, this was not possible in Balancan because of the low water visibility. All interactions were therefore initiated and terminated by the manatee.

At the level of genera, the 27 plant species selected coincide with the genera reported as food for manatees in other locations (Appendix 1). In addition, most of the genera of the plant species that were rejected were from genera that are not reported as manatee food in other locations (Appendix 1). The only exceptions were *Mimosa pigra*, which was rejected on two independent trials (in 2011 and 2012), *Nelumbo lutea*, and *Salvinia* spp. (*S. auriculata* and *S. minima* were presented together as one because of the difficulty in distinguishing and separating the two species). However, based on the results of this study, listing food items at the level of genera can be misleading at best. For example, two species of the genera *Ludwigia* were rejected, while *Ludwigia peploides* was selected. Bengtson found that manatees avoided *Hydrocotyle umbellate* during feeding experiments in Florida, however the genus has been reported as food in other locations, including another area of Tabasco, Mexico (7, 23, 27).

The small natant ferns in the genera *Salvinia* were both rejected (*S. minima* and *S. auriculata*), however they have been reported as manatee food elsewhere (23). There are two possibilities that could account for the differences between the findings of this study and those reported elsewhere. The first is that *Salvinia* is indeed not a preferred food item, but is rather ingested accidentally when consuming other preferred food items such as *Eichhornia crassipes* (water hyacinth) or *Pistia stratiotes* (water lettuce) because it is very small (1-3 cm). *Salvinia* is found in dense mats adjacent to and often inside other larger natant species

and would therefore be very difficult and or inefficient for manatees to remove when consuming them. This might also be the case for other small natant species such as *Lemna* spp. and *Azolla* spp. that are reportedly consumed by manatees (23). The other explanation might be that while all of the other plant species offered to the manatee during feeding experiments were large enough for the manatee to test them from a relative distance from the hand of the assistant (at least 15 cm), the *Salvinia* spp. were so small that the manatee had to take them literally out of the hand of the assistant. While we believe the former is more likely, we cannot completely rule out the later.

Despite being rather abundant at the study site, *Mimosa pigra* was rejected on two separate occasions in two different years (15). This contradicts both local reports by fishermen and previously published reports from other locations (23, 27). It could be that the *Mimosa* sp. reported in other studies was a different species or that the plant material found in fecal samples represents loose leaves ingested accidentally along with other plant material. *Mimosa pigra* is an invasive legume shrub that tolerates being submerged seasonally for extended amounts of time and is found along the margin of most lakes in Tabasco, Mexico. Thorns on the stems and between the small leaf blades heavily guard it and may be the reason that this manatee avoided it.

Because the feeding experiments were conducted during the dry season when no other food was available and the adult manatee was presumably hungry, selected items may include both preferred and fallback foods, thereby increasing the overall diversity of selected items. A study of the diet of the Amazonian manatee, living in very similar seasonally fluctuating habitats, found that while plant species availability is presumably higher during the wet season, the number of species found in the digesta was lower (8 species) than during the dry season (21 species) when the diversity of plants available is much lower (11). The offered explanation was that Amazonian manatees focused on a few preferred food items during the wet season, but relied on many more fallback food items during the dry season (11). In contrast, digesta samples from Chetumal Bay, Mexico were found to have only 8 plant species in total and there was no effect of manatee sex, age, or season on the plant composition in the digesta (10). While our feeding experiment in Balancan, Tabasco is representative of the available species, containing 14 of the 15 most common species, it was limited to the species that could be found during the dry season (15). Some of these would not be available to manatees due to the low water levels. Many emergent species that were tested are available to manatees during the rising water season immediately after the dry season (15).

Bengtson tested food preference between four plants species previously identified as food items and found that manatees ate the first plant species encountered on 68.2% of the trials (7). This suggests that manatees had a similar preference for all four of these food items. Preference between selected items in our study was not evaluated because only one food item was presented at a time and was therefore outside the scope of this study.

This study expands our understanding of Antillean manatee diet in the region (Central America including Mexico) by 11 genera (9 previously unknown and 2 previously unconfirmed), which amounts to an increase of 18% from the previously known freshwater vascular plant genera consumed by manatees (Table 4). For the West Indian manatee, 10 genera are new reports (7 previously unknown and 3 previously unconfirmed), amounting to an increase of 12.8% from the previously known freshwater vascular plant genera consumed by manatees (Table 4).

Implications for Conservation

The determination of wild manatee diet is very difficult due to the complications of the habitats they live in and the cryptic nature of the animals. Here we present one of only two studies of manatee diet in a freshwater site in Mexico. While this study does significantly advance our knowledge of the manatee diet in the freshwater wetlands of Tabasco, it is limited to the food choice of one adult manatee and should thus be understood in that context. Future studies of other manatees in the area are still needed to better understand what manatees eat during the wet season, which were not explored in this study.

The results indicate that this manatee fed on a variety of vascular plants, both aquatic and terrestrial, which corresponds with the anecdotal accounts reported by local fishermen and with previous studies of manatees living in freshwater (23, 27). Results also indicate that while the manatee in our study can be considered a dietary generalist because it feed from a wide variety of plant genera, it was very selective in what it consumed. Most of the selected species (16 out of 27) came from two families (Poaceae and Cyperaceae). Several genera had selected and rejected species, including some that are closely related (e.g. *Ludwigia peploides* and *Ludwigia helminthorrhiza*). Therefore, caution must be

	Geographic and Taxonomic Level			
Plant Genera	Region[1]	Subspecies[2]	Species[3]	Family[4]
Aeschynomene	**	**	**	*
Bacopa	**	**	**	**
Caperonia	**	**	**	*
Dalbergia	**	**	**	**
Eragrostis	*	*	*	*
Eriochloa	**	**	**	**
Fimbristylis	**	*	*	*
Leptochloa	**	**	**	**
Neptunia	**	*	*	
Phyla	**	**	**	**
Pontenderia	*	*		
Total Previously Unconfirmed	2	4	3	4
Total Previously Unknown	9	7	7	5

*Table 4: Summary of plant genera consumed by manatees in this study previously unknown or unconfirmed at the regional (Central America), subspecies (Antillean manatee), species (West Indian manatee), and family (Trichechidae) level. ** Previously unknown, * previously unconfirmed (inferred from fisherman observations or reports and feeding signs). Manatee diet data from Appendix 1a-d. [1]Includes Central America (Belize, Mexico, Nicaragua, Panama). [2]Includes Central America, the Antilles, and South America (Brazil, French Guiana, Guyana, and Surinam). [3]Includes the whole range of the West Indian manatee (Florida, the Antilles, Central and South America). [4]Includes all known genera consumed by the West Indian, Amazonian, and West African manatee.*

taken when generalizing about manatee diet at the level of plant genera.

The result from this study provides a list of 27 food items that can be provided to captive manatees that have been rescued and are being rehabilitated for future reintroduction into the wetlands of Tabasco, Mexico. Presenting manatees with a wide variety of food options in captivity may be vital to ensure long-term success once they are released back into the wild, especially if preferred food items are not found year round.

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Appendix 1. *Please refer to next pages 29-32 (Appendix 1a-d) re Freshwater plant genera selected and rejected in this study compared with genera reported as consumed by other manatee populations inhabiting similar freshwater habitats determined by various techniques.*

Appendix 1. Freshwater plant genera selected and rejected in this study compared with genera reported as consumed by other manatee populations inhabiting similar freshwater habitats determined by various techniques[1]

	Manatee Species[2]					
	West Indian					
	Florida	South America	Central America	Bal. Tab. Mexico[3]	Amazonian	West African
Submerged						
Cabomba	D	O			D	
Ceratophyllum	B,D,O	O	B,D		U	U
Egeria	D					
Elodea	B,O	O				
Hydrilla	D,O	U				
Myriophyllum	D,O	O			U	U
Najas	B,D,O	U	D		B,S	S
Nitella	U	U				
Ruppia	B,D,O	O	D			U
Utricularia	B	O				
Vallisneria	B,D,O	O			U	
Natant (floating)						
Azolla	U	O			U	U
Bacopa				+		
Eichhornia	B,D,O	B,O	B, D	+	B,S	B
Hymenachne	U	O			B,D,S	
Lemna	O	U				B
Ludwigia				+(1) -(1)	B,S	
Nelumbo	U	O		-		
Neptunia	U	U		+	B,D,S	B
Nuphar	B					
Nymphaea	B	O			B,S	B
Nymphoides				-		B
Pistia	B,D,O	O	B, D		B,D,S	B
Salvinia	O	O		-	B,D,S	U
Sagittaria	D	O				
Victoria	U	O				
Unidentified			B			

Appendix 1a: Summary of freshwater plant submerged and natant.

Basis for records are as follows: B inferred from observations of wild manatees or reports from local fishermen; D recorded in digesta; O confirmed from observations of wild manatees by a scientist; S inferred from manatee feeding signs; U basis for report unknown.
[1]Table modified from Appendix Tables 4.2, 4.3, and 4.4 in Marsh *et al*. (23) and Ponce-Garcia *et al*. (27).
[2]All previously known genera of freshwater plants consumed by West Indian manatees are provided, as well as all genera from this study. Amazonian and West African manatees are included for comparison purposes and only include data on the genera listed for the West Indian manatee.
[3]+ selected by manatee during feeding experiment; - rejected by manatee during feeding experiment; if more than one species from that genus was tested the number is indicated in parenthesis.

Appendix 1. Freshwater plant genera selected and rejected in this study compared with genera reported as consumed by other manatee populations inhabiting similar freshwater habitats determined by various techniques[1]

	Manatee Species[2]					
	West Indian					
	Florida	South America	Central America	Bal. Tab. Mexico[3]	Amazonian	West African
Emergent herbaceous						
Sagittaria	B	O	B, D	+	B,S	
Caperonia				+	B,S	
Thalia				-		
Polygonum			D			
Pontenderia	B,O		B	+		
Typha	B,D,O	O	B, D	+		U
Terrestrial herbaceous or woody stem (also continued next page appendix 1c						
Aeschynomene				+(1),-(1)	B,S	
Albizia			D			
Alternanthera	O	O			B,S	U
Ambrosia				-		
Asclepias				-		
Casuarina	D					
Chara	B	O				
Cleome				-		
Cocos	O					
Colocasia	O					
Combretum			D			
Commelina			D			
Croton				-		
Cyperus		B	B, D	+(5)	B,S	B,O
Dalbergia				+		
Distichlis	B					
Echinochloa			D	+	B,D,S	U
Eleocharis	B	B	B		B,S	
Eragrostis			B,S	+		
Eriochloa				+		

Appendix 1b: Summary of freshwater plant emergent herbaceous and terrestrial herbaceous.

Basis for records are as follows: B inferred from observations of wild manatees or reports from local fishermen; D recorded in digesta; O confirmed from observations of wild manatees by a scientist; S inferred from manatee feeding signs; U basis for report unknown.
[1]Table modified from Appendix Tables 4.2, 4.3, and 4.4 in Marsh *et al*. (23) and Ponce-Garcia *et al*. (27).
[2]All previously known genera of freshwater plants consumed by West Indian manatees are provided, as well as all genera from this study. Amazonian and West African manatees are included for comparison purposes and only include data on the genera listed for the West Indian manatee.
[3]+ selected by manatee during feeding experiment; - rejected by manatee during feeding experiment; if more than one species from that genus was tested the number is indicated in parenthesis.

Appendix 1. Freshwater plant genera selected and rejected in this study compared with genera reported as consumed by other manatee populations inhabiting similar freshwater habitats determined by various techniques[1]

	Manatee Species[2]					
	West Indian					
	Florida	South America	Central America	Bal. Tab. Mexico[3]	Amazonian	West African
Terrestrial herbaceous or woody stem continued						
Ficus	D				B,S	
Fimbristylis		B		+	B,S	
Fuirena			D			
Genipa		B			B,S	
Haematoxylum				-		
Heliotropium				-		
Hydrocotyle	O		D		B,S	
Ipomoea	U	O	D		B,D,S	
Juncus	D					
Laguncularia		B				
Leersia			D			
Leptochloa				+(2)		
Lippia				-		
Lonchocarpus				-		
Ludwigia			D	-	B,D,S	
Luziola	U	O			B,D,S	
Machaerium			B, D			
Malachra				-		
Malvaviscus			D			
Mikania			D			
Mimosa	U	O	D	-		B
Momordica				-		
Montrichardia	S	B,O,S			+	
Muntingia			D			
Neurolaena			D			
Panicum	B,D,O	B,O	B, D	+	B,D,S	
Paspalum	B,D,O	O	D	+(3)	B,D,S	U
Passiflora				-		

Appendix 1c: Summary of freshwater plant terrestrial herbaceous

Basis for records are as follows: B inferred from observations of wild manatees or reports from local fishermen; D recorded in digesta; O confirmed from observations of wild manatees by a scientist; S inferred from manatee feeding signs; U basis for report unknown.
[1]Table modified from Appendix Tables 4.2, 4.3, and 4.4 in Marsh *et al*. (23) and Ponce-Garcia *et al*. (27).
[2]All previously known genera of freshwater plants consumed by West Indian manatees are provided, as well as all genera from this study. Amazonian and West African manatees are included for comparison purposes and only include data on the genera listed for the West Indian manatee.
[3]+ selected by manatee during feeding experiment; - rejected by manatee during feeding experiment; if more than one species from that genus was tested the number is indicated in parenthesis.

Appendix 1. Freshwater plant genera selected and rejected in this study compared with genera reported as consumed by other manatee populations inhabiting similar freshwater habitats determined by various techniques[1]

	Manatee Species[2]					
	West Indian					
	Florida	South America	Central America	Bal. Tab. Mexico[3]	Amazonian	West African
Terrestrial herbaceous or woody stem continued						
Paullinia			D			
Phragmites	D,O		B,D			B
Phyla				+		
Potamogeton	D					
Portulaca	B					
Quercus	O					
Rhabdadenia		B			B,S	
Rhynchospora		B				U
Sabal		O				
Sambucus	O					
Scirpus	O					
Scleria	S					
Senna				-		
Serenoa	O					
Setaria			D	+		
Solanum				-		
Spartinia	B,D,O,S	B				
Sphenoclea				-		
Stachytarpheta				-		
Tabebuia				-		
Thelypteris			D			
Tournefortia				-		
Urochloa	O					
Urtica			D			
Vigna	B		D			
Zizaniopsis	B,S					
Zygia				-		
Unidentified				-		

Appendix 1d: Summary of freshwater plant terrestrial herbaceous

Basis for records are as follows: B inferred from observations of wild manatees or reports from local fishermen; D recorded in digesta; O confirmed from observations of wild manatees by a scientist; S inferred from manatee feeding signs; U basis for report unknown.
[1]Table modified from Appendix Tables 4.2, 4.3, and 4.4 in Marsh *et al*. (23) and Ponce-Garcia *et al*. (27).
[2]All previously known genera of freshwater plants consumed by West Indian manatees are provided, as well as all genera from this study. Amazonian and West African manatees are included for comparison purposes and only include data on the genera listed for the West Indian manatee.
[3]+ selected by manatee during feeding experiment; - rejected by manatee during feeding experiment; if more than one species from that genus was tested the number is indicated in parenthesis.