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Consumption of pelagic tunicates by cetacean calves in the Mediterranean Sea

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Abstract

Gelatinous zooplankton, including jellyfish, ctenophores and pelagic tunicates, constitute fragile marine animals that live in the water column, and represent an important resource for marine food webs through seasonal pulses. Although there is scarce evidence for gelatinous zooplankton occurring in the stomach contents of apex, endothermic predators such as cetaceans, the ecological significance of such observations requires consideration. We herein report the occurrence of pelagic tunicates in the stomach of three individual calves of two cetacean species from the western Mediterranean, and collate all previous reports of gelatinous zooplankton in cetacean diets. We briefly discuss the possible dietary significance of these observations.

Keywords: Pelagic tunicates; stomach content; suction feeding; juvenile cetacean; common minke whale; Risso's dolphin; *Pyrosoma*; *Salpa*.

Introduction

Gelatinous zooplankton encompasses fragile marine animals living in the water column that are of crucial importance as a source of secondary production, and includes jellyfish, ctenophores and pelagic tunicates, i.e. appendicularians and thaliaceans (Bone, 1998; Madinand & Harbison, 2001). As the body of these animals is composed of over 90% water, they generally represent poor-quality prey (Lucas & Dawson, 2014), except for predators with relatively low metabolic rates (fish, sea turtles) that can take advantage of these animals' great abundance and low mobility (Mianzan *et al*., 1996; Tomas *et al*., 2001). Interestingly, there have also been a few reports about gelatinous zooplankton in the stomach contents of apex, endothermic predators, such as cetaceans (e.g. Blanco *et al*., 2006), but the ecological meaning of these observations is open to interpretation. It is possible that gelatinous zooplankton is accidentally consumed by cetaceans or represents secondary prey (i.e. prey of prey). Alternatively, cetaceans could intentionally eat these animals, in which case it would be worthy paying further attention to the circumstantial and functional meaning of such behaviour. Here we report the occurrence of pelagic tunicates in the stomachs of calves of two cetacean species from the western Mediterranean, and analyse all previous reports of gelatinous zooplankton in cetaceans. We briefly discuss the meaning of these observations.

Materials and Methods

Stomach contents were obtained from two female common minke whale *B. acutorostrata* and one male Risso's dolphin *G. griseus* calves, which were found stranded on the Mediterranean coast of Spain in 2014 and 2016, respectively (Table 1). One of the minke whales has been previously reported by Fraija-Fernández *et al*. (2015) to be in an advanced state of decomposition, i.e., state 4 *sensu* Geraci and Lounsbury (2005); the other minke whale was found freshly dead, i.e., state 2 of decomposition; and Risso's dolphin stranded alive and naturally died after stranding. The body condition of both minke whales did not reveal any emaciated condition, whereas Risso's dolphin displayed poor nutritional status. Access to cetacean carcasses was authorised by the Wildlife Service of the Valencian Regional Government (Spain). During necropsies, the gastrointestinal tract was removed and stored overnight at 4ºC. Stomach contents were flushed through a 0.2 mm mesh and fixed in 70% ethanol for the minke whales, and deep frozen (-20ºC) for Risso's dolphin. The stomach wall was also thoroughly examined for small prey fragments. Pelagic tunicate prey were identified using the

Table 1. Biometric data and stomach content of the cetaceans analysed in this study. "n" is the number of items counted and "g" is the dry weight in grams of items not counted.

Cetacean species	Date and place of stranding	Body length (cm) / Gender	Stomach content	n	g
Balaenoptera acutorostrata	28/04/2014 Santa Pola (Alicante) 38.20º N – 0.57º W	300 / F	*Salpa maxima*	45	-
			Vegetal debris	2	-
	23/05/2016 Javea (Alicante) 38.77º N – 0.15° E	381 / F	*Salpa maxima*	123	-
			Pyrosoma atlanticum (large colony)	-	282.1
Grampus griseus	16/09/2016 Burriana (Castellón) 39.88° N – 0.08° W	183 / M	*Salpa maxima*	71	-
			Pyrosoma atlanticum (small colony)	30	-
			Plastic	1	-
			Vegetal debris	1	-
			Unidentified gelatinous zooplankton	-	11.5

dichotomic keys for Thaliacea by Fraser (1982) and Godeaux (1998). Intact individual colonies of pyrosomids, and stomachs and salps, were counted. Partially digested tunicate remains were placed in a 0.2 mm mesh to drain excess fixative and were then weighed to the nearest 0.01 g. Next, this material was dried in an oven at 60ºC for 72 h to obtain the dry weight.

Results and Discussion

Partially digested large colonies (wet weight 472.3 g; dry weight 282.1 g) and the intact colonies of *Pyrosoma atlanticum* (Pyrosomatidae) were found in one minke whale and in Risso's dolphin, respectively (Fig. 1A, B), whereas the intact stomachs of *Salpa maxima* (Salpidae) were found in all three calves (Fig. 1C, D). Partially digested and unidentified gelatinous zooplankton (wet weight 40.7 g; dry weight 11.5 g) was found in Risso's dolphin (Fig. 1E). Vegetal debris was also found in one minke whale, and vegetal debris and a small (~ 5cm^2) piece of plastic (duct tape) were observed in Risso's dolphin (Table 1).

Reports about gelatinous zooplankton eaten by cetaceans are shown in Table 2. We found no records of jellyfish in stomach contents, but there is a published observation of a young killer whale, *Orcinus orca*, having eaten a jellyfish (Similä *et al*., 1996). Species of tunicates, mostly *Pyrosoma atlanticum*, have been found in stomach contents of eight species of cetaceans, including minke whale, sperm whale, three species of dolphin, and three species of beaked whale (Table 2). All these species, except the striped dolphin, *Stenella coeruleoalba* and Commerson's dolphin *Cephalorhynchus commersonii,* are filter or suction feeders (see Werth, 2006). Most records involve juvenile or adult individuals in which remains of cephalopods, or cephalopods and fish, have also been found in the stomach. Only the calves of the minke whale and Risso's dolphin reported herein, and a calf of a southern bottlenose whale, *Hyperoodon planifrons*, only had remains of tunicates (Table 2).

The significance of gelatinous zooplankton in the diet of most pelagic predators has generally been overlooked (Sullivan & Kremer, 2011) because these prey items are either readily digested (Harbison, 1998; Lucas & Dawson, 2014) or not easily recognised. However, the scarcity of records about gelatinous zooplankton in cetaceans strongly suggests that they would seldom be eaten as prey; this conclusion is further supported in striped dolphins by stable isotope analysis results (e.g. Cardona *et al*., 2012). Moreover, the fact that most records about tunicates in the stomach contents of cetaceans involve suction-feeder species may suggest that tunicates are accidentally eaten along with the actual prey (see Walker *et al*., 2002).

However, the finding that tunicates were the only constituent of the stomach contents of calves is more puzzling because they suggest intentional ingestion. Calves of cetaceans exhibit a more limited ability to capture swift prey than adults, thus they often select slower prey that are easier to catch (see Ichii & Kato, 1991; Bowen & Siniff, 1999; Blanco *et al*., 2006). However, according to the slight level of digestion of the thaliaceans found herein, not much time would have passed between the cetaceans' last meal and their stranding. This suggests a couple of scenarios: firstly, these calves perhaps presented an abnormal state (e.g. separated from their mothers), so the ingestion of gelatinous zooplankton could have been a last resort before death; secondly, the animals were playing or practicing engulfment filter-feeding by targeting slow-moving species. Whether the consumption of tunicates formed part of a natural behavioural repertoire of these calves thus remains an open question. In any event,

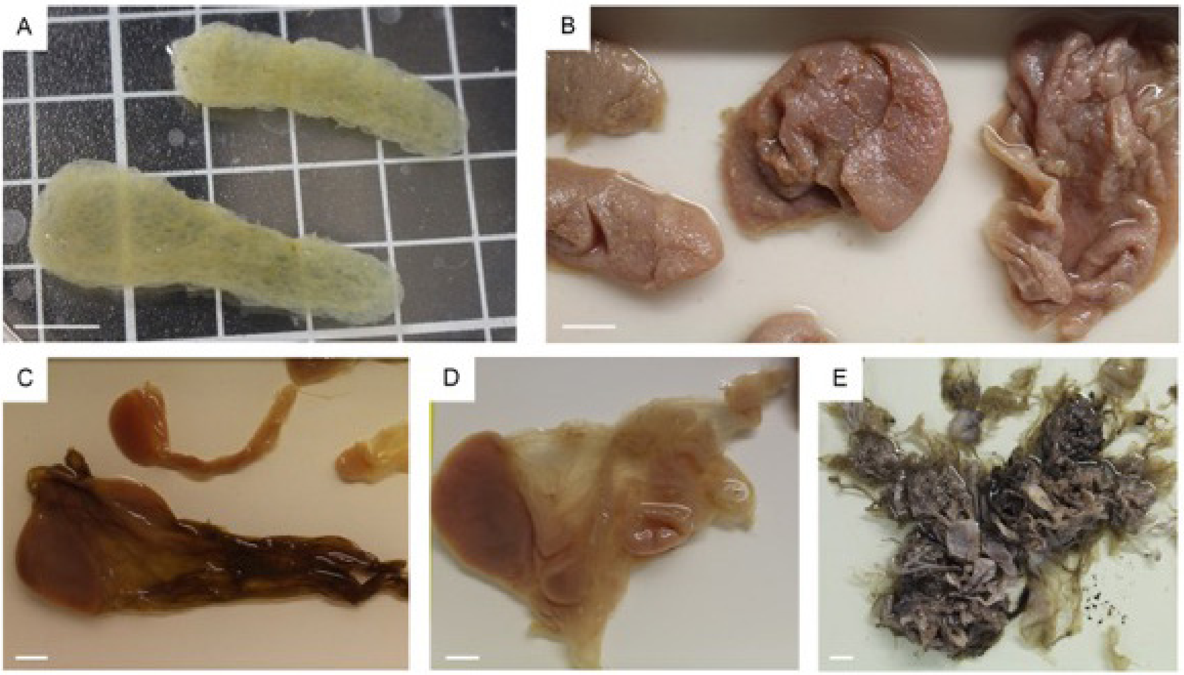

Fig. 1: Thaliaceans found in the stomach of two common minke whales calves *Balaenoptera acutorostrata* and one Risso's dolphin calf *Grampus griseus*. A) Small colonies of *Pyrosoma atlanticum*; B) large colonies of *P. atlanticum*; C-D) *Salpa maxima;* E) unidentified gelatinous zooplankton. Small colonies of *P. atlanticum* (A) and the unidentified gelatinous zooplankton (E) were found in the stomach of Risso's dolphin, whereas large colonies of *P. atlanticum* (B) and *S. maxima* (C-D) were found in the stomach of the common minke whale. Scale bars: 1 cm.

Table 2. Gelatinous zooplankton reported to date in the stomach contents of cetaceans. Missing data from original articles are noted with ?. Gender: (F) female; (M) male.

Cetacean species	Body length (cm) / Gender	Age class	Tunicata	Other prey	Source
Balaenopteridae					
Balaenoptera acutorostrata	300 / F	Nursing calf [1]	*Salpa maxima* *Pyrosoma atlanticum*	No	This study
	381 / F	Nursing[1] calf	*Salpa maxima, Pyrosoma atlanticum*	No	This study
Delphiniidae					
Cephalorhynchus commersonii	?	?	Unidentified tunicates	?	Goodall and Galeazzi 1985
Grampus griseus	172 / M	Calf	Colonial ascidian	Cephalopods, fish and bryozoans	Blanco *et al*. 2006
	183 / M	Calf	*Salpa maxima, Pyrosoma atlanticum*	No	This study
	292 / F	Adult	*Salpa fusiformis, Pyrosoma atlanticum, Iasis zonaria*	Cephalopods	Blanco *et al*. 2006
Stenella coeruleoalba	?	?	Undetermined tunicates	?	Hernán-dez-Millán 2014

(continued)

Table 2 continued

Cetacean species	Body length (cm) / Gender	Age class	Tunicata	Other prey	Source
	196 / M	Adult	Salps	Cephalopods and fish	Aznar *et al*. 2017
	218 / M	Adult	Pyrosomids	Cephalopods and fish	Aznar *et al*. 2017
Physeteridae					
Physeter macrocephalus	980 / M	Juvenile	Salps	Cephalopods	Clarke *et al*. 1993
	1,000 / F	Juvenile	*Pyrosoma atlanticum*	?	Best 1999
	1,040 / F	Juvenile	*Pyrosoma atlanticum*	?	Best 1999
	1,040-1,190 / M [2]	Juveniles	*Pyrosoma atlanticum*	?	Best 1999
	1,220-1,520 / M [2]	Adults	*Pyrosoma atlanticum*	?	Best 1999
	1,320 / M	Adult	*Pyrosoma* sp.	Cephalopods	Clarke *et al*. 1993
	1,490 / M	Adult	*Pyrosoma* sp.	Cephalopods	Clarke *et al*. 1993
Ziphiidae					
Berardius bairdii	950 / M [3]	Juvenile	*Pyrosoma atlanticum*	Fish and squid [3]	Walker *et al*. 2002
	950 / M	Juvenile	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
	1,000 / M	Adult	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
	1,002 / F	Adult	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
	1,004 / F	Adult	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
	1,005 / F	Adult	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
	1,010 / F	Adult	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
	1,020 / F	Adult	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
	1,040 / F	Adult	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
	1,110 / F	Adult	*Pyrosoma atlanticum*	Fish and squid	Walker *et al*. 2002
Hyperoodon planifrons	367 / M	Calf	*Pyrosoma atlanticum*, *Thetys vagina*	No	Dixon *et al*. 1994
Mesoplodon stejneri	544 / F	Adult	*Pyrosoma* sp.	Squid	Walker and Hanson 1999

[1] The age class of the two common minke whales was established according to their body length (see Fraija-Fernández *et al*. 2015 for specific details).

[2] Body length expressed as the range of measurements from 12 juvenile and 11 adult male sperm whales reported by Best (1999).

[3] Information on gender, body length and stomach contents of beaked whales were provided as a personal communication from Dr William Walker (Alaska Fisheries Science Center at the National Marine Fisheries Service, NOAA, 7600 Sand Point Way, N.E., Seattle, Washington 98115, USA) in November 2017.

we believe that more attention should be paid to pelagic tunicates as the occasional prey of cetacean juveniles or calves. A thorough examination of stomach contents, as well as the implementation of stable isotope and genetic analyses, could help circumvent the drawbacks associated with the difficult detection and identification of these animals by visual scrutiny.

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