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SHORT COMMUNICATION

Supportive behavior of free-ranging Atlantic spotted dolphins (*Stenella frontalis*) toward dead neonates, with data on perinatal mortality

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Abstract This study adds the Atlantic spotted dolphin *Stenella frontalis* to the list of species displaying nurturant behavior as a response to perinatal mortality. It is based on two in situ behavioral observations off Madeira Island (Portugal) (but with only one continuing uninterrupted). Additionally, postmortem exams were carried out on four fresh neonate carcasses, two from the previous events and two from distinct events where carcasses were found floating with no individuals in the vicinity. The in situ observations show that adult Atlantic spotted dolphins try to support their dead calves at surface, either involving a single individual (presumably the mother) or several individuals. The highly fresh condition of the carcasses suggests that the adults abandon them after a short period of time (hours). The postmortem exams suggest that the four neonates died from natural causes, and not from anthropogenic causes, predation, or other intra- or interspecific behavioral interaction as described in some cetacean populations. Accurate lengths at birth are also provided, which are scarce in literature for this species.

Keywords Birth lengths · Cetacea · Madeira · Nurturant behavior · Postmortem exams

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Introduction

Epimeletic behavior involves the giving of care or attention, and is termed "nurturant" if directed toward young (Caldwell and Caldwell 1966a). Apparent intraspecific nurturant behavior toward dead calves in the wild has been documented for several delphinid species, such as bottlenose dolphin *Tursiops truncatus* (Fertl and Schiro 1994), gray dolphin *Sotalia fluviatilis* (Santos et al. 2000), or long-beaked common dolphin *Delphinus capensis* (Park et al. 2013). Yet, this type of behavioral response remains undocumented for many species, such as the Atlantic spotted dolphin *Stenella frontalis*.

The Atlantic spotted dolphin is a free-ranging species endemic to the tropical and warm-temperate Atlantic (Perrin 2002). In the West Atlantic, it is known to occur in coastal shallow waters, as in the Bahamas sand flats, where it has been well studied (e.g., Herzing 1996; Elliser and Herzing 2014). In the Central and East Atlantic, this species inhabits offshore deep waters, as in the oceanic archipelagos of the Azores and Madeira, respectively (Quérouil et al. 2013). The events described here were recorded up to five nautical miles off the southern coast of Madeira Island (Portugal) during nautical surveys carried out by the Madeira Whale Museum (MWM) (described in Alves 2013), and also by a tourist operator (see "Acknowledgments"). This warm-temperate volcanic island, located 600 km West off Morocco (Africa), is surrounded by steep submarine canyons and deep waters (ca. 1500 m) due to a reduced continental shelf (Geldmacher et al. 2000). Calves of Atlantic spotted dolphins are commonly observed in Madeira, mainly during summer and autumn when the species is more abundant (Quérouil et al. 2013). Mean group size

reported for this area is 18 individuals (SD=14), including all age classes (Quérouil et al. 2010).

This note reports in situ observations of Atlantic spotted dolphins supporting dead neonates at surface, based on two anecdotal events, one presumably uninterrupted (event #1) and another interrupted by the researchers (event #2). The present observations shed light on the nurturant behavior of this species, especially in the eastern Atlantic population where its social behavior is scarcely documented. Additionally, two other dead neonates were found abandoned on distinct occasions (events #3 and #4). The postmortem exams of the four fresh carcasses provide possible causes of death, as well as accurate lengths at birth (given that three were newborns). This type of data is scarce in literature for this species, plus difficult to determine from live animals in the wild.

Methods and results

Event #1

The first event was recorded on 20 July 2005 by a tourist operator that immediately contacted the MWM. At 11 a.m., the boat approached, to about 15 m, a group of 20 individuals, and noted that four adult individuals were constantly in the proximity of the dead calf, trying to support the carcass at surface with the melon and the anterior dorsal region. The rest of the group kept close but apparently did not actively participate. After 30 min of observation, several individuals performed few high jumps and all group members moved away at high speed, abandoning the carcass. Then, the carcass was collected into the boat. An hour later, the MWM scientific team confirmed that the fresh carcass was a newborn, based on its size (Table 1) and on the presence of an umbilical cord and fur on the beak. The body and fins had many parallel scratches and bite marks, which were freshly made by adult teeth. The calf was preserved in formol and integrated in the MWM biological collections.

Event #2

The second event was recorded on 28 June 2006 onboard the research rigid inflatable boat (RIB) "Roaz." At 3:45 p.m., the boat approached, to about 10 m distance, one adult individual supporting a dead calf at the surface. The adult, presumably the mother, measured approximately 1.90 m (based on an image that allowed comparison with the calf). Neither other individuals nor boats were in the area. After a 30-min period supporting the calf at surface with the melon or with the anterior dorsal region (see "Electronic Supplementary Material"), the boat approached the carcass and one researcher lifted it into the boat. The adult behavior was carefully observed, which showed no signs of distress and started to swim slowly in a southern direction. The fresh carcass was identified as newborn, based on its size (Table 1) and on the presence of an umbilical cord and fur on the beak. It did not present teeth scratches, despite the observed effort demonstrated by the adult to support the carcass at the surface. The x-ray showed no skeleton fracture. The necropsy showed that the lungs had air, indicating that the neonate did breathe. The only abnormality found during the necropsy was a perforation on the right lung and a pneumothorax, which was probably the cause of death. The absence of external edemas and bone fractures exclude the hypothesis of an external physical impact to have caused the pulmonary edema. The necropsy also revealed no stomach contents, and that there was still meconium in the large intestine. The histopathologic exam to the kidney did not detect any abnormality, and the microbiologic exam detected the presence of *Escherichia coli* and *Enterobacter sakazakii* in hemoculture, and of *Staphylococcus epidermis* and *E. sakazakii* in the innards.

Event #3

The third event was recorded on 08 September 2006. A dead calf was seen floating a few meters off Reis Magos beach at 12:30 p.m. by local people, with no other individuals nearby. The MWM was immediately contacted, collecting the fresh carcass approximately 30 min later. Although the carcass' total length was within the sizes of the other measured calves identified as newborns in the present study, this one was heavier and more robust, as corroborated by the larger maximum perimeter (Table 1). Moreover, its muscles were stronger, and had neither an umbilical cord nor fur on the beak. Although it is still considered as neonate according to Herzing (1997) (1–3 months) and Noren and Edwards (2007) (<2 weeks), the physical characteristics suggest that it lived longer than the remaining calves presented here. The carcass did not present teeth scratches, bite marks, or external edemas. The x-ray showed no skeleton fracture. The necropsy revealed an internal hemorrhage in the abdominal cavity with signs of infection on the spleen, which was probably the cause of death. It also revealed that the stomach and the small intestine contained milk. The histopathologic exam confirmed a diffuse hemorrhage in the spleen. The same exam also showed samples of hyaline necrosis in the liver, tubular vacuolisation in the kidney, and no lesions in the lungs and myocardial. The microbiologic exam did not detect microorganisms. Therefore, the hepatic lesions suggest an infectious process of non-bacterial origin. The highly fresh condition of the carcass, of state 2 according to Geraci and Lounsbury (2005), suggests that the calf had died recently, and that it was abandoned after a short period (of hours, based on the similar decomposition state when compared with the carcasses from the two previous events). The absence of physical

Table 1 General physical characteristics and measurements of Atlantic spotted dolphin neonates from Madeira

	Event/neonate				Mean±SD at birth	Mean±SD of neonates
	#1	#2	#3	#4	(#1, #2, #4)	(#1, #2, #3, #4)
Gender	F	M	M	M		
Umbilical cord	Y	Y	N	Y		
Fur on the beak	Y	Y	N	Y		
Weight (kg)	–	6.14	7.68	6.06	6.1±0.1	6.6±0.9
Lengths (cm)						
Total	75.5	75.3	80.5	82.0	77.6±3.8	78.3±3.4
Maximum perimeter	42.0	45.0	54.0	46.0	44.3±2.1	46.8±5.1
Beak	4.8	4.6	4.1	4.5	4.6±0.2	4.5±0.3
Snout–eye	15.0	14.6	15.5	14.0	14.5±0.5	14.8±0.6
Snout–blowhole	13.5	13.0	11.8	14.5	13.7±0.8	13.2±1.1
Snout–ant. ins. of flip	22.0	21.7	21.0	21.5	21.7±0.3	21.6±0.4
Snout–tip of dorsal fin	50.5	37.0	48.0	52.0	46.5±8.3	46.9±6.8
Snout–navel	38.5	39.5	41.5	41.0	39.7±1.3	40.1±1.4
Snout–genital	49.5	51.0	52.5	54.0	51.5±2.3	51.8±1.9
Snout–anus	55.0	56.5	59.0	58.0	56.5±1.5	57.1±1.8
Dorsal fin height	7.0	8.2	7.7	7.5	7.6±0.6	7.6±0.5
Dorsal fin base	12.3	11.6	11.8	12.0	12.0±0.4	11.9±0.3
Fluke width	14.8	15.5	18.0	15.0	15.1±0.4	15.8±1.5

Mean at birth considers only newborns

F female, *M* male, *Y* yes, *N* no

marks (teeth or bite marks) does not exclude the hypothesis of rescue attempts by any adult of the group, as shown in the previous event (where an adult that was observed supporting a dead calf caused no physical marks).

Event #4

The fourth event was recorded on 01 July 2007 onboard the research RIB "Roaz." At 3:15 p.m., a carcass was seen floating, with no other individuals in the area. The fresh carcass was identified as newborn, based on its size (Table 1) and on the presence of an umbilical cord and fur on the beak. The calf had many parallel scratches and bite marks from adult teeth in the body, fluke, and flippers. The visual inspection showed no external edemas, and the x-ray revealed no skeleton fracture (that does not exclude possible harassment by conspecifics). The postmortem exam did not yield a conclusive cause of death. As in the previous event, the fresh condition of the carcass suggests that the calf had died recently, and that it was abandoned after a short period.

Discussion

This study shows that adult Atlantic spotted dolphins invest efforts in supporting their calves at the surface when in distress/dead. It can involve a single individual (presumably the mother), or several adult individuals. The involvement of group effort to support a dead calf at surface is documented for other delphinid species such as bottlenose dolphin (Cockcroft and Sauer 1990) or long-beaked common dolphin (Park et al. 2013). An investment to rescue a dead calf as a mother's response to perinatal mortality is expected in a mammal species with a long gestation period. However, the highly fresh condition of the abandoned carcasses suggests that the Atlantic spotted dolphin invest a short period of time (hours).

The postmortem exams suggest that the four neonates died from natural causes, and not from anthropogenic causes, predation, or other intra- or interspecific behavioral interaction such as harassment, aggression, or infanticide, as described in some cetacean populations (e.g., Patterson et al. 1998; Mann and Watson-Capps 2005; Robinson 2014). Additionally, the exams revealed that one calf was possibly born dead, two lived between minutes to few hours, and one lived between days to weeks, based on physical characteristics according to Noren and Edwards (2007). There is no information on first-year calf mortality in this species in Madeira, but Herzing (1997) described a high average mortality (24 %) for a group of Atlantic spotted dolphin in the Bahamas. The data of the four postmortem exams presented here were compared with available data from five necropsies of adults from the same population to try to put the results into perspective. Adults were all fresh (decomposition state 2 according to Geraci and Lounsbury (2005)) and the necropsies revealed that one died

from a septicaemia caused by a bacterial infection, one from a wound caused by a harpoon, and three were inconclusive (unpublished data from the MWM). Therefore, such data did not provide very useful information to assess if the causes of death of neonates were relatively well-known for the species or unique to calves.

In the present study, the total length of the observed neonates ranged between 75 and 82 cm (see Table 1). In the literature (e.g., Perrin 2002), the average length at birth of Atlantic spotted dolphins is described as within the range of the smallest record (78 cm, Caldwell and Caldwell 1966b), the largest fetus (88 cm, Perrin et al. 1994), and the smallest free-swimming animal (120 cm, Perrin and Reilly 1984). The data presented here suggests that length at birth in this species is closer to the values described in Caldwell and Caldwell (1966b). Nevertheless, it must be taken into account that body size varies geographically, and that lengths at birth may be smaller in the eastern Atlantic population, corroborating that the smallest animals are found around offshore islands and on high seas (Perrin et al. 1994).

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