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EVIDENCE FOR INFANTICIDE IN BOTTLENOSE DOLPHINS OF THE WESTERN NORTH ATLANTIC

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ABSTRACT: Nine bottlenose dolphin (*Tursiops truncatus*) calves that stranded in Virginia in 1996 and 1997 died of severe blunt-force trauma. Injuries were concentrated on the head and chest and multiple rib fractures, lung lacerations, and soft tissue contusions were prominent. Skeletal and/or soft tissue trauma occurred bilaterally in all of the calves. One had a bite wound across the left mandible that exhibited deep punctures consistent with the tooth placement in an adult bottlenose dolphin. The lesions were not compatible with predation, boat strike, fisheries interactions, rough-surf injury, or blast injury. However, they were similar to traumatic injuries described in stranded bottlenose dolphin calves and harbor porpoises (*Phocoena phocoena*) in Great Britain attributed to violent dolphin interactions. The evidence suggests that violent dolphin behavior was the cause of the trauma in the nine calves reported here and that infanticide occurs in bottlenose dolphins of the western North Atlantic.

Key words: Bottlenose dolphin, cetacean, infanticide, marine mammal, pathology, strandings, trauma, *Tursiops truncatus.*

INTRODUCTION

Infanticide, the taking of infant life, has been documented in numerous species of animals (insects, amphibians, fishes, birds, and primates, including humans; Hrdy, 1979; Hausfater and Hrdy, 1984). Only recently has this list grown to include cetaceans. Patterson et al. (1998) reported evidence for infanticide in the bottlenose dolphin (*Tursiops truncatus*) population of the Moray Firth, Scotland.

Bottlenose dolphins appear in Virginia (USA) waters seasonally from May to October (Barco et al., 1999). During 1996 and 1997, 85 bottlenose dolphin strandings were investigated in the state. Of these, 37 were dependent calves probably ≤1 yr (<160 cm). Blunt-force trauma was determined to be the cause of death in nine of 20 calves necropsied. Here we present evidence that the traumatic lesions present in these nine calves resulted from infanticide.

MATERIALS AND METHODS

Virginia Marine Science Museum Stranding Program personnel collected all stranded animals. Three of the nine dolphins (VMSM 19971049, 19971058, and 19971060) were chilled and necropsied within 48 hr at the Virginia Marine Science Museum. The other animals were frozen and postmortem examinations and developmental studies were conducted later at the University of North Carolina at Wilmington (North Carolina, USA). Photographs and videotapes of the necropsies were taken when possible. The degree of decomposition determined the extent of the necropsy examination. Using Smithsonian Condition Codes (Geraci and Lounsbury, 1993), animals classified as code 2 (fresh dead) received a complete standard necropsy (McLellan et al., in press) with systematic examination of all organ systems. Animals classified as code 3 (moderate decomposition) received a necropsy abbreviated only by the degree of decomposition. Specimens of selected tissues and lesions from code 2 animals were collected in 10% neutral buffered formalin for histiologic examination at the Armed Forces Institute of Pathology (Washington, D.C., USA). Tissue specimens examined histologically were embedded in paraffin, cut into 5 μm sections and stained with hematoxylin and eosin.

RESULTS

The nine calves we studied (Table 1) stranded in 1996 ($n=2$) and 1997 ($n=7$). Strandings occurred between May and September from Hampton, Virginia

TABLE 1.. Bottlenose dolphin (*Tursiops truncatus*) calves killed by blunt-force trauma attributed to infanticide.

Case number	Stranding date	Stranding location	Condition code	Length (cm)	Sex	Multiple fractures	Soft tissue injuries	Bilateral trauma
1. 19961028	09-May-96	36° 35.6′N/75° 52.1′W	2	111	male	x	x	x
2. 19961035	28-May-96	37° 9.1′N/76° 20.3′W	2	106	male	x	x	x
3. 19971045	08-Aug-97	36° 47.2′N/75° 58.3′W	2	144	male	x	x	x
4. 19971049	17-Aug-97	36° 53.0′N/75° 59.0′W	2	138	male	x	x	x
5. 19971053	25-Aug-97	36° 51.3′N/75° 58.7′W	2	112	female	x	x	x
6. 19971056	29-Aug-97	36° 47.3′N/75° 57.5′W	3	115	male	x	x	x
7. 19971058	04-Sep-97	36° 55.9′N/76° 1.8′W	2	158	male	x	x	x
8. 19971059	12-Sep-97	37° 0.9′N/76° 18.36′W	3	125	female	x	x	x
9. 10071060	23-Sep-97	36° 55.2′N/76° 2.4′W	2	153	female	x	x	x

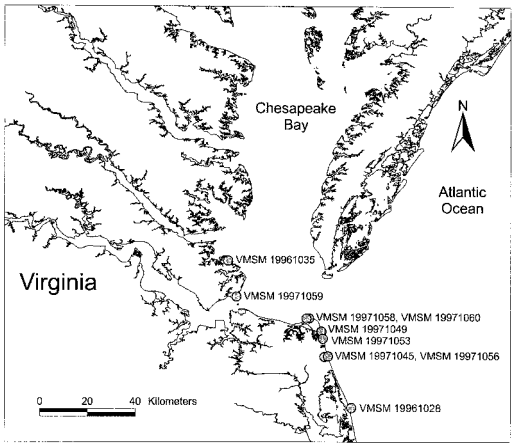

FIGURE 1. Locations of 1996 and 1997 strandings of traumatized bottlenose dolphin calves in southeastern Virginia.

(37°9.1′N, 76°20.3′W) along the western coast of Chesapeake Bay, to the southern ocean coast of Virginia Beach, Virginia (36°35.6′N, 75°52.1′W) near the North Carolina state line (Fig. 1). Seven of the nine calves were classified as fresh dead and two were moderately decomposed. All of the calves were ≤158 cm in length (mean=129 cm) and were, therefore, estimated to be within their first year of life (Mead and Potter, 1990) and still dependent upon their mothers (Connor et al., 1996). Milk curd was found in the forestomachs of two. Fetal folds indicated that five calves were probably ≤2 mo. of age (Cockcroft and Ross, 1990). Six of the nine calves were males.

Only three calves had any external evidence of injury. One had a bite wound across the left mandible that exhibited deep punctures consistent with tooth placement in an adult bottlenose dolphin. Two of the calves had a few parallel linear skin abrasions (i.e., tooth rakes) that were judged by their spacing to have been caused by the teeth of an adult bottlenose dolphin. Injuries were concentrated on the head and thorax. All of the animals had multiple, antemortem bone fractures, including multiple rib fractures (Fig. 2). Rib fractures occurred at various locations, often in a linear pattern involving adjacent

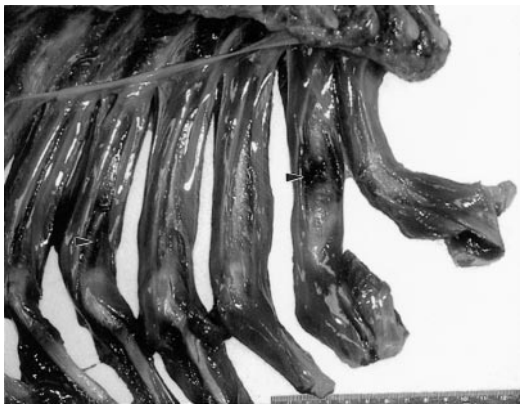

FIGURE 2. Traumatized bottlenose dolphin calf (VMSM 19971045). Periosteal hemorrhage (arrows) and fractured ribs 2, 5, and 6.

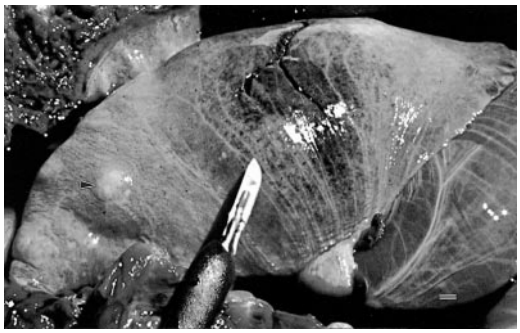

FIGURE 3. Traumatized bottlenose dolphin calf (VMSM 19971058). Laceration and contusion of the lung and verminous pneumonia in the cranial aspect (arrow). Bar=1 cm.

ribs, and were frequently present on both sides of the thorax. In addition to antemortem fractures at least two animals (VMSM 19971045 and VMSM 19971049) had postmortem rib fractures. Four calves had fractured and/or luxated vertebrae, one with a concomitant severed spinal cord. There also were fractures of scapula, skull, and tympanic bulla in separate calves. Other findings included lung lacerations and contusions (eight of nine) (Fig. 3), soft tissue contusions (seven of nine), hemothorax (five of nine), hemoperitoneum (two of nine), liver contusions (two of nine), liver lacerations (one of nine), and lacerations of the diaphragm (one of nine). As with rib fractures, soft tissue trauma was often bilateral. Soft tissue contusions were frequently separate and discrete. Skeletal and/or soft tissue trauma occurred bilaterally in every calf. An additional gross finding was the presence of a few, small, raised, white nodules in the lungs (five of nine) interpreted to be evidence of verminous pneumonia.

Gross necropsy findings indicated severe blunt-force trauma was the cause of death. The pattern of bilateral, multiple fractures and discrete soft tissue injuries suggests repeated trauma and trauma inflicted from multiple directions.

Tissues collected from five of the seven fresh dead animals, including four of the five suspected of having verminous pneumonia, were examined microscopically. A fibrocartilaginous callus observed histologically at one rib fracture site (VMSM 19971060) suggested that the traumatic events were not always immediately fatal. Acute injuries on the same animal suggested that trauma may have been repeated over a period of several weeks. Verminous pneumonia attributed to *Halocerus* sp. was confirmed in one animal. Microscopic examination of the remaining tissue specimens revealed no additional significant histologic lesions.

DISCUSSION

These postmortem findings are unusual in three ways: 1) the absence of significant external signs of trauma in six of nine calves, 2) the cranial and thoracic orientation of lesions, and 3) a pattern suggestive of repeated blunt-force injury inflicted from multiple directions. For these reasons, the lesions in these dolphin calves are not compatible with predation, boat strike, fisheries interactions, rough-surf injury, or blast injury, but are compatible with the reported evidence of infanticide. If predation from sharks was involved there would be evidence of bite marks. Boat strike could produce blunt-force trauma but the trauma would not likely be repetitive, multidirectional, and consistently focused on the head and thorax. If

propeller strike was involved it would produce sharp-force injuries (Wright et al., 1995). Fisheries interaction is a well-known cause of mortality in bottlenose dolphins (Waring et al., 2000); however, none of these animals had the characteristic marks produced by contact with, or release from, fishing gear. Moreover, while skull fractures occasionally have been reported in fisheries interactions, the multiple skeletal fractures and massive internal injuries present in these cases have not (Kuiken, 1994). Rough surf injury could potentially produce blunt-force lesions, but evidence of sharp-force injury also would be expected, i.e., cuts, scrapes, and possibly punctures. Blast injury, another potential cause of blunt-force trauma, also seems implausible because it would most likely have affected a wider range of ages and animal species and probably would not have produced discrete lesions on the head and thorax.

A comparison of the postmortem findings in our calves with traumatic injuries described in stranded harbor porpoises (*Phocoena phocoena*) (Ross and Wilson, 1996) and bottlenose dolphin calves (Patterson et al., 1998) in Great Britain revealed remarkable similarities. Ross and Wilson (1996) reported multiple, internal, antemortem injuries in 63% of harbor porpoises stranded around the Moray Firth of Scotland. The injuries included subcuticular bruising and hemorrhage, particularly over the head, dorsum, upper chest wall and flank; multiple rib fractures; perforated lungs; and spinal dislocations. Most of the harbor porpoises with these injuries had no skin lesions; however, the remainder bore teeth marks that, by their pattern and spacing, were attributed to adult bottlenose dolphins. The authors also personally observed four instances of violent dolphin-harbor porpoise interaction. Patterson et al. (1998) described similar antemortem injuries in five bottlenose dolphin calves from the same region. Interestingly, the injuries included contusions around the head and thorax, multiple rib fractures, lacerated lungs, and spinal dislocations. In each case, the only external signs of injury were teeth marks attributed to adult bottlenose dolphins. A violent interaction between two adult bottlenose dolphins and a dead dolphin calf also was observed.

Based on physical evidence obtained on postmortem examination and field observations, the authors (Ross and Wilson, 1996; Patterson et al., 1998) concluded that purposeful violent dolphin interaction was the cause of the traumatic deaths in the harbor porpoises and dolphin calves. Given the similarities in the postmortem evidence obtained in Great Britain and Virginia, the cause of the trauma appears to be the same in both locations. Although no reports of dolphin behavior resulting in the death of a calf were reported in Virginia, one of the authors (SGB) observed several behavioral events benignly dubbed "calf tossing" in the near shore waters of Virginia Beach. These events involved a calf-sized dolphin, interacting with one or more larger conspecifics. The observations ($n<10$) all involved the calf becoming airborne, sometimes repeatedly. In retrospect, these events could be violent dolphin interactions and could be related to the injuries sustained by the stranded dolphin calves.

Although interactions were observed between dolphin calves and other dolphins, it is possible that another species could have caused trauma to the calves. Based on stranding records, bottlenose dolphins are by far the most numerous marine mammal in Virginia waters. Between 1991–97, Virginia recorded the following odontocete cetacean strandings: 192 bottlenose dolphins, 36 harbor porpoises, eight pilot whales (*Globicephala* sp.), three pygmy sperm whales (*Kogia breviceps*), two striped dolphins (*Stenella coeruleoalba*), one Risso's dolphin (*Grampus griseus*), and one white-sided dolphin (*Lagenorhynchus acutus*) (Swingle and Barco, 1997, 1998). The relative abundance of bottlenose dolphins in Virginia, physical evidence of teeth marks on the

dead calves, and observations of violent dolphin behavior in Great Britain and possibly in Virginia, suggest that bottlenose dolphins caused the death of these calves.

Hausfater and Hrdy (1984) suggest predation, limited resources, social pathology, parental manipulation, and sexual selection may result in infanticide. Limited resources, for example suitable nesting areas or burrows, may lead adults of a species to kill young of cohorts to increase the fitness of their own offspring. Two other possible explanations for infanticide are social pathology and parental manipulation (generally of gender ratio), both of which occur in humans (Hrdy, 1979; Hausfater and Hrdy, 1984). Sexual selection, another hypothesis for infanticide, is a likely explanation for infanticide in long-lived animals that do not breed annually (Hausfater and Hrdy, 1984). Mammals such as primates and eusocial carnivores (e.g., lions, *Panthera leo*) have relatively long inter-birth periods during which time young are dependent on the mother. If a female loses her offspring prematurely, she soon becomes sexually receptive, reducing time between births (Hrdy, 1979). Males who have not invested time and energy toward rearing the offspring may carry out infanticide and gain the chance to mate with the newly receptive female whose infant has been killed.

Female dolphins also have a long interbirth period, 4 yr or more for Indian Ocean bottlenose dolphins and become sexually receptive following death of a dependent offspring (Connor et al., 1996). Connor et al. (1996) cite reports of males directing sexual and aggressive behavior toward post-parturient females in a captive setting and add their own observations of similar behavior in dolphins of the Indian Ocean. In discussing the potential for infanticide by male bottlenose dolphins for sexual reasons Connor et al. (1996) predicted that newborns would be most at risk and that external evidence of trauma (scars) would be lacking in survivors of such attacks.

Of the possible explanations for infanticide, predation is the only one that can be reasonably ruled out in the case of bottlenose dolphins. Studies of food habits of coastal bottlenose dolphins, determined by examining the stomach contents of stranded animals, indicate their primary prey is sciaenid fishes (Barros and Odell, 1990). Additionally, there was no evidence of consumption of any of the examined calves.

The population ecology and natural history of coastal dolphins in Virginia are not well understood. Currently, all bottlenose dolphins in Virginia waters belong to the Atlantic coastal migratory stock. The stock structure, distribution, and current or historic abundance are not currently known (Wang et al., 1994). Metabolic requirements, growth rate, reproductive rate, age structure, parasite load, disease prevalence, and level of human interaction are also poorly understood. This lack of data makes it difficult to further examine the hypotheses for infanticide. We suggest here, instead, that resource limitations, parental manipulation, social pathology, and/or sexual selection could be factors driving infanticide in dolphins in Virginia.

What effect infanticide could have on Atlantic coastal dolphin populations cannot be fully addressed until an accurate assessment of its prevalence can be made. A determination of the prevalence of infanticide will only come through increased awareness and recognition of this behavior. Researchers studying captive and wild dolphins should pay close attention to the interactions between adult animals and the young of other dolphins and report observations of unusual behavior. Because observing and interpreting social interactions among wild dolphins is difficult, it is likely that the best opportunity for recognizing infanticide lies in documenting the associated postmortem findings. With few visible external lesions observed in this study, all stranded bottlenose dolphin calves should receive a thorough postmortem examination to determine whether evidence of infanticide; i.e., blunt-force trauma to the head and chest consisting of multiple fractures and soft tissue contusions, is present.

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