Stranded cetaceans in Costa Rica: Microorganism and diseases with public health and conservation impact.

HERNÁNDEZ-MORA G. (1,2)*, J.D. PALACIOS-ALFARO (2), and R. GONZÁLEZ-BARRIENTOS (1).

1 Servicio Nacional de Salud Animal (SENASA), Ministerio de Agricultura y Ganadería, Heredia, Costa Rica.
2 Keto Foundation Apartado 1735-1002. San José, Costa Rica

*Correspondence: Gabriela Hernández Mora, Microbiología Médico Veterinaria, Servicio Nacional, Salud Animal (SENASA), Barreal de Heredia, Costa Rica e-mail: gabbytica@gmail.com, gherandez@fundacionketo.org.

Abstract

Costa Rican oceans represent one of the major breeding sites for cetaceans (e.g. humpback whales, Megaptera novianglea). At least 30 species have been observed in, or are thought to visit these regions, including 27 in the Pacific and 29 in the Caribbean (Wehrtmann and Cortés, 2009). For decades, the inhabitants of these coasts have witnessed the stranding of cetaceans, and scientists have found it a unique opportunity to collect biological and medical information from animals in the wild (Dierauf and Gulland, 2001), which has helped to describe the effects of fisheries, as well as diseases and microorganisms present in these stranded animals. This is a review of the research of diseases and microorganisms along with public health and conservation impacts from stranded cetaceans that have been investigated in Costa Rica during the last seven years.

Keywords: Disease, endoparasites, strandings, reproduction, Pacific Ocean.

Introduction

Cetaceans integrate and reflect numerous ecological variations across large geographic areas and extended temporal scales, making them prime candidates as sentinels to measure important changes in marine ecosystems (Moore, 2008).

In recent years, there has been an important increase in the association of high pollutant concentrations and the presence of new infectious diseases in marine mammals, especially small cetaceans. Thus, scientists have begun to consider a possible link between these toxic substances and marine mammal mortality events due to immunosuppression (G Vos et al., 2003).

Strandings are a natural phenomena that occurs when marine mammals float onto shore and become “beached” in shallow water (Geraci and Lounsbury, 2005; Dierauf and Gulland, 2001). Within these events each case represents a unique opportunity to collect biological and medical information from wild animals, which would be otherwise impossible to obtain. Data collected help to describe the effects of different stressors like fisheries, diseases and microorganisms that could be playing an important role in the strandings of these animals (Dierauf and Gulland, 2001). Some of the diseases associated with cetacean strandings in Costa Rica represent a potential risk for human and animal species. Therefore, health authorities need to maintain continuous monitoring and research of this phenomenon in order to guarantee public health as well as to support science and conservation efforts. The wide habitat range of the majority of the cetacean species in Costa Rican waters, underscores the necessity of establishing a
regional stranding investigation network to fulfill the lack of information within the Central American region.

**Material and Methods**

From August 2004 to December 2011 at least 39 cetaceans were reported to strand on the Pacific and Caribbean coasts of Costa Rica (Table 1). Stranded animals, alive or dead, were attended on the beach, with logistic support from Programa de Investigación en Enfermedades Tropicales (P.I.E.T), Escuela de Medicina Veterinaria (E.M.V), Universidad Nacional (U.N.A) and Marine Rescue Program (M.R.P) from the Keto Foundation. Most of the live stranded cases died during rehabilitation attempts, and were transported to the Pathology Department of the EMV-UNA for sampling and necropsy, as well as, anatomo-histopathological, immunochemical, bacteriological and biological studies. In cases where the size of the animal made transportation impossible, necropsy and sampling were performed on the beach.

Parasite identification from stranded cetaceans of the Pacific Coast of Costa Rica was performed from 2001 to 2009.

**Table 1.** Stranded cetaceans in Costa Rica from 2004-2011.

<table>
<thead>
<tr>
<th>Specie</th>
<th>No. individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Striped dolphin (<em>Stenella coeruleoalba</em>)</td>
<td>25</td>
</tr>
<tr>
<td>Dwarf sperm whale (<em>Kogia sima</em>)</td>
<td>3</td>
</tr>
<tr>
<td>Pantropical Spotted dolphin (<em>Stenella attenuata</em>)</td>
<td>3</td>
</tr>
<tr>
<td>Cuvier’s beaked whale (<em>Ziphius cavirostris</em>)</td>
<td>2</td>
</tr>
<tr>
<td>Bottlenose dolphin (<em>Tursiops truncatus</em>)</td>
<td>2</td>
</tr>
<tr>
<td>Sperm whale (<em>Physeter macrocephalus</em>)</td>
<td>2</td>
</tr>
<tr>
<td>Spinner dolphin (<em>Stenella longirostris</em>)</td>
<td>1</td>
</tr>
<tr>
<td>Humpback whale (<em>Megaptera novaeangliae</em>)</td>
<td>1</td>
</tr>
</tbody>
</table>

**Results and Discussion**

*Brucella ceti* in stranded cetaceans

According to the World Health Organization, brucellosis is one of the most important diseases transmitted from animals to humans (zoonotic disease). This disease has been classically associated with abortion and inflammation of reproductive organs (Moreno et al., 2002). There are ten species of bacteria in the genus *Brucella*, eight of them affecting terrestrial mammals and two species affecting marine mammals. Recently, *Brucella* affecting pinnipeds and cetaceans were described as new species *B. pinnipedialis* and *B. ceti*, respectively (Foster et al. 2007).

The presence of *Brucella ceti* in stranded cetaceans on the Pacific coast of Costa Rica was first reported by the Center of Disease Control and Prevention (CDC) (Hernández-Mora et al., 2008). The authors emphasized the need for effective management of sick animals and their role in public health.

Due to the need of a diagnostic test for brucellosis in cetaceans worldwide, an indirect Enzyme-Linked ImmunoSorbent Assay (ELISA) was developed in Costa Rica. The assay was validated using samples from captive and stranded cetaceans from the United States and stranded cetaceans from Spain and Costa Rica (Hernández-Mora et al., 2009). This indirect brucellosis test for odontocete cetaceans has a better
sensitivity and specificity than those developed and standardized for terrestrial animals (Hernández-Mora et al., 2009).

González-Barrientos et al., (2010), provide a detailed description of the pathologies of stranded dolphins presenting brucellosis in the Pacific of Costa Rica, including placental inflammation (placentitis) as has been found in terrestrial mammals affected by brucellosis. Neuropathologies were also described, including consistent nonsuppurative inflammation of the meninges and brain (meningoencephalomyelitis), in all of the stranded striped dolphins, Stenella coeruleoalba, examined. Additionally, this study was the first to describe inflammation of a cardiac valve (endocarditis) in a dolphin infected by brucellosis. Endocarditis is the second most lethal lesion in human brucellosis after meningoencephalitis. Moreover, arthritis due to the infection of Brucella ceti was also described in these dolphins.

Central nervous system (CNS) brucellosis infection affects coordination in these animals, frequently evidenced by locomotion and buoyancy problems, and also causes inability to catch prey. Almost all stranded dolphins had empty stomachs, which is indicative of a lack of feeding for days and even weeks before they stranded.

The investigations of confirmed cases of brucellosis in striped dolphins in Costa Rica during the last seven years have helped to increase our current knowledge about this disease worldwide. As such, Costa Rica will be responsible for the chapter of marine brucellosis in the special edition of Brucellosis published by the World Organization of Animal Health (OIE) in 2013 (Hernández-Mora In preparation). In addition, Costa Rican investigators have recently published a review on Brucella ceti and brucellosis in cetaceans (Guzmán-Verri et al., 2012).

**Toxoplasma gondii and other parasites in stranded cetaceans**

Parasites in marine mammals are relatively common. Some have been implicated in disease processes and are one of the prominent causes of cetacean strandings (Geraci and St. Aubin., 1987, Gibson et al., 1998; Mignucci-Giannoni et al., 1998; Colón-Llavina et al., 2009).

*Toxoplasma gondii* infections in marine mammals are of interest because of induced mortality and indeterminate mode of transmission. Numerous studies reported the existence of *T. gondii* infections in marine mammals including sea otters, dolphins, seals, and whales (Dubey et al., 2003). It has been suggested that marine mammals become infected with *T. gondii* oocysts washed from land to sea and that infections with this parasite are widely prevalent in human and other animals worldwide (Dubey and Beatie, 1988). However, recent work has suggested that the transmission of *T. gondii* reported from a diversity of marine mammals may not be completely explained by a land-to-sea transport of infective oocysts (Conrad et al., 2005; Colegrove et al., 2011).

In 2007, Dubey and collaborators reported on the isolation and genetic characterization of viable *T. gondii* from a striped dolphin found stranded on the Pacific Coast of Costa Rica; the first description for this host. The animal died the next day and had severe nonsuppurative meningoencephalomyelitis in the brain and spinal cord. However, histology and immunohistochemistry failed to identify *T. gondii* in brain and spinal cord tissues of this dolphin; thus *T. gondii* was not considered as the cause of death. In addition, portions of the brain and heart were bioassayed in mice for isolation of infective oocysts (Conrad et al., 2005; Colegrove et al., 2011).

Interestingly, the prevalence of *Toxoplasma gondii* antibodies in bottlenose dolphins, *Tursiops truncatus*, from the United States is very high but *T. gondii* has not been isolated from this host (Dubey et al., 2007). Generally, the presence of *T. gondii* infection in dolphins is intriguing because these animals ingest little or no water, and their nutritional requirements are derived from fish, squid, and other marine invertebrate species consumed; thus the source of infection is unclear.
Parasites

Oliveira and collaborators provide the first systematic survey regarding the parasitic fauna of cetaceans from the Pacific coast of Costa Rica (Oliveira et al., 2011). All identified parasites and commensals represent new geographic records for the Pacific coast of Central America and an increase the occurrence of some parasites in new hosts.

The most represented cetacean species was the striped dolphin, with a prevalence of parasites of 89.5%. Other species, including the pantropical spotted dolphin, S. attenuata, spinner dolphin, S. longirostris, bottlenose dolphin, and Cuvier’s beaked whale, Ziphius cavirostris, also had parasites. No parasites were recovered from a single dwarf sperm whale, Kogia sima (Oliveira et al., 2011).

Fourteen helminth taxa were observed and identified morphologically, including six species of cestodes, four digeneans and four nematodes. Nematodes and cestodes were the most prevalent parasite groups (90.9%), followed by digeneans (22.7%). The most prevalent species were Anisakis spp. (90.9%), followed by Tetrabothrius forsteri (63.6%), Halocercus lagenorhynchi (54.5%) and tetraphyllidean plerocercoids (40.9%). Additionally, a commensal crustacean species was also identified. (Oliveira et al., 2011).

Cestodes were one of the most represented groups of helminth. For the first time the pantropical spotted dolphin is presented as a new host of tetraphyllidean plerocercoids. There was also a new record of the digenean Nasitrema globicephalae for pantropical spotted dolphin specimens.

Parasitological information for parasites in Cuvier’s beaked whale is very limited (Demaree et al., 1997; Fernández et al., 2004; Berón-Vera et al., 2008). The only record of digeneans in the Family Ziphiidae, was published by Demaree et al., (1997) who identified a new species, Oschmarinella macrorchis, from the liver sinuses of a Stejneger’s beaked whale, Mesoplodon stejnegeri. Oliveira et al. (2011) reported a new host record for O. albamarina from Cuvier’s beaked whale.

Nematodes parasites were also highly prevalent within the cetacean species surveyed. Morphologically, all nematode specimens recovered (adults and larvae) belonged to the Anisakis genus. Anisakis spp. is medically and economically relevant because it is a causative agent of human anisakiosis (Gibson et al., 1998). Both cetaceans and humans can be infected with this parasite by eating raw fish. All cetaceans studied in this Costa Rica survey are documented hosts for species of Anisakis. Similar to cetaceans from Brazil observed by Motta et al., (2008), four of the infected cetaceans examined, presented mild gastritis, but no gastric ulcers were observed in any infected cetacean. Additionally, Halocercus lagenorhynchi was collected from the lungs of S. coeruleoalba, and Halocercus sp. from S. attenuata and S. longirostris causing a moderate to severe granulomatous pneumonia.

The spirurid Crassicauda anthonyi was found solely in the kidneys of Z. cavirostris, resulting in necrosis, fibrosis and partial destruction of the organs due to huge number of parasites, similar to reports from Australia and Puerto Rico (Robson, 1984; Mignucci-Giannoni et al., 1998).

The pseudo-stalked barnacle, Xenobalanus globicipitis, a nonpathogenic crustacean, was observed on left fluke of a pan tropical spotted dolphin.

Morbillivirus in stranded cetaceans

Cetacean morbillivirus (CeMV) is considered the most pathogenic virus in cetaceans (Bellière et al., 2011). CeMV may trigger epidemics of lethal disease characterized by pneumonia, nonsuppurative meningoencephalitis and prominent lymphoid cell depletion (Domingo et al., 1992).

High mortality events due to CeMV have been described in Europe during the 1990s. Due to the similarity of the pathological presentation of this disease and neurobrucellosis, CeMV was rejected as a cause of strandings of cetaceans in Costa Rica by González-Barrientos et al., 2010. In the current study, brain and lung tissues from 17 stranded dolphins showing neurological signs prior to death (16 with meningoencephalomyelitis) were analyzed by immunohistochemistry methods for the presence of CeMV, all of them being determined to be negative for this pathogen.
Conclusions

Since 1990, people in at least 114 countries worldwide have consumed one or more of the 65 species of cetaceans reported that are used as food for humans (Robards and Reeves, 2011). Therefore, the prevalence of marine brucellosis in humans may be significantly underestimated in the developing countries of Africa, South America and Southeast Asia, as well as Arctic indigenous regions where cetaceans are frequently freshly killed for the human consumption or as bait used by fishermen without hygienic precautions.

*Brucella* infection from terrestrial animals in humans is associated with consumption of unpasteurized dairy products and is considered an occupational risk for laboratory personnel, veterinarians, farmers, meat industry workers and hunters from exposure – particularly to fetal tissues and fluids. However, the transmission mode and the source of infection of marine *Brucella* to humans is not yet established, but human patients confirmed to have been infected with this marine bacteria developed severe symptoms like intracerebral neurobrucellosis and brain tumors, as well as spinal osteomyelitis (Guzmán-Verri *et al.*, 2012).

Further, experiments *in vitro* have shown that *Brucella* from cetaceans show diverse ability to cause disease in humans, with the capacity to infect that is similar to the most virulent terrestrial *Brucella* species described for humans (*B. melitensis, B suis* and *B. abortus*) (Maquart *et al.*, 2009).

Due to the role of brucellosis as a major cause of stranding in striped dolphins in Costa Rica, it is critical for government institutions to maintain close monitoring of stranded cetaceans and to provide detailed protocols for response to these events. Limiting contact between the general public and sick stranded animals during stranding events will help achieve a measure of increased public welfare.

The striped dolphin is a widely distributed species, found in the Pacific, Atlantic and Indian oceans, as well as many adjacent seas. A recent report from El Salvador of two striped dolphin specimens showing the same symptomatology for brucellosis as is found in Costa Rica (http://www.elsalvador.com/mwedh/nota/nota_completa.asp?idCat=47673&idArt=6474849#.TuvEy21wg50.facebook), indicates the need of investigations in the countries of the Central American region regarding diseases present in stranded animals.

Small cetaceans are generally at the top trophic level of a complex food chain and are known to accumulate large amounts of pollutants. Due to this fact and to the possible immunosuppressive role played by these compounds, cetaceans are continuously predisposed to numerous classical and emerging diseases. Therefore more research on brucellosis and other infections is needed worldwide. In this way hunters, consumers and agencies will be better aware of the risk from eating cetaceans.

Cetacean species that are infected with *Brucella ceti* are more likely to have reproductive problems, and therefore lower birth rates than uninfected conspecifics. Therefore, conservation policies must specifically address population with infection rates and lower birth rates.

These studies contribute to a growing worldwide effort of marine megafauna biomonitoring, not only to monitor and assess health in these animals, but also to assist in determining anthropogenic impacts on the animals, marine food chains and marine ecosystem health.

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