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Tattoo-like skin disease in the endangered subpopulation of the Humpback Whale, *Megaptera novaeangliae*, in Oman (Cetacea: Balaenopteridae)

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The presence of tattoo-like skin disease is reported in an endangered, non-migratory subpopulation of Humpback Whales (Megaptera novaeangliae) from Oman. We examined 522 images taken during small-boat surveys in the Gulf of Masirah and in Dhofar in 2000-2006 and in 2010-2011. Tattoo-like lesions were detected in regular, good and outstanding images. They appeared as irregular or rounded, light grey marks often showing a whitish outline, and were located on the flanks, dorsum, dorsal fin and caudal peduncle. They could be relatively small to very large and cover up to an estimated 40% of the visible body surface. Over the whole study period disease prevalence reached 21.7% in 60 whales and 16.7% in 36 adults. In this category, prevalence was higher in males (26.7%, N=15) than in females (9.1%, N=11), but the difference was not significant. Lesions appeared larger in males than in the positive female and progressed in two males. Disease prevalence increased significantly from 2000 through 2011 (r^2 =0.998). Advanced tattoo skin disease, with lesions extending over more than 10% of the visible body surface seemed to occur more frequently in 2010-2011 than in 2000-2006, but samples were small. This is the first confirmed report of tattoo-like disease in the Balaenopteridae family and the first time it is documented in the Arabian Sea. The disease high prevalence, its increase over time and its progression in some individuals are of concern.

Keywords: Megaptera novaeangliae, tattoo skin disease, Oman, conservation medicine, endangered species.

Introduction

The epidemiology of tattoo skin disease (TSD) has been relatively well-studied in odontocetes (Flom & Houk, 1979; Geraci, Hicks, & St Aubin, 1979; Van Bressem & Van Waerebeek, 1996; Van Bressem, Gaspard, & Aznar, 2003; Van Bressem et al., 2009) but not in mysticetes, with only two isolated cases reported in a Bowhead Whale (*Balaena mysticetus*) (Bracht et al., 2006) and in a North Atlantic Right Whale (*Eubalaena glacialis*) (Hamilton & Marx, 2005). The infection is characterised by irregular, grey, black, whitish or yellowish skin lesions that, with some experience, are readily distinguished macroscopically from other types of integument conditions and scars, even in free-ranging cetaceans. TSD is caused by poxviruses (Flom & Houk, 1979; Geraci et al., 1979; Van Bressem, Van Waerebeek, Reyes, Dekegel, & Pastoret, 1993)

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Figure 1. Three main study areas in Oman: Muscat region, Gulf of Masirah and Dhofar region.

that belong to a newly recognised genus (provisionally named *Cetaceanpoxvirus*) of the subfamily *Chordopoxvirinae* (family *Poxviridae*) (Bracht et al., 2006; Blacklaws et al., 2013). Poxviruses affecting odontocetes and mysticetes are related but different (Bracht et al., 2006; Blacklaws et al., 2013). In odontocetes individual tattoo lesions, commonly referred to as 'tattoos', may persist for months or even years, or may heal and sometimes recur (Van Bressem et al., 2003; Sanino, Van Bressem, Van Waerebeek, & Pozo, 2014). Generally, sex does not significantly influence TSD prevalence. In healthy populations there is a pattern of TSD increase in juveniles compared to calves, likely due to the loss of maternal humoral immunity after weaning. Juveniles have a higher probability of suffering TSD than adults, presumably because adults acquired active immunity following infection (Van Bressem & Van Waerebeek, 1996; Van Bressem et al., 2003, 2009). This pattern was found inverted in Short-beaked Common Dolphins (*Delphinus delphis*) and Harbour Porpoises (*Phocoena phocoena*) that died in poor health (i.e. starvation, infectious and parasitic diseases) in the Northeast Atlantic, with adults showing a higher TSD prevalence than juveniles (Van Bressem et al., 2009).

A non-migratory subpopulation of Humpback Whales (*Megaptera novaeangliae*) occurs along the coast of Oman and in the wider Arabian Sea region (Reeves, Leatherwood, & Papastavrou, 1991; Mikhalev, 1997, 2000; Minton et al., 2008, 2011; Willson, Baldwin, Minton, & Collins, 2012; Willson et al., 2013; Pomilla et al., 2014). It is thought to have a restricted range and is reproductively isolated (Rosenbaum et al., 2009; Pomilla et al., 2014), with a very small population size (n=82; 95% CI=60-111) (Minton et al., 2008). It is threatened by human activities including fisheries, vessel traffic and ongoing coastal development (Baldwin, Gallagher, & Van Waerebeek, 1999;

Period	2000-2002	2003-2006	2010-2011
N _t	32	18	20
Prev (%)	15.6	22.2	30.0

Table 1. Time variation in prevalence (Prev) of tattoo-like skin disease in Humpback Whales (*Megaptera novaeangliae*) from Oman waters; N_t = total number of documented whales.

Baldwin et al., 2010; Minton et al. 2008; Willson et al., 2012). This subpopulation is listed as Endangered by the IUCN (Minton et al., 2008). In 2010 the Scientific Committee of the International Whaling Commission strongly recommended additional research to monitor its status (IWC 2010; Willson et al., 2013).

During the course of photo-identification (PI) studies off the coast of Oman in November 2002, extensive tattoo-like skin lesions were observed in a male *M. novaeangliae*. As diseases are important factors in the decline of endangered species (Smith, Acevedo-Whitehouse, & Pedersen, 2009) and TSD may be a potential indicator of cetacean population health (Van Bressem et al., 2009), we decided to study the characteristics and epidemiology of this condition in *M. novaeangliae* using serial images taken for PI purposes between 2000 and 2011 in Oman waters.

Material and Methods

Photographs were collected using standard procedures during small-boat surveys conducted in the Gulf of Masirah and in Dhofar in 2000-2006 and in 2010-2011 (Figure 1; Minton, Collins, Findlay, & Baldwin 2010; Minton et al., 2011; Willson et al., 2012; Baldwin, Collins, Minton, Willson & Corkeron, 2013). Individual whales were identified using the distinctive pigmentation pattern and scarring marks on the underside of their flukes and on the left and right sides of the dorsal fin (Katona & Whitehead, 1981). All images from the Oman M. novaeangliae photo-ID database were examined for the presence of tattoo-like skin lesions. Each image was rated as outstanding, good, regular or poor through an evaluation of focus, clarity and proximity. For the purpose of the present study only whales were included in the analysis for which at least one image of minimally regular quality of one flank was available, limiting the total sample to 60 individuals for the whole study period. The sex of 30 whales observed in 2000-2011 was determined through singing (known to be done only by males), presence of a calf (known to be closely accompanied only by females) or genetic sampling (Palsboll, Vader, Bakkea, & El-Gewely, 1992; Rosenbaum et al., 2009; Minton et al., 2011). Whales estimated to measure 11 meters and over were considered adults. As the aetiology of the lesions has not yet been studied in Oman M. novaeangliae, for lack of samples, we conservatively call them 'tattoo-like'. Estimated lesion size (LS), in comparison to body parts (e.g. dorsal fin), was classified according to its widest diameter, as small (LS<50 mm), medium-sized (50 mm<LS<100 mm), large (100 mm<LS<200 mm) or very large (LS>200 mm). Differences in prevalence between sexes and between time periods were tested with a two-tailed Z-test for two population proportions.

Results and Discussion

We examined 522 images of *M. novaeangliae* flanks, dorsum and flukes taken in 2000–2011. Tattoo-like skin lesions were detected in regular, good and outstanding images. The lesions appeared as irregular or rounded, light grey marks often showing a whitish outline (Figures 2, 3). Several resembled the tattoo-like marks seen in an adult male *E. glacialis* (Hamilton & Marx, 2005). Sometimes associated with unrelated scars, the lesions were located on the flanks, dorsum, dorsal fin and caudal peduncle (Figures 2, 3). Their size ranged from relatively small to very large and could cover up to an estimated 40% of the visible body surface (VBS; Figures 2, 3). The disease was observed in



Figure 2. Numerous tattoo-like lesions (arrows) of variable sizes on the back and flanks of adult male Humpback Whale (*Megaptera novaeangliae*) OM002-16 off Oman, in November 2002.

13 of 60 whales (21.7%) during the whole study period. This prevalence level is similar to that reported in a small, declining community of 32 resident Common Bottlenose Dolphins (*Tursiops truncatus*) from the Sado Estuary, Portugal (21.9% in 1994–1995 and 15.6% in 1996–1997, Van Bressem et al., 2003), but higher (z-score =4.767; p<0.001) than the one described in a larger and healthier community of 334 *T. truncatus* in the Strait of Gibraltar (4.5%; Jiménez-Torres et al., 2013).

Tattoo-like disease affected 6 of 36 (16.7%) M. novaeangliae classified as adults. Large to very large lesions covering 10% or more of the VBS were seen in two adult males and in three whales of unknown sex and maturity. A high prevalence of TSD in adult odontocetes is suspected to reflect a depressed immune system (Van Bressem et al., 2009). Furthermore, the presence of very large tattoos in adults was also suggested to point to immunological deficiencies (Van Bressem & Van Waerebeek, 1996; Van Bressem et al., 2003, 2009). In the adult whale category, the prevalence of tattoo-like disease was higher in known males (26.7%, N=15) than in known females (9.1%, N=11), though not significantly so (z-score =1.123, p=0.263). In the positive female (OM02-015) size of the eight visible tattoo lesions ranged from small to medium and affected less than 1% of the VBS. In the four males the lesions were small to very large and were estimated to cover between 1 and 35% of the VBS. Furthermore, in males OM02-019 and OM02-020, repeatedly sighted during the study period, the disease had greatly progressed from the first documented observations in 2002 through October 2011 and March 2011, respectively (Figure 2a,b). In odontocetes sexual variation in TSD susceptibility has until now only been documented in Burmeister's Porpoises (Phocoena spinipinnis) in Peru. Differences in social organisation between male and female P. spinipinnis were suggested as mechanisms that could play a role in this variation (Van Bressem & Van Waerebeek, 1996; Van Bressem et al., 2009). Male M. novaeangliae are known to engage in aggressive interactions involving a great deal of body contact which may inflict cutaneous abrasions and wounds (Tyack & Whitehead, 1983; Baker & Herman, 1984). Although not as frequently observed in Oman as in



Figure 3 (above): Small and medium-sized tattoo-like lesions (arrows) on the back of adult male Humpback Whale (*Megaptera novaeangliae*) OM2-020 in November 2002 off Oman; Figure 3 (below): Numerous tattoo-like lesions (arrows) of variable sizes on the back and flank of the same whale in March 2011.

other *M. novaeangliae* populations (Minton et al., 2011), these antagonistic male-male interactions may play a role in spreading an infectious cutaneous disease such as TSD. Habitat separation between males and females has also been documented, with a pre-dominance of males in the Dhofar region in February-March 2000-2004 (Minton et al., 2011). The apparently higher prevalence of tattoo-like marks in male *M. novaeangliae* from Oman could also reflect the accumulation of immunosuppressive lipophilic con-taminants in adult males and the depuration of females through lactation, as described in *T. truncatus* from Florida (Wells et al., 2005). However the latter would imply that

waters of southern Oman are polluted with such contaminants, for which there is no evidence.

To examine if prevalence levels varied over time we divided the whole study period into three sub-periods: 2000-2002, 2003-2006 (no data were collected in 2005) and 2010-2011. Prevalence of the disease increased significantly from 2000 through 2011 (linear regression, r^2 =0.998, p=0.031; see also Table 1). Interestingly, two authors (RB and TC) reported that most of the whales sighted in 2012-2014 had tattoo-like lesions, further suggesting a prevalence increase of the disease over time. Advanced TSD, with lesions extending over more than 10% of the VBS, was observed during all periods but seemed to occur more frequently in 2010-2011 (4 of 6 whales) than in 2000-2006 (2 of 9 whales), but samples were small.

This is the first confirmed report of tattoo-like skin disease in a member of the Balaenopteridae family and the first time it is documented in the Arabian Sea. Possible tattoo-like skin lesions were reported in a Blue Whale (*Balaenoptera musculus*) photographed off Isla Grande de Chiloé, Chile, in 2007 but this report awaits further confirmation (Brownell, Carlson, Galletti-Vernazzani, & Cabrera, 2007). Our paper provides the first insights into the epidemiology of tattoo-like skin disease in mysticetes. Its high prevalence, increase over time and progression in some individuals are of concern and may reflect underlying health issues. Interestingly, among 38 *M. novaeangliae* caught by the Soviet whaling fleets in the Arabian Sea in 1966, 26 (68.4%) had hepatic pathologies (Mikhalev, 1997). Anthropogenic stressors like underwater noise pollution, fisheries, intensive vessel traffic, coastal development and chemical pollution may act synergistically to increase disease severity and baseline prevalence.

During the course of this study the authors identified tattoo-like lesions also in two Eden's Whales (*Balaenoptera edeni*) from the waters of Thailand (Dr Adulyanukosol, pers. commn. to MFB and GM, February 2011), a Bryde's Whale (*Balaenoptera brydei*) from coastal waters off Hermanus, South Africa (photo published by Ken Moore www.dreamstime.com/royalty-free-stock-photo-bryde-s-whale-2-2-image1660775), and a *M. novaeangliae* from Gabon (G. Minton, pers. observations), suggesting that this condition may be more widely distributed in mysticetes than accounted for by the few papers published on this issue. Tattoo-like lesions were not observed in 83 Common Minke Whales (*Balaenoptera acutorostrata*) photographed off Iceland in 2004-2009 and closely examined for the presence of skin disorders (Bertulli, Cecchetti, Van Bressem, & Van Waerebeek, 2013). Further studies on the geographic distribution, aetiology and epidemiology of tattoo-like disease in whales should elucidate global trends and enhance understanding of potential health impacts.

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