The sero-prevalence of *Toxoplasma gondii* in British marine mammals

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Serum samples from 101 stranded or bycatch cetaceans from British waters were screened for Toxoplasma gondii*-specific antibodies using the Sabin Feldman Dye Test. Relatively high seropositivity was recorded in short-beaked* Delphinus delphis *and this study presents the first documented case of* Toxoplasma *in a humpback whale* Megaptera novaeangliae.

Key words: cetacean - conservation - environmental contamination - protozoa - toxoplasmosis

Toxoplasma gondii is a globally ubiquitous, Apicomplexan protozoan parasite, capable of infecting all warm blooded animals (Wong & Remington 1993). *Toxoplasma* is a zoonotic parasite responsible for toxoplasmosis, a disease which can affect the survival of many free-living mammalian species. The only known definitive hosts for *T. gondii* are members of the Felidae (cat) family. It has frequently been demonstrated that wild animals are important reservoirs of many infectious diseases (e.g. SARS, H5N1 Avian influenza) and play an important role in transmission and disease ecology (Simpson 2002). We, therefore consider it essential that baseline measurements of *T. gondii* prevalence and occurrence are determined in wild animals in order to understand their role in *T. gondii* epidemiology.

Previously, *Toxoplasma* studies in wild animals has been restricted to terrestrial species, however, an increasing area of research has focused on marine mammals. Of particular concern is the effect on populations of endangered marine mammals such as sea otters (*Enhydra lutris nereis*), a mustelid species in which toxoplasmosis has been linked to many instances of mortality on the Western seaboard of the United States. *T. gondii* positive free-living marine mammals have been identified in many marine ecosystems including the Eastern, Central and Western Pacific, Western Atlantic and Mediterranean (Dubey et al. 2003). This study presents the initial findings of serological screening from a range of cetacean species inhabiting the Northeastern Atlantic and provides the first documented cases of positive *Toxoplasma* in this marine region.

MATERIALS AND METHODS

Sera samples from 101 individual cetaceans were obtained by *postmortem* examination of animals stranded in England and Wales between 2001-2003. All *postmortem* examinations were conducted according to standardised methodology (Law 1994) by staff at the Institute of Zoology, London. Sera were analyzed using the Sabin Feldman *Toxoplasma* Cytoplasma Modifying Antibody Dye Test at the *Toxoplasma* Reference Unit (TRU 2007), National Public Health Service for Wales, Singleton Hospital, Swansea, United Kingdom, according to the TRU protocol (TRU 2007). Titers deemed positive at ¼ ($\geq$ 2 IU mL^{-1}) according to TRU standards were classified as positive results. To facilitate analysis, marine zones were demarcated using geographical areas based upon Hammond et al. (2002).

RESULTS

A total of eight animals (7.9%) demonstrated seropositivity with *T. gondii* antibody levels ranging from 8 IU mL^{-1}-250 IU mL^{-1} (Table). Sero-positive animals were recorded in three of the five marine zones from which samples were screened (Figure).

DISCUSSION

The majority of seropositive animals were short-beaked common dolphins (*Delphinus delphis*) and seroprevalence data revealed the first ever documented *Toxoplasma* infection in a baleen whale species (humpback whale *Megaptera novaeangliae*). These findings represent the first *T. gondii*-seropositive cases from cetaceans in British waters and demonstrate that cetacean populations frequenting British waters are exposed to *T. gondii* at some stage, although the specific route of transmission has not yet been confirmed. It seems likely that infection in cetaceans is via *T. gondii* oocysts in contaminated water as these animals predominantly feed on fish, invertebrates and cold-blooded animals which would not be expected to support the tachyzoite and bradyzoite life-cycle stages of *T. gondii*. This is supported by seropositivity in a single humpback whale, as humpback whales are primarily planktivorous and piscivorous (Barros & Clark 2002).

The humpback whale is generally understood to be a seasonal migrator with Northern Atlantic populations thought to have breeding grounds in the West Indies (Smith et al. 1999). Known feeding grounds exist in waters off Norway, Iceland, Greenland and Canada (Stevick et al. 2003). Humpback whales have been detected consistently between October-March from the Western

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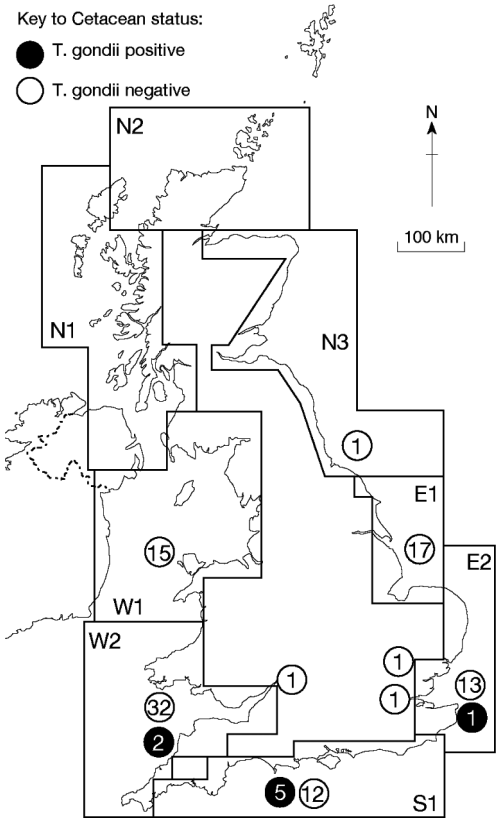
TABLE

Animals tested and percentage occurrence of *Toxoplasma gondii*, including titer range (IU mL-1)

Species	Number tested	Number positive	Percentage Occurrence	Titer Range (IU mL-1)
Delphinus delphis (Shot-beaked common dolphin)	21	6	28.6	8-250
Grampus griseus (Risso's dolphin)	1	0	0.0	< 2
Lagenorhynchus acutus (Atlantic white-sided dolphin)	1	0	0.0	< 2
Megaptera novaeangliae (Humpback whale)	1	1	100.0	8
Phocoena phocoena (Harbour porpoise)	70	1	1.4	125
Stenella coeruleoalba (Striped Dolphin)	5	0	0.0	< 2
Tursiops truncatus (Bottlenose dolphin)	1	0	0.0	< 2
Ziphius cavirostris (Cuvier's Beaked Whale)	1	0	0.0	< 2



Outline map of UK and surrounding waters, number of *Toxoplasma gondii* sero-positive and sero-negative cetaceans found in each marine zone.

edge of the English Channel to the Western waters of the Shetland Islands (Charif et al. 2001). *Postmortem* examination indicated the infected animal in this study was a juvenile and the probable cause of death was starvation. The recovery location (Figure, Zone E2) is a considerable distance from the closest known migratory route. It seems plausible this individual became disorientated during migration and accidentally entered the English Channel. The lack of productive food sources here could have lead to starvation. Since latent infections of *T. gondii* are know to affect behavior in other animals, the question arises as to what extent behavioral changes contributed on this occasion. It is recognized that this is only one of many possible explanations; but this raises concerns about the nature of the threat posed to marine species by *T. gondii*.

Many marine mammals inhabit coastal environments and most, with the exception of the planktivores and herbivores, occupy a high position in their associated food webs. Since much of their dietary intake is of commercial importance to humans they may be used as important sentinels of marine environmental health (Le Blanc 1997). Recent work in California (Miller 2002) associated *T. gondii* infection with mortality in Southern Sea Otters. Furthermore, sub-clinical toxoplasmosis has been linked with behavioral changes in both rodents (Webster et al. 1994) and humans (Yolken et al. 2001). As such it is conceivable that marine mammals may also undergo such changes and that these changes may have a direct impact on the fitness of the infected species concerned. We suggest that *T. gondii* seroprevalence should be routinely tested for in all *postmortems* of marine mammals from the UK and other national waters in order to provide an assessment of the potential risk from *T. gondii* infection in marine mammals.

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