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Review

A review of fibropapillomatosis in Green turtles (*Chelonia mydas*)

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ABSTRACT

Despite being identified in 1938, many aspects of the pathogenesis and epidemiology of fibropapillomatosis (FP) in marine turtles are yet to be fully uncovered. Current knowledge suggests that FP is an emerging infectious disease, with the prevalence varying both spatially and temporally, even between localities in close proximity to each other. A high prevalence of FP in marine turtles has been correlated with residency in areas of reduced water quality, indicating that there is an environmental influence on disease presentation.

Chelonid herpesvirus 5 (ChHV5) has been identified as the likely aetiological agent of FP. The current taxonomic position of ChHV5 is in the family *Herpesviridae*, subfamily *Alphaherpesvirinae*, genus *Scutavirus*. Molecular differentiation of strains has revealed that a viral variant is typically present at specific locations, even within sympatric species of marine turtles, indicating that the disease FP originates regionally. There is uncertainty surrounding the exact path of transmission and the conditions that facilitate lesion development, although recent research has identified atypical genes within the genome of ChHV5 that may play a role in pathogenesis. This review discusses emerging areas where researchers might focus and theories behind the emergence of FP globally since the 1980s, which appear to be a multi-factorial interplay between the virus, the host and environmental factors influencing disease expression.

Introduction

The Green turtle (*Chelonia mydas*) is one of seven species of marine turtle and is internationally recognised as endangered by the International Union for the Conservation of Nature (Seminoff, 2004). Eleven discrete population segments of Green turtles have been identified, each of which is considered biologically and ecologically significant (NMFS (National Marine Fisheries Service) and USFWS (US Fish and Wildlife Service), 2014). Green turtles also hold great cultural significance for many indigenous peoples and are of economic interest, playing a significant role in ecotourism (Dobbs, 2001; Gulko and Eckert, 2004). The species has a global distribution and a complex life history, occupying a range of habitats. Hatchling turtles have a pelagic existence and recruit into benthic inshore waters at the age of 3–5 years (Reich et al., 2007). With the exception of migration for breeding, turtles typically remain in these inshore environments, which are commonly associated with seagrass meadows or coral reefs, for the remainder of their life (Musick and Limpus, 1997) (Fig. 1).

Green turtles are exposed to a number of threats including ingestion of marine debris, degradation, urbanisation and pollution of nesting habitats and foraging areas, nest and hatchling depredation by wild, feral and domestic animals, boat strike, traditional hunting and egg harvest, the impacts of climate change on the marine and terrestrial environment, and entanglement in fishing nets and lines (Bjorndal, 1995; Herbst and Klein, 1995a; Lutz, 2002; Van Houtan et al., 2010). Conservation efforts which aim to abate many of these threats have assisted in the recovery of some of the major Green turtle populations (Chaloupka et al., 2008a). However, outbreaks of disease are also contributing to morbidity and mortality in this already vulnerable species (Foley et al., 2005; Chaloupka et al., 2008b; Flint et al., 2010b).

Fibropapillomatosis (FP) is a disease that has now been reported in every species of marine turtle: Green (Smith and Coates, 1938), Loggerhead (*Caretta caretta*) (Harshbarger, 1991), Kemp's Ridley (*Lepidochelys kempii*) (Barragan and Sarti, 1994), Hawksbill (*Eretmochelys imbricata*) (D'Amato and Moraes-Neto, 2000), Olive Ridley (*Lepidochelys olivacea*) (Aguirre et al., 1999), Flatback (*Natator depressus*) (Limpus et al., 1993), and Leatherback (*Dermochelys coriacea*) (Huerta et al., 2002) turtles. FP is of greatest concern in Green turtles as it has only reached a panzootic status in this species (Williams et al., 1994).

FP is a neoplastic condition which may lead to the growth of lesions on the skin, oral cavity, shell, eyes and internal organs of the affected turtle, which in severe cases reduces the probability of survival (Herbst, 1995; Work et al., 2004; Flint et al., 2010a). The disease was first identified in a Green turtle with multiple wart-like lesions on display at the New York Aquarium, although originally

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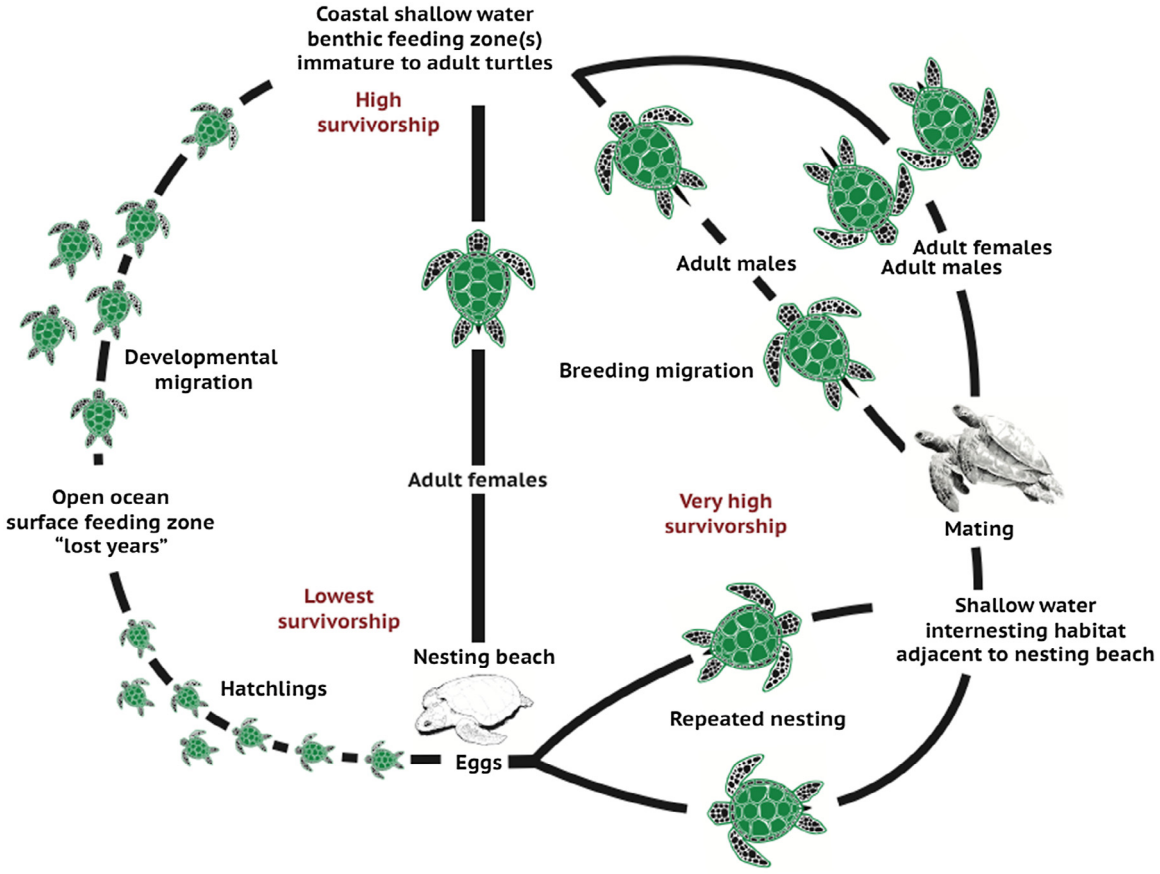

Fig. 1. The complex life history of Green turtles. Adapted from Lanyon et al. (1989).

from Key West, Florida (Smith and Coates, 1938). Despite being described in 1938 (Lucke, 1938; Smith and Coates, 1938), FP did not reach epizootic proportions until the 1980s (Herbst, 1994; Herbst et al., 2004) and has now been reported from every major ocean basin that Green turtles inhabit (Herbst, 1994).

This review covers the epidemiology and proposed aetiology of FP in Green turtles, with considerable emphasis on the primary candidate for the aetiological agent, chelonid herpesvirus 5 (ChHV5).

Disease presentation

FP can be identified in marine turtles by the presence of single or multiple benign fibroepithelial lesions. The characteristic lesions are easily noticed and are pathognomonic for FP, often limiting or obstructing the vision, feeding and locomotive ability of the affected turtle (Herbst, 1994, 1995; Work et al., 2004; Flint et al., 2010a). Cutaneous lesions are typically present on the external soft tissue of the turtle, but may grow on the carapace, plastron (Smith and Coates, 1938; Jacobson et al., 1989; Balazs and Pooley, 1991; Brooks et al., 1994; Herbst, 1994) and cornea of affected turtles (Brooks et al., 1994; Flint et al., 2010a). The lesions can be observed on all visceral organs (Herbst, 1994; Work et al., 2004; Foley et al., 2005) and are thought to develop during later stages of the disease (Herbst et al., 1999; Wyneken et al., 2006). However, as most visceral lesions are observed during post mortem investigations, the data available on the prevalence of this type of lesion are skewed. Individual lesions can range from 0.1 to 30 cm in diameter and can be sessile or pedunculated. The appearance of these lesions can vary from smooth to verrucous and the colour is dependent on the pigment at the site of origin (Herbst, 1994) (Fig. 2).

Myxofibromas, fibrosarcomas, papillomas, fibromas and fibropapillomas have all been found to be associated with FP (Norton et al., 1990; Work et al., 2004). Three of these lesions are thought to be linked with different stages of lesion development (Herbst, 1994; Kang et al., 2008). The early development phase is associated with papilloma lesions, proliferation of epidermal cells, with little or no involvement of the dermal layer. The chronic phase of lesion development is marked by the presence of fibromas, with proliferation of the dermal layer, while the epidermal layer remains

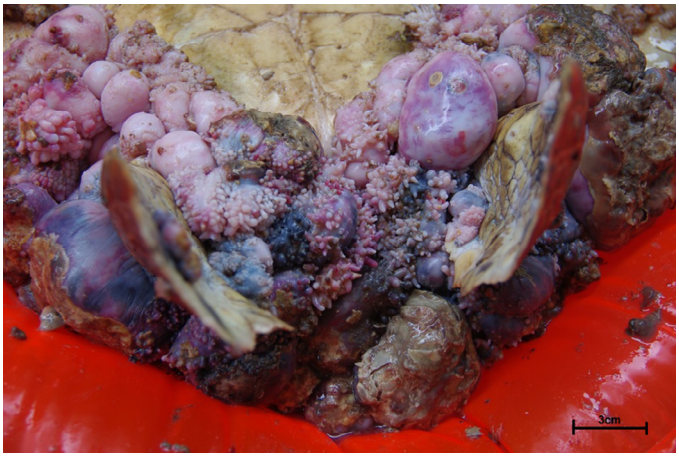

Fig. 2. The plastron and hind flippers of a Green turtle severely affected by fibropapillomatosis highlighting the diverse range of lesion appearance.