

**A qualitative and quantitative study of the somnogenic  
neural systems in the brains of Cetaceans and closely  
related species.**

Leigh-Anne Dell

PhD Thesis

Supervisor: Prof. P.R. Manger

A thesis submitted to the Faculty of Health Sciences, University of the Witwatersrand, in  
fulfillment of the requirements for the degree of Doctor of Philosophy.

Johannesburg, 2015

## **Abstract:**

Cetaceans show an unusual form of mammalian sleep, with unihemispheric slow waves (USWS), suppressed REM sleep and continuous bodily movement, however the mechanism by which USWS occurs is unclear. This thesis describes the detailed anatomy of the neural systems involved in the control and regulation of sleep in the basal forebrain, diencephalon, midbrain and pons in three Cetartiodactyla species namely the Harbour porpoise, Northern minke whale and the Hippopotamus, as well as a broader study of the orexinergic system in Cetartiodactyls by means of immunohistochemistry and stereological analysis. All the neural elements involved in sleep regulation and control found in bihemispheric sleeping mammals were present in the harbour porpoise, minke whale and hippopotamus with no specific nuclei being absent, and the only novel nuclei being identified was the parvocellular orexinergic cluster in the hypothalamus- a feature seen in cetartiodactyla and the Africa elephant. This qualitative similarity of nuclear organization relates to the cholinergic, noradrenergic, serotonergic and orexinergic systems and is extended to the GABAergic elements involved with these nuclei. Quantitative analysis of the cholinergic and noradrenergic nuclei of the pontine region and the orexinergic nuclei of the hypothalamus revealed that in comparison to other mammals, the numbers of pontine cholinergic, noradrenergic and orexinergic neurons are markedly higher in the harbour porpoise and minke whale than in other large-brained bihemispheric sleeping mammals previously examined. Furthermore, the diminutive telencephalic commissures (anterior commissure, corpus callosum and hippocampal commissure) along with an enlarged posterior commissure and supernumerary pontine cholinergic and noradrenergic neurons in cetaceans indicate that the control of unihemispheric slow wave sleep is likely to be a function of interpontine competition, facilitated through the posterior commissure, in response to unilateral telencephalic input related to the drive for sleep. In addition, an expanded peripheral division of the dorsal raphe nuclear complex appears likely to play a role in the suppression of REM sleep in cetaceans. Thus, this thesis provides several clues to the understanding of the neural control of the unusual sleep phenomenology present in cetaceans.