

**Health assessment and hatching
success of two Western Australian
loggerhead turtle (*Caretta caretta*)
populations**

Sabrina Trocini DVM, MVS (Cons Med)

This thesis is presented for the degree of Doctor of Philosophy

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I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution.

.....

Sabrina Trocini

“Any glimpse into the life of an animal quickens our own and makes it so much the larger and better in every way.” John Muir



Abstract

Most of the existing sea turtle populations worldwide are in decline, and loggerhead turtles (*Caretta caretta*), in particular, are listed as Endangered. The loggerhead nesting population in Western Australia is the largest nesting population in Australia and one of the largest in the Indian Ocean and the world.

This research project investigated hatching success and health, two critical aspects for loggerhead turtle conservation and management, on two important nesting sites in Western Australia: Turtle Bay on Dirk Hartog Island and Bungelup Beach in Cape Range National Park. This project undertook an interdisciplinary approach encompassing the disciplines of conservation medicine, ecology and epidemiology to investigate questions about sea turtle conservation that could not be addressed by any of these disciplines alone.

Morphological and reproductive measurements were collected during two nesting seasons, between 2006 and 2008, obtaining important baseline reproductive data about the Western Australian population. It was found that the presence of deformed and yolkless eggs was associated with smaller clutch size. At the same time several biotic and abiotic factors were assessed in relation to embryonic and hatchling mortality. Hatching success was significantly reduced by high temperatures during the pre-emergent period, the presence of roots in the nest and nest location along the beach. Results suggest that bacterial contamination of sand on the high nesting density beach sectors may, in part, be responsible for the differences in hatching success along the beach. High nest temperature during the pre-emergent period also significantly reduced emergence success and influenced emergence patterns

and duration. Prolonged emergence duration, associated with increased nest temperatures, may further reduce hatchling survival due to diminished energy reserves and increased risk of predation.

On the mainland nesting site, Bungelup Beach, predation of eggs and hatchlings severely limited reproductive success with over 80% of the monitored nests showing signs of partial or complete predation. In contrast with that reported in the literature, ghost crabs (*Ocypode* spp) were the main predator at this site and the first among the identified predators to dig into nests. Perentie (*Varanus giganteus*) and introduced foxes (*Vulpes vulpes*) also preyed on eggs and hatchlings, making the level of predation recorded unlikely to be sustainable in the long term.

Health monitoring of the nesting populations enabled the determination of baseline blood health parameters and toxin levels in blood. Two cases of fibropapillomatosis were confirmed for the first time in Western Australian loggerhead turtles. Changes in the leukogram and some biochemical parameters were detected in association with the presence of barnacles, in particular burrowing barnacles. In order to establish the connection between the nesting turtles' health and reproductive success, maternal health indices were compared to hatching success and reproductive output. Several blood health parameters, including alpha and gamma proteins, iron, zinc and vitamin E levels, were correlated with hatching success or clutch size, suggesting that these parameters influence reproduction in loggerhead turtles. Additionally, sea turtles with reproductive abnormalities, such as soft-shelled or deformed eggs, had higher blood mercury levels than turtles without any egg or clutch

abnormalities. This finding raises important questions about the toxic effect of mercury, at low blood concentrations, on sea turtle reproduction.

During the health assessment, a novel intraerythrocytic protozoal parasite species, similar to a malaria parasite (*Haemoproteus* and *Plasmodium* spp), was identified for the first time in sea turtles and was described through the use of light microscopy and diagnostic molecular techniques. The phylogenetic analysis indicated that this new parasite is closely related to other haemosporidia isolated from chelonians, but is well separated from malaria parasites isolated from other hosts (e.g. mammals, birds and other reptiles). This parasite appears to be largely benign. Although parasitaemia was low in all infected individuals, further studies are required to assess the potential impact of this haemoparasite on sea turtle fitness.

In conclusion, this study provided further understanding of factors affecting reproductive success, identified threats to the Western Australian nesting population whilst at the same time enabling assessment of the general health of nesting loggerhead turtles in Western Australia.

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List of abbreviations

A/G ratio	Albumin/globulin ratio
ALT	Alanine aminotransferase
ANOSIM	Analysis of similarity
As	Arsenic
AST	Aspartate aminotransferase
Ca	Total calcium
CCL	Curved carapace length
CCW	Curved carapace width
Cd	Cadmium
CFPHV	Chelonid fibropapilloma-associated herpesvirus
CI	Confidence intervals
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CK	Creatine kinase
Cl	Chloride
CMS	Convention for the Conservation of Migratory Species of Wild Animals
Co	Cobalt
Col	Cytochrome c oxidase I
CR	Cape Range Peninsula
Cr	Chromium
Cu	Copper
DEC	Department of Environment and Conservation
DHI	Dirk Hartog Island
DNA	Deoxyribonucleic acid

EF2	Elongation factor 2
EPBC	Environment Protection and Biodiversity Conservation
EPH	Electrophoresis
ES	Emerging success
ESS	Effective sampling size
Fe	Iron
FP	Fibropapillomatosis
GPS	Geographic Positioning System
Hg	Mercury
HS	Hatching success
ICP-AES	Inductively coupled plasma atomic emission spectroscopy
ICP-MS	Inductively coupled plasma mass spectrometry
IEP	Incubation to emergence period
IUCN	International Union for Conservation of Nature and Natural Resources
K	Potassium
MCMC	Markov chain Monte Carlo
Mn	Manganese
Na	Sodium
Ni	Nickel
NMP	Ningaloo Marine Park
NP	National Park
NTP	Ningaloo Sea Turtle Program
OCs	Organochlorine pesticides
OR	Odds ratio
P	Inorganic phosphate
Pb	Lead

PCA	Principal Component Analysis
PCBs	Polychlorinated biphenyls
PCR	Polymerase chain reaction
PCV	Packed cell volume
Pers.obs.	Personal observation
RI	Reference interval
Se	Selenium
SCL	Straight carapace length
SCW	Straight carapace width
SD	Standard deviation
SIMPER	Similarity percentages
TP	Total protein
TSD	Temperature dependent sex determination
Urea	Blood urea nitrogen
V	Vanadium
WA	Western Australia
WAMTP	Western Australian Marine Turtle Program
WBC	White blood cell
Zn	Zinc

