B-1246
[1-5]

RESEARCH ARTICLE Indian Journal of Animal Research, Volume Issue : ()

Lesson to Learn from an Endangered Green Turtle (*Chelonia mydas*): Marine Debris Ingestion, Rehabilitation and Satellite Tracking

Tsung-Hsien Li[1], Ya-Ru Cai[2], Po-Yu Wu[1], Connie Ka-Yan Ng[3], George H. Balazs[4]

10.18805/ijar.B-1246

ABSTRACT

Background: Marine debris is an environmental pollution problem affecting the oceans worldwide. Recent studies reveal that marine debris ingestion by sea turtles is rising. Sea turtles brought in for rehabilitation allows an opportunity to provide insights into the possible effects of anthropogenic debris on animal's survivorship during rehabilitation.

Methods: A green turtle (*Chelonia mydas*) was bycaught in fishing gear in south-western Taiwan in 2016. Debris were collected in the holding tank during rehabilitation. After a 3-month rehabilitation, the turtle was fit for release. Prior to the release, the turtle was tagged with a satellite transmitter.

Result: Marine debris were found in turtle feces or floating on the surface of basins during rehabilitation. The debris were dominated by fishing line, hard plastic, soft plastic, rope, wood and styrofoam. The turtle survived and was successfully released back into the wild attached with a satellite transmitter. The turtle remained residing in waters of southern Taiwan, possibly its foraging ground, for almost two months. This study presents an apparent successful rehabilitation of an endangered green sea turtle, that hopefully helps further enhance environmental education and public awareness, as well as concerted actions against marine pollution in general and anthropogenic debris related problems in particular.

Key words: Anthropogenic debris, *Chelonia mydas*, Hematology, Plastic, Rehabilitation, Satellite.

INTRODUCTION

Recent studies show that marine debris ingestion by sea turtles is rising (Schuyler *et al*., 2014). Green turtles (*Chelonia mydas*) brought in for rehabilitation allows an opportunity to provide insights into the possible effects of anthropogenic debris on animal's survivorship during recovery and rehabilitation (Hoarau *et al*., 2014). Hematology and biochemical parameters, as measured in peripheral blood, are a useful diagnostic tool in animal health management (Barkakati *et al*., 2015; Li *et al*., 2015; Ramulu *et al*., 2015; Yaqub *et al*., 2018; Abdullah *et al*., 2020). Here, we present and discuss a rehabilitation case of buoyancy disorder occurring in a green sea turtle, which resulted from fishing activities and marine debris ingestion.

MATERIALS AND METHODS

Turtle rehabilitation

A 32.76-kg green turtle *C. mydas* of curved carapace length 65.1 cm was bycaught in fishing gear near the Sicao of Tainan (23°00'39.1N, 120°08'27.1E) in south-western Taiwan in January 2016. The green turtle was rescued and entrusted to the National Museum of Marine Biology and Aquarium (NMMBA) for medical care. The turtle was rehabilitated, given appropriate treatment (included physical examination, evaluation of swimming activity, food ingestion, weight, core body temperature and blood sample analysis) and kept under observation in isolation for three months. When the turtle was initially taken into rehabilitation, exhibited conditions of poor appetite and positive buoyancy (Fig 1) due to weakness. Based on a physical examination, the turtle was in good body condition. A series of blood gas, blood biochemical and hematology parameters profiling was performed. The blood gas values included potential hydrogen (pH), partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), base excess in extracellular fluid (BEecf), bicarbonate (HCO_3^-), total carbon dioxide (TCO_2), saturated oxygen (sO_2), ionized calcium (iCa), potassium (K), sodium (Na), glucose (Glu) and creatinine (CRE). Biochemistry profiles included total protein (TP), albumin (ALB), total bilirubin (TBIL), aspartate

[1]National Museum of Marine Biology and Aquarium, Pingtung, Taiwan.
[2]Marine National Park Headquarters, Kaohsiung City 811, Taiwan.
[3]Department of Chemistry and State Key Laboratory in Marine Pollution, City University of Hong Kong, Kowloon Tong, Hong Kong Special Administrative Region.
[4]Golden Honu Services of Oceania, 992 Awaawaanoa Place, Honolulu, Hawaii.

Corresponding Author: Tsung-Hsien Li, National Museum of Marine Biology and Aquarium, Pingtung, Taiwan.
Email: lith@nmmba.gov.tw

How to cite this article: Li, T.H., Cai, Y.R., Wu, P.Y., Ng, C.K.Y. and Balazs, G.H., Lesson to Learn from an Endangered Green Turtle (*Chelonia mydas*): Marine Debris Ingestion, Rehabilitation and Satellite Tracking. Indian Journal of Animal Research. ():

Submitted: 16-01-2020 **Accepted:** 09-06-2020 **Published**:

aminotransferase (AST), alanine aminotransferase (ALT), alalkaline phosphatase (ALP), γ-glutamyltranspeptidase (GGT), creatinine kinase (CK), lactate dedehydrogenase (LDH), cholesterol (CHOL), triglyceride (TRI), glucose (GLU), blood urea nitrogen (BUN), uric acid (UA), phosphorus (PHOS), calcium (CA) and magnesium (MG). Hematological examinations included quantitative analysis of hemoglobin (HB), white blood cell (WBC) and packed cell volume (PCV).

Satellite tracking

After a 3-month recovery, the turtle was physically fit for release. Prior to the release, the turtle was tagged with Inconel tags on its fore- and/ or hind-limbs and microchip for identification (Balazs, 1999). The satellite tracking work was permitted under the protected wildlife use permissions of Forestry Bureau, Council of Agriculture, Executive Yuan, Taiwan (1051700373). A satellite Argos-linked transmitter was also attached to its carapace with fiberglass resin following the protocol as described by Balazs *et al*. (1996). The weight of the transmitter package was less than 5% of the body weight of the turtles to minimize potential impact to their health (Watson and Granger, 1998; Ng *et al*., 2018a). The turtle was successfully released with a satellite transmitter at Haikou Beach (22°05´28N, 120°42´52E) in southern Taiwan on March 31, 2016. Satellite track of the oceanic movement was plotted using the basemap at Google Earth (Maptool (SEATURTLE.ORG, Inc.; http://www.seaturtle.org/maptool/) primarily with positional Argos data derived from the more accurate Location Class (LC) 1 to 3 signals; large spatial gaps were filled using data points of LC 0, A and B where appropriate following visual filtering for obviously inaccurate points (Chan *et al*., 2003; Parker *et al*., 2009), on the basis of excluding biologically unreasonable results of location points, including travel speed (>5 km/hr), points located on land and a turn of greater than 90 degrees in less than a 24-hour period (Parker *et al*., 2009). A maximum of one fix per day was selected with the highest accuracy LC and if more than one fix had this LC, the one closest to midday was selected (Casale *et al*., 2012; Parker *et al*., 2009). The end of a track was determined either by the last Argos position or when positional locations aggregated at a specific area 'near shore' if the turtle settled in areas along the open coast generally for approximately one month, implying that the tracked turtle had arrived and settled down at its foraging ground (Parker *et al*., 2009).

RESULTS AND DISCUSSION

Results of metabolic parameters indicated an elevation in pO_2 (mmHg) at 37°C, temperature corrected pO_2 and TCO_2; all other values (included PCV) were within the reference interval (Aguirre and Balazs, 2000; Anderson *et al*., 2011; Bolten and Bjorndal, 1992; Lewbart *et al*., 2014; Hamann *et al*., 2006; Phillips *et al*., 2015). Two days after intake, buoyancy of turtle improved as it was able to submerge. Within 3 to 26 days of rehabilitation, debris were found in turtle feces or floating at the surface of basins. The debris included fishing line, hard plastic, soft plastic, rope, wood and styrofoam (Fig 2 and Fig 3). After release on March 31,

Fig 1: The green sea turtle (*Chelonia mydas*) with buoyancy problems.

Fig 2: Marine debris recovered from the green sea turtle (*Chelonia mydas*) during rehabilitation. Debris dominated by hard plastic, soft plastic, rope, wood and styrofoam.

Fig 3: Marine debris recovered from the green sea turtle (*Chelonia mydas*) during rehabilitation. Debris dominated by fishing line, hard plastic and soft plastic.

Fig 4: Picture of a satellite-tracked green sea turtle (*Chelonia mydas*).

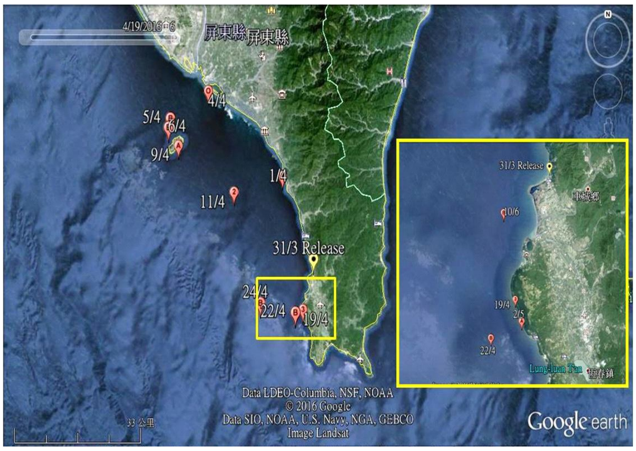

Fig 5: Migration pathways of a green sea turtle (*Chelonia mydas*) from Haikou Beach in southern Taiwan.

2016 (Fig 4), during the 81-day satellite tracking, the turtle moved northward and reached Xiao Liu Chiu Island, where foraging green turtles are found around the Island waters harboring coral reef (Doo *et al*., 2012) and seaweed (Chang and Tseng, 2010) communities. The turtle stayed around Xiao Liu Chiu Island for 5 days and then moved southward back towards its release spot. The turtle remained residing in waters off Hengchun of southern Taiwan, possibly its foraging ground, for almost two months until the satellite signal went off (Fig 5).

In several studies of hospitalized sea turtles (Camacho *et al*., 2015; Keller *et al*., 2012), metabolic acidosis has been identified as a common acid/base disorder. In general, most of the blood analytes we recorded were similar to those reported previously for healthy sea turtles (Bolten and Bjorndal, 1992; Aguirre and Balazs, 2000; Hamann *et al*., 2006; Anderson *et al*., 2011; Lewbart *et al*., 2014; Phillips *et al*., 2015) .This indicated that the turtle in this study was not affected by metabolic and respiratory derangements. Green turtle is the most common species recorded in Taiwanese waters (Kuo *et al*., 2017; Cheng *et al*., 2019). Major threats to *C. mydas* populations worldwide include habitat degradation (Cheng *et al*., 2009), marine pollution (Ng *et al*., 2018b), disease (Chen *et al*., 2012; Li *et al*., 2017; Tsai *et al*., 2019), fishing activities (Chen *et al*., 2012) and ingestion of plastics and other anthropogenic debris (Ng *et al*., 2016; Jerdy *et al*., 2017; Jung *et al*., 2018; Duncan *et al*., 2019). Marine debris is a serious pollution problem affecting the oceans worldwide. With its increasing presence at sea, marine debris interaction pose a major threat to marine fauna (Laist, 1997). Ingestion of anthropogenic debris is well documented in sea turtles (Clukey *et al*., 2017; Jerdy *et al*., 2017; Godoy *et al*., 2018; Jung *et al*., 2018). In a dietary study of green turtles in Hong Kong by Ng *et al*. (2016), apart from the regular food items such as red algae, plastic fragments and a small plastic bag of tissue packaging and other foreign materials, such as rope strands, were found in the stomach contents of 2 of the 8 individuals sampled during necropsy. Marine pollution and debris has been considered one of the threats to foraging green turtles in the South China Region as revealed by Ng *et al*. (2016, 2018b). However, there are limited studies involving detailed analysis of anthropogenic debris obtained from fecal samples of live sea turtles.

CONCLUSION

Endangered green turtles are well-known to be the marine turtle species that most commonly ingest and interact with anthropogenic marine debris (Schuyler *et al*., 2014). Despite the recent increasing public awareness in marine pollution in Taiwan, such as banned use of plastic bags by law and beach clean-up activities organized by local concern groups, international, regional and local efforts are still required to tackle the trans-boundary pollution problem for the conservation of migratory green turtles in the vast ocean. This study presents an apparent successful rehabilitation of an endangered green turtle in Taiwan that hopefully helps further enhance public awareness and concerted actions against marine pollution in general and anthropogenic debris related problems in particular.

ACKNOWLEDGEMENT

Rescue and rehabilitation work for sea turtles at the National Museum of Marine Biology and Aquarium (NMMBA) was approved and supported by the Forestry Bureau of Taiwan. We also thank the Southern Coastal Patrol Office for their contribution to the rescue of sea turtle and temporarily holding of the injured sea turtle.

REFERENCES

Aguirre, A. A. and Balazs, G. H. (2000). Plasma biochemistry values of green turtles (*Chelonia mydas*) with and without fibropapillomas in the Hawaiian Islands. Comparative Haematology International. 10: 132-137.

Abdullah, S.W., Khan, M.U.R., Aslam, A., Masood, S., Bajwa, A.G., Sheikh, A.A. (2020). Detection of Bovine Ephemeral Fever Virus and Its Effects on Blood Parameters and Serum Calcium Levels in Cattle Population of District Swabi, Pakistan. Indian Journal of Animal Research.

54(4): 456-461. DOI: 10.18805/ijar.B-1019.

Anderson, E.T., Harms, C.A., Stringer, E.M., Cluse, W.M. (2011). Evaluation of hematology and serum biochemistry of cold-stunned green sea turtles (*Chelonia mydas*) in North Carolina, USA. Journal of Zoo and Wildlife Medicine. 42: 247-255.

Balazs, G.H. (1999). Factors to consider in the tagging of sea turtles. In: Research and Management Techniques for the Conservation of Sea Turtles [K.L. Eckert, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly, (eds.)]. IUCN/SSC Marine Turtle Specialist Group Publication, No. 4: 101-109.

Balazs, G.H., Miya, R.K., Beavers, S.C. (1996). Procedures to attach a satellite transmitter to the carapace of an adult green turtle, *Chelonia mydas*. [Keinath, J.A., Barnard, D.E., Musick, J.A. and Bell, B.A. (Eds.)], Proceedings of the Fifteenth Annual Symposium on Sea Turtle Biology and Conservation, February 20-25, 1995, South Carolina., U.S. (pp: 21-26).

Barkakati, J., Sarma, S., Kalita, D.J. (2015). Effect of foot and mouth disease on haematological and biochemical profile of cattle. Indian Journal of Animal Research. 49(5): 713-716.

Bolten, A.B. and Bjorndal K.A. (1992). Blood profiles for a wild population of green turtles (*Chelonia mydas*) in the southern Bahamas: size-specific and sex-specific relationships, Journal of Wildlife Diseases. 28(3): 407-413.

Camacho, M., Quintana, MdP., Calabuig, P., Luzardo, O.P., Boada, L.D., Zumbado, M., Orós, J. (2015) Acid-Base and Plasma Biochemical Changes Using Crystalloid Fluids in Stranded Juvenile Loggerhead Sea Turtles (*Caretta caretta*). PLoS ONE. 10(7): e0132217.

Casale, P., Affronte, M., Scaravelli, D., Lazar, B., Vallini, C., P. Luschi. (2012). Foraging grounds, movement patterns and habitat connectivity of juvenile loggerhead turtles (*Caretta caretta*) tracked from the Adriatic Sea. Marine Biology. 159(7): 1527-1535.

Chan, S.K.F., Chan, J.K., Lo, L.T., Balazs, G.H. (2003). Satellite tracking of the post-nesting migration of a green turtle (*Chelonia mydas*) from Hong Kong. Marine Turtle News letter. 102: 2-4.

Chang, J.S. and Tseng, C.C. (2010). Effects of recent ecological events on the distribution and growth of macroalgae in marine waters around Taiwan. Bulletin of Fisheries Research Agency. 32: 11-17.

Chen, H., Kuo, R.J., Chang, T.C., Hus, C.K., Bray, R.A., Cheng, I.J. (2012). Fluke (*Spirorchiidae*) infections in sea turtles stranded on Taiwan: Prevalence and Pathology. Journal of Parasitology. 98: 437-439.

Cheng, I.J., Huang C.T., Hung P.Y., Ke, B.Z., Kuo C.W., Fong C.L. (2009). Ten years of monitoring the nesting ecology of the green turtle, *Chelonia mydas*, on Lanyu (Orchid Island), Taiwan. Zoological Studies. 48(1): 83-94.

Cheng, I.J., Wang, H.Y., Hsieh, W.Y., Chan, Y.T. (2019). Twenty-three Years of Sea Turtle Stranding/bycatch Research in Taiwan. Zoological Studies. 58(44): doi:10.6620/ZS.2019.58-44.

Clukey, K.E., Lepczyk, C.A., Balazs, G.H., Work, T.M., Lynch, J.M. (2017). Investigation of plastic debris ingestion by four species of sea turtles collected as bycatch in pelagic Pacific longline fisheries. Marine Pollution Bulletin. 120 (1-2): 117-125.

Doo, S.S., Mayfield, A.B., Byrne, M., Chen, H.K., Nguyen, H., Fan, T.Y. (2012). Reduced expression of the rate-limiting carbon fixation enzyme RuBisCO in the benthic foraminifer Baculo--gypsina sphaerulata holobiont in response to heat shock. Journal of Experimental Marine Biology and Ecology. 430e431: 63e67.

Godoy, D.A. and Stockin K.A. (2018). Anthropogenic impacts on green turtles *Chelonia mydas* in New Zealand. Endangered Species Research. 37: 1-9.

Duncan, E.M., Arrowsmith, J.A., Bain, C.E., Bowdery, H., Broderick, A.C., Chalmers, T., Fuller, W.J., Galloway, T.S. Lee, J.H., Lindeque, P.K., Omeyer, L.C.M., Snape, R.T. E., Godley, B.J. (2019). Diet-related selectivity of macroplastic ingestion in green turtles (*Chelonia mydas*) in the eastern Mediterranean. Scientific. Reports. 9: 11581.

Hamann, M., Schäuble, C.S., Simon, T., Evans, S. (2006). Demographic and health parameters of green sea turtles *Chelonia mydas* foraging in Gulf of Carpentaria, Australia. Endangered Species Research. 2: 81-88.

Hoarau, L., Ainley, L., Jean, C., Ciccione, S. (2014). Ingestion and defecation of marine debris by loggerhead sea turtles, *Caretta caretta*, from by-catches in the South-West Indian Ocean. Marine Pollution Bulletin. 84 (1): 90-96.

Jerdy, H., Werneck, M.R., Da Silva, M.A., Ribeiro, R.B., Bianchi, M., Shimoda, E., De Carvalho, E. C. (2017). Pathologies of the digestive system caused by marine debris in *Chelonia mydas*. Marine Pollution Bulletin. 116: 192-195.

Jung, M.R., Balazs, G.H., Work, T.M., Jones, T.T., Orski, S.V., Rodriguez, C.V., Beers, K.L., Brignac, K.C., Hyrenbach, K.D., Jensen, B.A., and Lynch, J.M. (2018). Polymer identifi--cation of plastic debris ingested by pelagic-phase sea turtles in the Central Pacific. Environmental Science and Technology. 52: 11535-11544.

Keller, K.A, Innis, C.J, Tlusty, M.F, Kennedy, A.E, Bean, S.B, Cavin, J.M, Merigo, C. (2012). Metabolic and respiratory derangements associated with death in cold-stunned Kemp's ridley turtles (*Lepidochelys kempii*): 32 cases (2005-2009). Journal of the American Veterinary Medical Association. 240: 317-323.

Kuo, F.W., Fan, T.U., Ng, C.K.Y., Cia, Y., Balazs, B.H., Li, T.H. (2017). Tale of the unlucky tags: the story of a rescued, rehabilitated and released green sea turtle (*Chelonia mydas*) in southern Taiwan. Bulletin of Marine Science. 93(3): 689-690.

Laist, D. (1997). Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: Marine Debris SE-10, Springer Series on Environmental Management. [Coe, J., Rogers, D. (Eds.)], Springer, New York, pp: 99-139.

Lewbart, G.A., Hirschfeld, M., Denkinger, J., Vasco, K., Guevar, N., Garcı´a, J., Mun˜oz, J., Lohmann, K.J. (2014). Blood gases, biochemistry and hematology of Galapagos green turtles (*Chelonia mydas*). PLOS One. 9: e96487.

Li, T. H., Chang, C. C., Cheng, I. J., Lin, S. C. (2015). Development of a summarized health index (SHI) for use in predicting survival in sea turtles. PLoS One. 10(3): e0120796.pone. 0120796.

Li, T.H., Hsu, W.L., Lan, Y.C., Balazs, G.H., Work, T.M., Tseng, C. T., Chang, C.C. 2017. Identification of Chelonid herpesvirus 5 (ChHV5) in endangered green turtles (*Chelonia mydas*) with fibropapillomatosis in Asia. Bulletin of Marine Science. 93(4): 1011-1022.

Ng, C.K.Y., Ang, P.O., Russell, D.J., Balazs, G.H., B.M. Murphy. (2016). Marine macrophytes and plastics consumed by green turtles (*Chelonia mydas*) in Hong Kong, South China sea region. Chelonian Conservation and Biology. 15(2): 289-292.

Ng, C.K.Y., H.X. Gu, T.H. Li, M.B. Ye, Z.R. Xia, F.Y. Zhang, J.X. Duan, C.K. Hsu, G.H. Balazs, M.B. Murphy. (2018a). Insights into identifying habitat hot spots and migratory corridors of green turtles in the South China region. *Aquatic Conserv,* Mar Freshw Ecosyst: 1-11.

Ng, C.K.Y., Lam, J.C.W., Zhang, X.H., Gu, H.X., LI, T.H., YE, M.B., Xia, Z.R., Zhang, F.Y., Duan, J.X., Wang, W.X., Lam, I.K.S., Balazs, G.H., Lam, P.K.S., B.M. Murphy (2018b). Levels of Trace Elements, Methylmercury and Polybromi--nated Diphenyl Ethers in Foraging Green Turtles in the South China Region and their Conservation Implications. Environmental Pollution. 234: 735-742.

Parker, D.M., Balazs, G.H., King, C.S., Katabira, L., Gilmartin, W. (2009). Short-range movements of Hawksbill turtles (*Eretmochelys imbricata*) from nesting to foraging areas within the Hawaiian Islands. Pacific Science. 63(3): 371-382.

Phillips, B.E., Cannizzo, S.A., Godfrey, M.H., Stacy, B.A., Harms, C.A. (2015). Case report: Exertional myopathy in a juvenile green sea turtle (*Chelonia mydas*) entangled in a large mesh gillnet. Case Reports in Veterinary Medicine. 2015: 1-6.

Ramulu, S P., Nagalakshmi, D., Kumar, M.K. (2015). Effect of zinc supplementation on haematology and serum biochemical constituents in Murrah buffalo calves. Indian Journal of Animal Research. 49(4): 482-486.

Schuyler, Q., Hardesty, B. D., Wilcox, C., Townsend, K. (2014). Global analysis of anthropogenic debris ingestion by sea turtles. Conservation Biology. 28: 129-139.

Tsai, M.A., Chang, C.C., Li, T.H. (2019). Multiple-antibiotic resistance of *Enterococcus faecalis* in an endangered olive ridley sea turtle (*Lepidochelys olivacea*): A case report. Indian Journal of Animal Research. DOI: 10.18805/ijar.B-1064.

Watson, K.P., Granger, R.A. (1998). Hydrodynamic effect of a satellite transmitter on a juvenile green turtle (*Chelonia mydas*). Journal of Experimental Biology. 201: 2496-2505.

Yaqub, A., Anjum, K.M., Munir, A., Mukhtar, H., Khan, W.A. (2018). Evaluation of acute toxicity and effects of sub-acute concentrations of copper oxide nanoparticles (CuO-NPs) on hematology, selected enzymes and histopathology of liver and kidney in *Mus musculus*. Indian Journal of Animal Research. 52(1): 92-98.