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Ingesta passage and gastric emptying times in loggerhead sea turtles (*Caretta caretta*)

A.L. Valente [a,*], I. Marco [a], M.L. Parga [b], S. Lavin [a], F. Alegre [b], R. Cuenca [a]

[a] *Servei d'Ecopatologia de Fauna Salvatge, Facultat de Veterinària, Universitat Autònoma de Barcelona, 08193-Bellaterra, Barcelona, Spain*
[b] *Centre de Recuperació d'Animals Marins, Camí Ral 239, 08330 – Premià de Mar, Barcelona, Spain*

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Abstract

Ingesta passage times of soft flat foam dishes and gastric emptying time of barium-impregnated polyethylene spheres (BIPS®) were measured in 22 and 8 loggerhead sea turtles (*Caretta caretta*), respectively. Transit time (T_1) was considered as the time between ingestion and first elimination, and retention time (T_{50}) and total transit time (T_{85}) the expulsion time of 50% and 85% of the markers, respectively. The experiments were carried out at different times of the year and water temperature was recorded. A set of dorso-ventral radiographs was taken to locate the BIPS®, and the gastrointestinal anatomy of 5 dead turtles was studied to help with interpretation of the radiographs. No significant correlation was observed between T_1, T_{50}, T_{85} and minimum straight carapace length (SCLmin) or body mass and no statistical difference was found in ingesta passage transit times between juvenile ($n = 6$) and sub-adult turtles ($n = 16$). Mean passage times of the dishes (in days) were: $T_1 = 9.05$, $T_{50} = 12.00$ and $T_{85} = 13.19$. Gastric emptying time using BIPS® was 24–48 h. The transit time (T_1) for the BIPS® was longer (13.25 ± 4.86 days) than the foam markers (8.5 ± 2.73 days) in 8 turtles studied simultaneously. Although the total transit time tended to be faster in turtles submitted to water temperatures between 20 °C and 23.6 °C no significant correlation was observed between T_1, T_{50} and T_{85} and the temperature.

Keywords: Loggerhead sea turtle; *Caretta caretta*; BIPS®; Ingesta passage time; Transit time; Gastrointestinal tract morphology

1. Introduction

The loggerhead sea turtle (*Caretta caretta*) is a worldwide endangered species which is highly susceptible to human activity. The accidental ingestion of waste products from oil operations, plastic bags and other kinds of debris is one cause of mortality of this species throughout its distribution (Balazs, 1985; Bjorndal et al., 1994; Tomás et al., 2002; Milton and Lutz, 2003).

In some areas, such as the Mediterranean Sea, gastrointestinal disorders are common due to the ingestion of fishhooks, which cause traumatic injuries to the gastrointestinal tract leading to death (Pont and Alegre, 2000). Most turtles accidentally captured by fishing activities are released without removal of the hook. On admitttance to the marine rescue centres, diagnosis of gastrointestinal disorders in these turtles is very difficult; necropsy findings frequently reveal severe gastrointestinal injuries such as enteritis followed by necrosis, bowel obstruction and intussusceptions produced by the folding effect of the line pulling through the intestine (Orós et al., 2005; Di Bello et al., 2006a,b).

In domestic animals, knowledge of the ingesta passage and the normal gastric emptying times are useful in detecting gastrointestinal motility disorders and partial obstructions of the pylorus or small intestine (Manfred and Camilleri, 1992; Guilford, 2001). The digestive passage time of inert and indigestible markers, normally plastic pieces, or their simultaneous use with another type of marker have been used in many species, including chelonians (Lanyon and Marsh, 1995; Spencer et al., 1998; Hernot et al., 2006; Hailey, 1997).

* Corresponding author. Tel.: +34 93 581 19 23; fax: +34 93 581 20 06.
E-mail address: schifinoval@hotmail.com (A.L. Valente).

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Barium sulphate suspension is the most frequently-used technique thanks to its inexpensiveness. However, it is not quantitative and evaluates the gastric emptying rate of the liquid but not the solid fraction of the ingesta (Guilford, 2001). When compared with a scintigram, the latter provides more accurate information (Goggin et al., 1998). Alternatively, barium-impregnated polyethylene spheres (BIPS®) have provided a range of diagnostic options which reduce the need to undertake exploratory surgery on cats and dogs (Nelson et al., 2001; Weber et al., 2002). The BIPS® are inert, white and have a density similar to food, but are sufficiently radiodense to show up clearly on abdominal radiographs.

In reptiles, mainly in herbivorous species, such as the iguana (*Iguana iguana*), Leopard tortoise (*Testudo pardalis*), desert tortoise (*Xerobates agassizii*), Galapagos Giant tortoise (*Geochelone nigra*), Greek tortoise (*Testudo hermanii*) and the short-necked turtle (*Emydura macquarii*), digestive studies have been performed to assess the normal transit and retention times and functional anatomy of the digestive tract (Barboza, 1995; Taylor et al., 1996; Meyer, 1998; Spencer et al., 1998; Smith et al., 2001; Hatt et al., 2002). The retention time in the aforementioned chelonians have varied from 7.5 to 14.8 days and were strongly influenced by both temperature and diet. Mean transit time of herbivorous species such as the Greek and Leopard tortoises were 2.6–17.3 h and 6–6.91 days, respectively (Taylor et al., 1996; Meyer, 1998). Hailey (1997) compared the digestive efficiency and gut morphology of omnivorous and herbivorous African tortoises (*Kinixys spekii* and *Geochelone pardalis*, respectively). The author found the transit time was lower in *K. spekki* (2.2 days) than in *G. pardalis* (3.8 days).

As to loggerhead sea turtles, Di Bello et al. (2006b) evaluated the post-enterotomy transit time of barium sulphate in the intestinal tract of six animals. Gastric emptying times and total digestive transit times were 34–264 h and 192–960 h, respectively. The authors stated that although often adequate for the diagnosis of obstruction, the procedures were not easily performed on some turtles.

The aim of the current study is to report on ingesta passage times in the healthy loggerhead sea turtles using specific indices such as the transit and retention times. Further, we have added the index T_{85} as 'total transit time' considering the long time of ingesta passage in chelonians. This work aimed to generate baseline data on digestive physiology, and to determine whether the established method of transit time assessment used in dogs and cats using BIPS® could be applied.

2. Materials and methods

Twenty-two loggerhead sea turtles (6 juvenile and 16 subadult specimens) accidentally caught in pelagic long line sets and fishing nets off the north-western Mediterranean coast of Spain were used in this study. Only those turtles in which the hook was superficially attached in or near the mouth and easily removed through the oral cavity were included in the study. Turtles showed minimum straight carapace length (SCLmin) of 31.5–54.5 cm and body weight of 4.4–22.2 kg. Juvenile turtles ($n = 6$) were considered to be those with a SCLmin of 21–40 cm and sub-adults ($n = 16$) those with a SCLmin of 41–65 cm (Dodd, 1988). The turtles were temporarily housed in the rehabilitation facilities of the Rescue Centre for Marine Animals (CRAM), in Premià de Mar, Barcelona, Spain. Complete blood count and serum chemistry values fell within normal limits. Only clinically normal animals were included in this study.

Turtles were accommodated in individual outdoor tanks measuring $100 \times 100 \times 50$ (deep) cm and were kept at the acclimatisation centre for a minimum of 2 weeks prior the study. The photoperiod ranged between 11 h/13 h and 13 h light/11 h dark according to season of the year. During the study, all turtles were fed at 48 h intervals with a diet based on hake (*Merluccius merluccius*) and sardines (*Sardina pilchardus sardina*) (1:1) in a quantity equivalent to 1.5–2.5% of the turtle body mass. No difference in the food intake was observed in the different seasons. Water temperature in the different tanks ranged according to the ambient temperature, and was measured twice daily (morning and afternoon), the mean values for each tank being used in the analyses.

Colour-marker experiments were carried out in 3 periods: early autumn, summer and winter, using 12 (8 subadults and 4 juveniles; mean body mass = 11.5 kg, mean SCLmin = 41.8 cm), 8 (6 subadults and 2 juveniles; mean body mass = 14.38 kg, mean SCLmin = 45.25 cm) and 2 turtles (2 subadults; mean body mass = 21.35 kg, mean SCLmin = 52.75 cm) respectively. We used different animals in each season. Each turtle, depending on its size, was given 10–20 coloured markers made with 5 mm of diameter dishes of soft flat foam (Evaland, Evapal® – Palencia, Spain) placed inside the fish at first feeding. The presence of the coloured markers in the faeces or floating in the water was recorded daily.

In the 8 turtles used in the study during the summer, BIPS® (Medical I.D. Systems, Inc.-Michigan, USA) were used simultaneously with the colour markers in the same animals to assess gastric emptying and digesta intestinal transit times. BIPS®capsules with two sphere sizes – 1.5 mm (30 U) and 5 mm (10 U) – were used. BIPS® and the colour markers were put inside of a mouth of one sardine that was swallowed by the turtle. Dorso-ventral radiographs were taken 2 h after the test meal to verify that all BIPS® were really swallowed. In the first week, radiographic monitoring was performed each 24 h. As no great changes in the position of the BIPS® were observed within the first 24 h, we decided to use a 48 h interval for subsequent radiographs for the remainder of the 21-day experiment. Lateral radiographs were extremely difficult to interpret because of the displacement and overlapping of the gastrointestinal tract with other soft tissue organs and carapace bony structure. Thus, all results reported are based on dorso-ventral radiographs only.