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Determination of gastrointestinal transit time in *Podocnemis expansa* Schweigger, 1812 (Amazon turtle) (Testudines: *Podocnemididae*)

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Abstract

The Amazon turtle is herbivorous but can feed on a small amount of food of animal origin. The speed of digestion of these animals is influenced by temperature and diet. Studies on the transit in the gastrointestinal tract are necessary in order to understand the food digestion process in the animal's organism. We therefore sought to establish the gastrointestinal transit time of this reptile, which is information widely used in the clinical care of wild animals. The study involved 10 animals from the Nova Crixás – GO breeding farm, weighing an average of 2.595 ± 3.22 Kg. The animals were fed orally with a barium sulfate suspension (10ml/Kg of Bariogel[®] mixed with mineral oil (Nujol[®]), in a proportion of 70% barium sulfate to 30% oil. The animals were then radiographed in the dorsiventral position, with the X-ray machine set at 80 kV, 250 mA and 0.74" of exposure, at preestablished intervals of time the

contrast remained in the organism. Five minutes after administration of the contrast fluid, the stomach was filled, while the jejunum and ilium were filled between 6 and 24 hours, the cecum between 24 and 96 hours, and the colon and rectum between 24 hours and the 5th day. Complete emptying of the stomach occurred between the 5th and 24th day. Elimination of the contrast material from the duodenum occurred from the 7th to the 15th day, and from the jejunum-ilium between the 7th and 17th day. The cecum expelled the contrast fluid from the 12th to the 29th day, with complete discharge occurring between the 15th and 29th day. Therefore, the total gastrointestinal transit time in *P. expansa* was, on average, 22.5 days, with a minimum of 15 days and maximum of 29 days.

Keywords: Radiology, Stomach, Intestine, *Podocnemis expansa*

Determinação do tempo de trânsito gastrointestinal de *Podocnemis expansa* Schweigger, 1812 (Tartaruga-da-amazônia) (Testudines: *Podocnemididae*)

Resumo

A tartaruga da Amazônia é herbívora, mas pode se alimentar de uma pequena quantidade de alimentos de origem animal. A velocidade de digestão desses animais é influenciada pela temperatura e dieta. Estudos sobre o trânsito no trato gastrintestinal são necessários para entender o processo de digestão dos alimentos no organismo do animal. Portanto, procuramos estabelecer o tempo de trânsito gastrintestinal deste réptil, que é uma informação amplamente utilizada no atendimento clínico de animais selvagens. O estudo envolveu 10 animais de um haras em Nova Crixás - GO, com peso médio de $2,595 \pm 3,22$ kg. Os animais foram alimentados oralmente, com suspensão de sulfato de bário (10ml/kg de Bariogel[®] misturado com óleo mineral (Nujol[®]), na proporção de 70% de sulfato de bário por 30% de óleo. Os animais foram radiografados na posição dorsoventral, com a máquina de raio-X fixada em 80 kV, 250 mA e 0,74" com exposição em intervalos de tempo pré-estabelecidos e

o contraste manteve-se no organismo durante todo o processo. Cinco minutos após a administração do contraste líquido, o estômago estava cheio, enquanto o jejuno e íleo foram preenchidos entre 6 e 24 horas, o ceco entre 24 e 96 horas, e o cólon e o reto entre 24 horas e no quinto dia. O esvaziamento completo do estômago ocorreu entre o quinto e o 24º dia. Eliminação do material do contraste do duodeno ocorreu do 7º ao 15º dia, e do jejuno-íleo entre o 7º e o 17º dia. O ceco expulsa o contraste líquido entre o 12º e o 29º dia, com descarga completa ocorrendo entre o 15º e o 29º dia. Portanto, o total tempo de trânsito gastrointestinal em *P. expansa* foi, em média de 22,5 dias, com um mínimo de 15 dias e máximo de 29 dias.

Palavras-chave: Radiologia, estômago, intestino, *Podocnemis expansa*

INTRODUCTION

Breeding wild animals for commercial purposes is still incipient in Brazil. More than a new commercial activity, it is a sustainable form of using natural resources, promotes the valuation of national faunal resources, and is also a source of animal protein highly adapted to the real natural conditions of the South American tropical environment (SÁ et al., 2004).

Among the Amazonian turtles, *Pocnodemis expansa* is a species with a very high potential for zootechnical exploitation, particularly due to its size, extreme prolificacy, rusticity and the high economic value of its meat and by-products (MALVASIO, 2001).

According to Lima (1998), the paucity of scientific information about the Amazon turtle makes it difficult to breed on a commercial scale in order to meet the demand for its meat, which is highly appreciated in urban centers, especially in the Amazon region.

Luz et al. (2003a) state that the exploitation of this chelonian for commercial purposes has directed the interest of producers on new forms of production. Commercial breeding comprises a set of alternatives and can contribute to reduce the pressure on animals in their natural environment, despite the legislation and regulation of breeders under government directive

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no. 142/92 (Brazil), offering economic alternatives for the sustainable and rational use of faunal resources.

The effective inclusion of the Amazon turtle as a commercially available source of protein will only be fully realized pursuant to the construction of a greater body of scientific knowledge about its biology. To date, little is known about the digestive system, especially about the gastrointestinal transit time of these freshwater chelonians, suggesting the need for research to corroborate and produce new information that contributes to the breeding of this turtle in captivity.

The morphological, anatomical and histological characteristics of the digestive tract of young and newly hatched *P. expansa* were recorded by the National Center of Amazonian Chelonians – CENAQUA (1992) and by Oliveira, Santos e Luz (1996), while Santos, Beletti e Queiroz (1998) and Luz et al. (2003b) reported on these characteristics in the adults of this species.

In the opinion of Morlock (1979), the Amazon turtle can be considered sturdy because it is not subject to a series of diseases that normally afflict wild and domestic species. The diseases that appear in turtles in captivity are, in large part, related to insalubrious conditions.

In this context, radiographic studies have been conducted on chelonians in order to elucidate physiological and pathological phenomena of their gastrointestinal tract (BEREGI et al., 2000, 2002) as well as to shed light on the transit through this structure (MEYER, 1998).

The purpose of this work, therefore, was to determine the gastrointestinal transit time of specimens of *Podocnemis expansa*, using contrast radiography.

MATERIAL AND METHOD

The study involved 10 Amazon turtles, 5 males and 5 females, weighing on average 2.595 ± 3.22 Kg. The animals, which were supplied by the Nova Crixás breeding farm in the state of Goiás, Brazil (13° 45' 55" S and 50° 47' 13,3" W – altitude: 223m), were kept in the Wild Animal Research Laboratory

at the Federal University of Uberlândia's Faculty of Veterinary Medicine in Uberlândia, state of Minas Gerais, Brazil (18° 53' 3,4" S and 48° 15' 37" W – altitude: 931 m).

The animals were clinically examined, pronounced healthy, and were kept without food for five days in a tank with running water and an electric heater to keep the temperature between 26 and 28°C.

The turtles were restrained manually by holding the carapace, plastron and the head extended. The mouth was held open with a pair of hemostatic pincers to administer the contrast fluid through a # 4 orogastric probe.

The contrast fluid consisted of a suspension of barium sulfate (Bariogel®), administered in a dosage of 10mL/kg, mixed with mineral oil (Nujol®) in a proportion of 70% barium sulfate and 30% mineral oil. This combination was chosen to prevent the barium sulfate from impacting the colon, as described by Schilbach & Mariana (2000).

The animals were radiographed in the dorsiventral position, since X-ray images taken in the laterolateral position are difficult to interpret due to the superposition of the gastrointestinal tract with other organic structures, including the carapace.

The X-ray machine (Triplunix 800mA) was set at 80kV, 250mA and an exposure time of 0.74 seconds for all the animals. The material used was 30x40cm medical X-ray film (Fujifilm®).

After administering the contrast fluid, a radiographic sequence was established for the following times: 5 minutes, 2, 4, 6, 8 and 24 hours. Thereafter, the animals were X-rayed at 24-hour intervals until each animal had completely excreted all the contrast fluid.

RESULTS AND DISCUSSION

All the animals survived the experiment.

The radiographic time sequence after administration of the contrast fluid enabled us to establish the time it took for the contrast to reach each region of

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the digestive tract and the length of time the contrast remained in each segment of the tract.

All the animals showed complete gastric contrast in 4 hours; the duodenum filled in 6 to 24 hours, the jejunum-ileum took 24 hours to become filled, the cecum took from 24 hours to 4 days, and the colon-rectum from 24 hours to 5 days.

The contrast fluid was excreted from the segments of the digestive tract as follows: the stomach emptied from the 5th to the 24th day, the duodenum from the 7th to the 15th day, the jejunum-ileum from the 7th to the 17th day, the cecum from the 12th to the 29th day, and the colon-rectum from the 15th to the 29th day.

The purposes of illustration, Figure 1 shows the structures that make up the gastrointestinal tract of *Podocnemis expansa*.

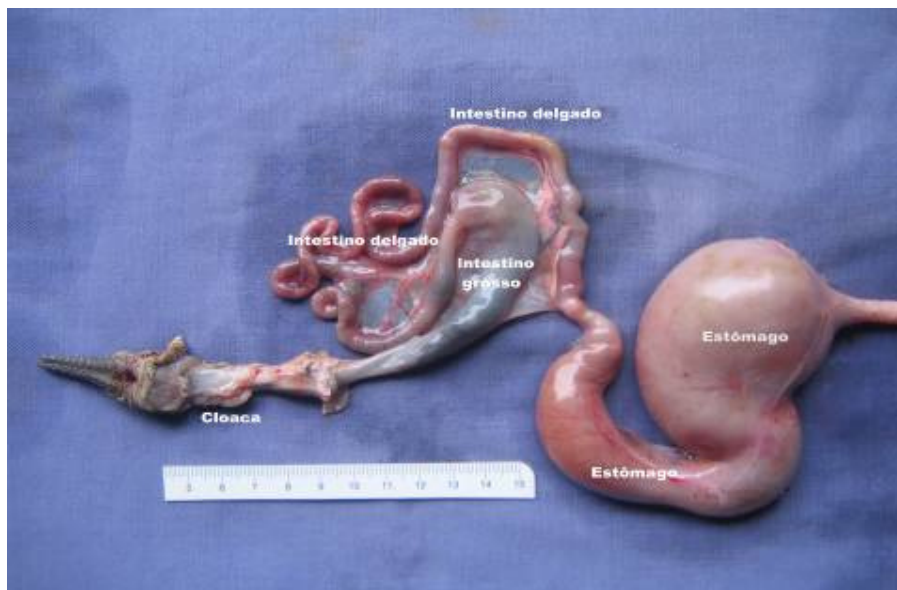


Figure 1 – Photograph of the gastrointestinal tract of *Podocnemis expansa*

SANTOS, A.L.Q. et al. Determination of gastrointestinal transit time in *Podocnemis expansa* Schweigger, 1812 (Amazon turtle) (Testudines: *Podocnemididae*). **PUBVET**, Londrina, V. 5, N. 12, Ed. 159, Art. 1073, 2011.

Filling up of the gastrointestinal tract of *P. expansa*. The proximal gastric segment of all the turtles was totally filled and their distal segment partially filled in 5 minutes (Fig. 2).



Figure 2 – Contrast radiograph of *P. expansa*, showing the stomach filled up 5 min after administration of the contrast fluid (arrow)

The duodenal segment of six animals was filled in 6 hours and that of the other four in 24 hours (Fig. 3).

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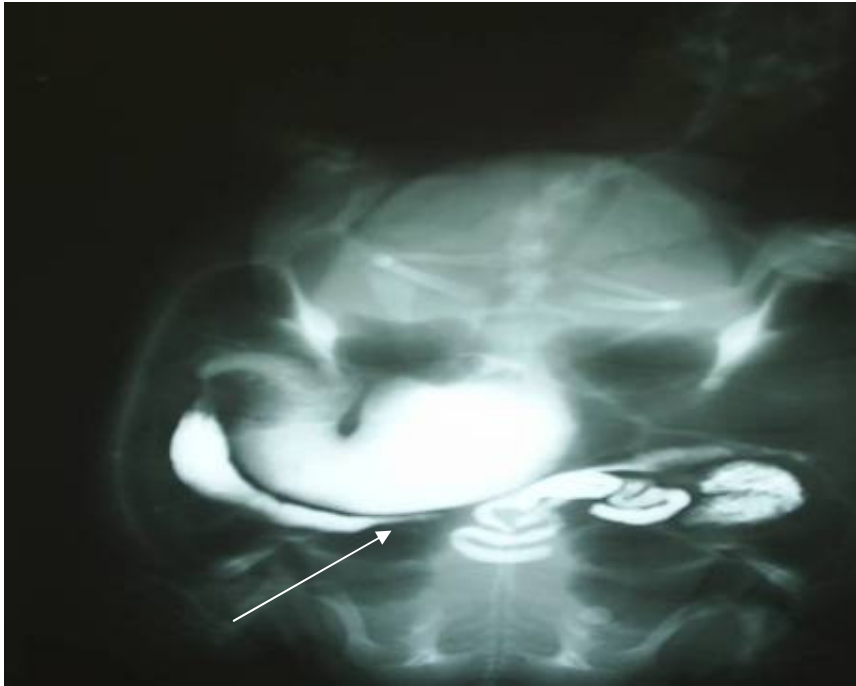


Figure 3 – Contrast radiograph of *P. expansa*, showing both the stomach and the duodenum completely filled up

The jejunum-ileum of all the turtles was filled with contrast fluid in 24 hours.

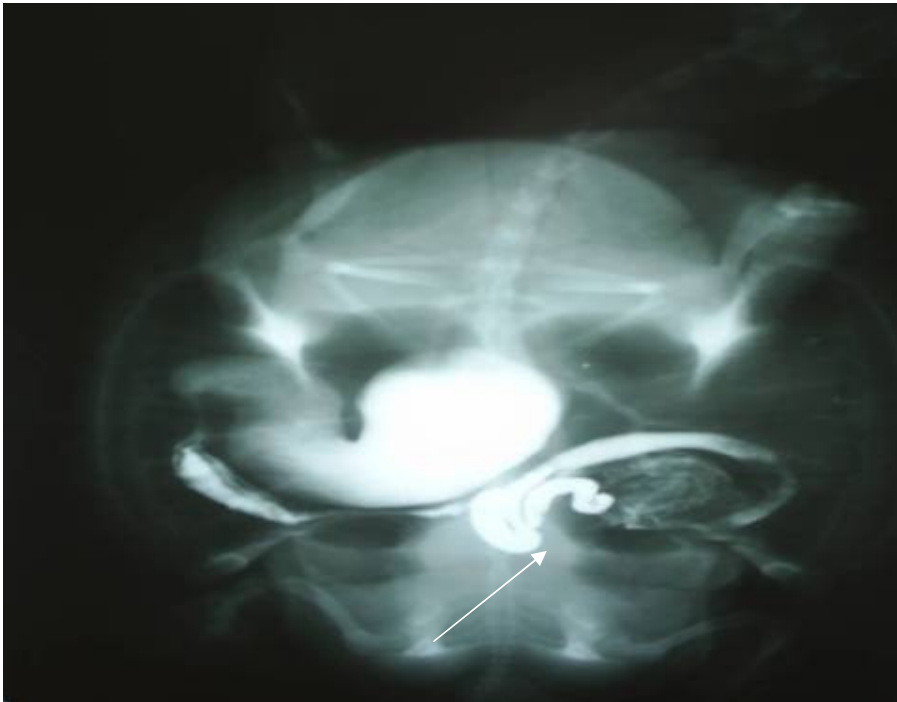


Figure 4 – Contrast radiograph of *P. expansa*, showing filled jejunum-ileum

SANTOS, A.L.Q. et al. Determination of gastrointestinal transit time in *Podocnemis expansa* Schweigger, 1812 (Amazon turtle) (Testudines: *Podocnemididae*). **PUBVET**, Londrina, V. 5, N. 12, Ed. 159, Art. 1073, 2011.

The cecum of two individuals was filled in 24 hours, four on the 2nd day, three on the 3rd day, and one on the 4th day.



Figure 5 – Contrast radiograph of *P. expansa*, showing filled cecum

Colon-rectum – After administration of the contrast fluid, the final segment of the digestive tract of two animals was filled in 24 hours, of four animals on the 2nd day, of three on the 4th day, and of one on the 5th day.

SANTOS, A.L.Q. et al. Determination of gastrointestinal transit time in *Podocnemis expansa* Schweigger, 1812 (Amazon turtle) (Testudines: *Podocnemididae*). **PUBVET**, Londrina, V. 5, N. 12, Ed. 159, Art. 1073, 2011.



Figure 6 – Contrast radiograph of *P. expansa*, showing filled colon-rectum

Table 1 – Lengths of time (hours or days) the digestive tract of the Amazon turtle took to fill up and empty (Uberlândia, MG, 2006)

FULL					
Individual	Stomach	Duodenum	Jejunum- ilium	Cecum	Colon- rectum
01	5 min	6h	24h	3 rd day	4 th day
02	5 min	6h	24h	3 rd day	5 th day
03	5 min	6h	24h	3 rd day	4 th day
04	5 min	6h	24h	2 nd day	2 nd day
05	5 min	24h	24h	2 nd day	2 nd day
06	5 min	6h	24h	2 nd day	2 nd day
07	5 min	24h	24h	4 th day	4 th day
08	5 min	24h	24h	2 nd day	2 nd day
09	5 min	24h	24h	24 h	24 h
10	5 min	6h	24h	24 h	24 h

SANTOS, A.L.Q. et al. Determination of gastrointestinal transit time in *Podocnemis expansa* Schweigger, 1812 (Amazon turtle) (Testudines: *Podocnemididae*). **PUBVET**, Londrina, V. 5, N. 12, Ed. 159, Art. 1073, 2011.

EMPTY					
Individual	Stomach	Duodenum	Jejunum- ilium	Cecum	Colon- rectum
01	9 th day	7 th day	7 th day	12 th day	15 th day
02	9 th day	9 th day	9 th day	12 th day	15 th day
03	9 th day	9 th day	9 th day	27 th day	28 th day
04	24 th day	9 th day	11 th day	26 th day	26 th day
05	5 th day	8 th day	8 th day	16 th day	16 th day
06	14 th day	13 th day	15 th day	28 th day	28 th day
07	15 th day	15 th day	16 th day	29 th day	29 th day
08	17 th day	17 th day	17 th day	27 th day	27 th day
09	9 th day	11 th day	15 th day	17 th day	17 th day
10	20 th day	9 th day	13 th day	24 th day	24 th day

h – hours, min – minutes

The use of radiographic exams proved efficient for diagnosis and therapeutic orientation, as demonstrated by Frye (1972) in the diagnosis of cystic calculi, by Rahal et al. (1998) and Helmick et al. (2000) in intestinal obstruction, by Innis e Boyer (2002) in reproductive diseases, and by Hyland (2002) in the surgical removal of a foreign body in the esophagus.

Studies conducted by Oliveira, Santos e Luz (1996) and by Santos, Beletti e Queiroz (1998) on *Podocnemis expansa* revealed that the stomach is flat-shaped, with a well-developed and curved pyloric region; the thin intestine is long and coiled, and the thick intestine begins with a dilation of the colon (cecum), which is very short. This information was confirmed in the X-ray images of the gastrointestinal tract of this species.

According to Luz et al. (2003b) and Pereira et al. (2004), the average lengths of the thin intestine and the thick intestine are 46.68 cm and 96.36 cm, 14 cm and 13.09 cm, respectively. However, albeit proportionally shorter, the thick intestine is able to retain the digestion for a sufficiently long time to

allow for ample microbial activity. In the present study, although the functional aspects of the digestion of *P. expansa* were not emphasized, the length of time the contrast remained in the thick intestine confirms the information of the above authors.

In reptiles (HILDEBRAND, 1995), the length of the intestine varies from one half to twice the length of the body, but tends to be longer in turtles. Zentek e Dennert (1997) stated that the characteristics of the digestive tract are adapted to the animal's feeding habits. These statements are in line with the findings of Luz et al. (2003b) and Pereira et al. (2004), and with the radiographic findings on *P. expansa*.

According to Silverman e Janssen (1996), reptiles and mammals have distinct dietetic habits. Reptiles have a long intestinal transit time (DI BELLO et al., 2006), although their gastrointestinal tract is short compared to that of mammals (BOYER e BOYER, 2005), a fact that was confirmed here for *P. expansa*, which showed an average transit time of 22.5 days.

For Spencer, Thompson e Hume (1998), because they are ectodermic, the digestion of chelonians is influenced by the ambient temperature, as Meyer (1998) reported for *Testudo hermanni*, adding that the dwell time of contrast in the gastrointestinal tract was relatively short and details of the intestinal mucosa could not be satisfactorily observed. Unlike *T. hermanni*, the transit time of contrast fluid in *P. expansa* was long, with the ambient temperature kept constant between 26°C and 28°C.

As for emptying of the stomach, some similarities were found between *P. expansa*, *Testudo graeca* (HOLT, 1978) and *Geochelone carbonaria* (SCHILBACH e MARIANA, 2000), although that was not the case in the transit time through the intestinal tract. With regard to this, Schilbach e Mariana (2000) reported that the intestinal tract was completely empty in 41 days, while that of *P. expansa* emptied in 29 days.

The total transit time in the gastrointestinal tract of *P. expansa*, 22.5 days (minimum of 15 and maximum of 29 days) was longer than in *Testudo pardalis* (TAYLOR et al., 1996) (7 days) and in *Testudo hermanni* (MEYER,

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1998) (2.6 hours) and shorter than in *Testudo graeca* (HOLT, 1978) (26.5 days) and in *Geochelone carbonaria* (SCHILBACH e MARIANA, 2000) (42 days).

The study of the gastrointestinal transit time by the radiographic method is widely applicable in the guidance of practical issues, be they clinical interventions or the formulation of specific diets.

Radiographic investigations of the thick intestine by the retrograde route could be done, as was noted by Di Bello et al. (2006), when a rapid diagnosis is needed.

In *P. expansa*, two segments of the digestive tract seem to play an important role in the gastrointestinal transit time, i.e., the stomach and the cecum, which in this study retained the contrast fluid for up to 24 and 29 days, respectively.

CONCLUSIONS

The following conclusions can be drawn from this study:

1 – The total time for elimination of the contrast was on average 22.5 days, with the minimum time 15 days and the maximum 29 days.

2 – It was possible to determine the entire radiographic sequence of the contrast in the gastrointestinal tract of these animals and to establish some parameters regarding the dwell time in each region of the digestive tube.

3 – The contrast fluid passes through the thin intestine more rapidly than through the thick intestine.

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