

Estimation of Gastrointestinal Transit Time in the West African Mud Turtle, *Pelusios castaneus* (Schwinger 1812) using Contrast Radiography

Folayemi Omotomilola Olayinka-Adefemi, Godwin Inalegwu Ogbole¹, Adenike Olatunji-Akioye

Department of Veterinary Surgery and Reproduction, Faculty of Veterinary Medicine, University of Ibadan, ¹Department of Radiology, College of Medicine, University of Ibadan, Ibadan, Nigeria

Abstract

Background: Gastrointestinal (GI) transit time is a useful diagnostic technique routinely done around the world in human medicine. In veterinary medicine, however, this has only been done in few species in developed nations. With veterinary science, still developing in many parts of Africa, this technique is not routinely done. Our aim was to determine GI transit (GIT) time in *Pelusios castaneus*, a small sized group of freshwater pleurodira turtles that inhabit the tropics of West Africa.

Materials and Methods: The study group comprised four males and four females with a mean weight of 0.81 ± 0.37 kg. Using a routine feeding technique, 10 ml of dilute barium sulfate suspension was administered orally and the GIT time of the contrast observed and monitored through radiography. The transit time was recorded in hours as it traveled through each section of the GIT. The time for complete contrast excretion was recorded for each turtle.

Results: The contrast mean transit time from the mouth through the esophagus to the stomach was 1.06 ± 0.20 h and the mean onset of gastroduodenal transit was 4.05 ± 0.09 h while mean intestinal transit time was 245.90 ± 53 h. The mean total contrast excretion time was 10.8 ± 2.4 days. The female excretion time was shorter than the males (males: 13.7 ± 3.33 days; females: 7.8 ± 3.27 days), but this was not statistically significant. Our findings were at variance with results obtained among freshwater turtle species that inhabit temperate climates.

Conclusion: These findings suggest an influence of turtles' natural habitat climatic conditions on their GIT time and possibly digestion.

Keywords: Contrast radiography, *Pelusios castaneus*, transit time

Address for correspondence: Dr. Folayemi Omotomilola Olayinka-Adefemi, Department of Veterinary Surgery and Reproduction, Faculty of Veterinary Medicine, University of Ibadan, Ibadan 200284, Nigeria. E-mail: folayemiadefemi@gmail.com

INTRODUCTION

The West African mud turtles (*Pelusios castaneus*) are a group of freshwater turtles belonging to the family Pelomedusidae.^[1] They are scattered around the river basins of Western and Middle African countries such as Nigeria, Ghana, Gabon, Mali, and Congo.^[2]

Unlike most turtle species listed by the International Union for the conservation of nature (IUCN) as endangered and extinct, *P. castaneus*, face no global threat of extinction.^[3] Recent reports, however, indicate some threats to this specie in their immediate environment. These include

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practices such as habitat disruption, slaughter during traditional cultural practices, inhumane capture and transport as well as trade in the wildlife market as pets.^[4,5] These factors pose a threat to the medical well-being of turtles and reptiles in general.

Although studies have been done on the digestive tract of fresh and Sea turtles in other parts of the world, report that gives insight into the digestive tract of *P. castaneus* is sparse.^[6,7] The aim of this study is to describe probably for the first time the radiographic pattern and contrast transit time in the digestive tract of this tropical West African turtles.

MATERIALS AND METHODS

Eight adult *P. castaneus* comprising four males and four females with mean body weight of 0.81 ± 0.37 kg were used in this study; however, the age of the turtles was not considered. Approval for the study was obtained from the Institutional Review Board and the Animal Care and Use Research Ethics Committee, University of Ibadan (Reference No. UI-ACUREC/App/2015/041). The turtles were acquired during the months April to July 2015 and kept in a simulated natural environment in the university laboratory and research unit. They were housed in box cages occasionally and allowed a daily swim in an artificial pond.

The turtles were manually restrained and the contrast barium sulfate (READI-CAT[®]) was administered through 10 ml syringe tubing orally at a concentration of 80% w/w, volume 7–10 ml/kg per os.

The digital X-ray equipment (Allegrs[®]) was used to create dorsoventral view images of the turtles using machine settings of 70 kV, 200 mA for 0.3 s. The images were recorded at 0, 15, and 30 min, and subsequently at 1, 2, 24, and every 36 h till total and complete contrast excretion for each turtle was achieved.

All quantitative results were analyzed for mean and standard error values as well as the p-values using the GraphPad[®] Prism (GraphPad Software, Inc. California, USA) statistical software pack.

RESULTS

Control

Preliminary images (gross images and dorsoventral plain radiographs) which served as the study control gross images of the turtle showed a hard carapace while the plain radiographs of the turtles displayed a radio-opaque bony structures and carapace surrounding a

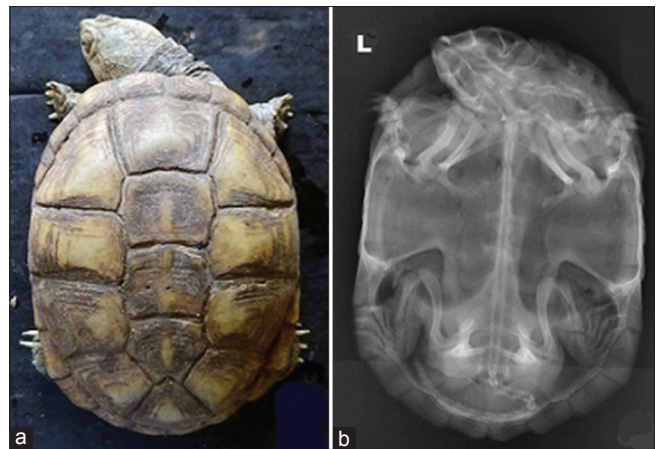


Figure 1: (a) Dorsal carapacial view of *Pelusios castaneus*. (b) Dorsoventral plain radiographic view of *P. castaneus* in which the coelomic cavity appear radiolucent, Bone and the Shell structures are radio-opaque



Figure 2: Radiograph depicting the radio-opaque contrast material within the esophagus on exiting the oral cavity



Figure 3: Contrast column within the oesophagus and stomach/gastric region at 2hrs post administration. The stomach is seen as pear shaped and located to the left

radiolucent coelomic cavity with indistinguishable visceral structures [Figure 1].

Contrast in the esophagus

At 0 min, the barium sulfate contrast is seen outlining the oral cavity before it progresses to the cranial first part of the esophagus. The average esophageal transit time was 1.06 ± 0.2 h [Figure 2]. In one of the turtles, the contrast was seen to have fully traversed the esophagus and moved into the stomach in an early as 30 min.

Gastroduodenal and intestinal contrast transit time

The mean time of onset for gastroduodenal transit for the eight turtles was 4.05 ± 0.90 h [Figure 3] while the mean intestinal contrast transit time was 245.90 ± 53.12 h. The contrast material can be seen outlining the pear shaped stomach and entire intestinal tract (S; Stomach, D; Duodenum, J; Jejunum, IL; Ileum, CR; Colon- Rectum as seen in Figure 4), signifying a very slow intestinal travel time in this species.

The mean total contrast excretion time was 10.8 ± 2.4 days, with a range of 2–21 days.

DISCUSSION

This study provided radiographic information useful in outlining the anatomy of the digestive tract of *P. castaneus*, which is essential in understanding the unique anatomy of their tract.



Figure 4: Dorsoventral radiographic X-ray view showing contrast outlining the entire Intestinal tract. S;Stomach, D;Duodenum, J; Jejunum, IL;Ileum, CR; Colon- Rectum

The associated radiographic anatomic details would allow elucidation and proper management of pathologies such as foreign body obstructions, intestinal ulcerations, and digestive tract lesions. Other field applications of the knowledge of the gastrointestinal (GI) transit time is in the development of efficient diet plans and feed formulations by pet nutritionist, conservation facilities, and turtle pet owners. The information from this study may help identify turtle feed formulation that may interrupt the physiologic transit time patterns and range.

In addition, the study revealed a sex variation in transit time, as male had a comparatively longer transit time compared to females. Although the difference appeared small and not statistically significant ($P < 0.05$ is considered statistically significant), it raises a concern which a larger study with an appropriate population sample size may help clarify [Table 1]. Nevertheless, this subtle gender difference may be as a result of hormonal or genetic factors, and the clinical relevance would be an interesting issue to investigate in future studies among this species.

Turtles have a unique rate of metabolism.^[8] As ectotherms, they rely predominately on heat from their environment for internal metabolic processes such as respiration and digestion.^[9] Like other reptiles, they have a decreased resting metabolism, which consequently cumulates in decreased energy requirements hence digestion is a much slower process in them when compared with other classes of animals.^[10]

Diagnostic imaging of the digestive tract of reptiles has been documented in some reptiles such as the ball python, *Python regius* and the green iguana, *Iguana iguana*.^[11,12] In chelonians, GI studies to show the transit time of contrast was reported in the spur-thighed tortoise, *Testudo graeca*, the Hermann's tortoise, *Testudo hermanni*, the loggerhead sea turtle, *Caretta caretta*, and in the South American freshwater turtle, *Podocnemis unifilis*.^[13-16]

The findings from this study showed that transit time in the *P. castaneus* was slow with the longest transit time recorded during intestinal travel. This agrees with observations of Di Bello (2006) in his study “*Contrast radiography of the gastrointestinal tract of sea turtles*” and Banzato’s (2013) “*Review*

Table 1: Summary of transit and excretion time of barium sulphate in Pelusios castaneus, in males and females

Sex	Weight	Esophageal transit time (h)	Onset of gastroduodenal transit (h)	Intestinal transit time (h)	Total contrast excretion time (h)
Male	0.62 ± 0.16	0.92 ± 0.14	5.67 ± 1.5	313.3 ± 64.49	13.7 ± 3.33
Female	1.00 ± 0.44	0.75 ± 0.25	3.33 ± 0.58	178.5 ± 73.84	7.8 ± 3.27
<i>P</i>		0.18	0.47	0.22	0.18

$P < 0.05$ is considered statistically significant (*P* signifies the *P*-value)

Table 2: Summary of transit and excretion time in *Pelusios castaneus*

Parameter	Time (h)
Esophageal transit time	1.06±0.20
Onset of gastroduodenal transit	4.05±0.90
Intestinal transit time	245.90±53.12
Total contrast excretion time	10.8±2.4*

*Total contrast excretion time in days. Statistical values were calculated using the GraphPad® Prism statistical software pack

of diagnostic imaging of Snakes and Lizards” that intestinal transit time is longer in chelonians and reptiles respectively.

The total contrast emptying time in the turtles used in this study was 10.8 ± 2.4 days [Table 2]. This greatly differed from similar studies on sea turtles and freshwater turtles. The total transit time in the yellow spotted Amazon river turtle, *P. unifilis* was on average 17.6 days, the loggerhead sea turtle *C. caretta*; 20.2 days, *Podocnemis expansa*; 22.5 days, *T. graeca*; 26.5 days and *Geochelone carbonaria*; 42 days.^[17-19] The above figures indicate that although the transit time in the *P. castaneus* was long as expected in any reptile (when compared with mammals), its transit time is shorter when compared with other reported chelonians.

A study by Spencer (1998) may best explain the findings of this study. In his study on the “*The diet and digestive energetics of the Australian short-necked turtle, Emydura macquarii*” he concluded that environmental temperature influenced digestion in *Testudines*.^[20] The geographical location of the *P. castaneus* is the muddy waters of countries like Nigeria, Mali, Ghana, Gabon located in Western and Middle Africa (latitude 4°N and 28°N, longitude 15° E and 16°W) where the climate is classified as hot or tropical.^[21] These regions have been characterized as having a uniformly high temperature (as high as 35°C) and sunshine throughout the year.^[22] The increased temperatures in these regions is thought to hasten the metabolism processes in the *P. castaneus*. Previous studies that have been done were in chelonians in Europe and South America (the Greek tortoise, the loggerhead sea turtles, yellow spotted Amazon river turtle) where temperate climate temperatures can go as low as -10°C . Therefore, it is extrapolated from this study that Tropical climate of the natural habitat of the *P. castaneus* is most likely responsible for the shorter contrast excretion time that was observed.

Another study that may additionally explain these findings is the relationship between metabolic rates and body size as described by Martinez (2010). This study reported that metabolic rate increases with decreased body size in endotherms especially in birds and this was similar in Reptiles.^[23] The results of this study may corroborate this finding as the *P. castaneus* is small sized, 7–12 inches than

previously studied turtles.^[24] The freshwater turtle *P. unifilis* has a size range of 14–27 inches and *C. caretta* can reach a size of about 35 inches when fully grown. Therefore, turtle size may also explain this difference in contrast excretion time.

Age factor was not considered as a parameter in this study as the aging of reptiles generally and turtles specifically, remain an aspect of modern science still been explored. While *P. castaneus* have been documented to achieve a maximum longevity of about 41 years in the wild, techniques such as the use of growth rings or skeletochronology used in age estimation of turtles have been described as unreliable and almost impossible to accurately perform.^[25]

CONCLUSION

The results of this study create a baseline radiological database for the *P. castaneus* which has not been documented before this study. This creates a radiological reference for clinicians and a scientific reference for conservationists, educationist, and Herpetologists. A scientific bank that will be useful for research comparisons and whose information can be extrapolated for other turtles, giving a better understanding of *Testudines*, as a scientific group.

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Conflicts of interest

There are no conflicts of interest.

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