Comp. Biochem. Physiol., Vol. 63A, pp. 509 to 510
© Pergamon Press Ltd 1979. Printed in Great Britain

0300-9629/79/0801-0509$02.00/0

URINE CONCENTRATIONS OF AMMONIA, UREA AND URIC ACID IN THE GREEN TURTLE, *CHELONIA MYDAS*

KAREN A. BJORNDAL
Department of Zoology, University of Florida, Gainesville, FL, U.S.A.

(*Received* 9 *October* 1978)

Abstract—1. Concentrations of ammonia-nitrogen, urea-nitrogen and uric acid-nitrogen are given for urine samples collected from four green turtles caught on their feeding grounds in the Miskito Cays, Nicaragua.

2. Of the three components measured, urea is present in the highest concentrations and ammonia in the lowest.

3. The pH of the urine varies from 5.5 to 8.9. Both pale-yellow and dark-green urine were observed.

INTRODUCTION

The nitrogenous waste products in the urine of the green turtle, *Chelonia mydas*, have been poorly studied. Khalil (1947) reported that the major excretory product of the green turtle was ammonia; uric acid was found in small quantities; and urea was absent in three of the four turtles that he sampled. These results are puzzling for several reasons. First, in Dantzler's (1976) thorough review of reptilian nitrogen excretion, there is no reference to any turtle that excretes as much of its total nitrogen in the form of ammonia-nitrogen as Khalil (1947) reported for the green turtle (43%). Dantzler (1976) also reports that freshwater turtles excrete urea in concentrations nearly equal to or greater than those of ammonia. Since sea turtles are believed to have evolved from freshwater forms (Gaffney, 1975), and since there is no obvious selective advantage for turtles to become ammoniotelic in the marine environment, Khalil's findings (1947) are indeed curious.

Second, it is well known that green turtles can live up to 2 months out of water if turned on their backs and kept in the shade (Carr, 1954). It was this characteristic that made the green turtle a very valuable source of fresh meat for the early explorers of the Caribbean and other regions. If ammonia were its major excretory product, the green turtle would soon succumb under these storage conditions from dehydration and/or auto-toxicity.

During August 1978, I had the opportunity to gather additional data on the nitrogenous waste products of the green turtle during an R/V *Alpha Helix* cruise to the Miskito Cays, Nicaragua, the major feeding grounds of the green turtle in the Caribbean.

MATERIALS AND METHODS

Four sub-adult green turtles ranging in size from 50 to 68 kg (three females and one male) were purchased from Nicaraguan turtlers in the Miskito Cays. Urine samples were collected as they were spontaneously excreted, and ammonia, urea and uric acid analyses were conducted within 15 min of collection. Urine samples were collected from the day the turtles were taken out of the water until 3 days later. During that period, the turtles were kept on their backs and regularly rinsed with sea water, but did not drink. All turtles continued to urinate during this period. Ammonia, urea and uric acid were analyzed with Mannheim Boehringer kits (No. 125857, 166421 and 124737, respectively; BMC, 9115 Hague Road, Indianapolis, IN 46250, U.S.A.). Analyses were run in duplicate with less than 2% variation between replicates.

RESULTS AND DISCUSSION

The amounts of ammonia-nitrogen, urea-nitrogen and uric acid-nitrogen found in six samples of urine collected from four turtles are shown in Table 1. Although there is considerable variation among the samples, and even in those from individual turtles, ammonia concentrations clearly are minor compared with urea and uric acid. Thus the results presented here do not agree well with those of Khalil (1947),

Table 1. Concentrations of ammonia-nitrogen, urea-nitrogen and uric acid-nitrogen in six urine samples from four green turtles, expressed in mg/dl

Turtle number	Sex	pH	Color	Days out of water	Ammonia-N (mg/dl)	Urea-N (mg/dl)	Uric acid-N (mg/dl)
1	♀	8.6	Green	<1	0.19	36.08	44.50
1	♀	8.9	Green	1.5	0.18	39.77	12.56
2	♀	8.8	Green	3	2.74	41.82	20.06
3	♀	8.9	Green	2	1.49	110.29	12.42
4	♂	6.0	Yellow	2	3.49	87.33	16.11
4	♂	5.5	Yellow	3	3.43	137.35	17.20

but do agree with what is known of the excretory products of other turtles (see Dantzler, 1976) and with the osmoregulatory demands of the green turtle's marine habitat.

The results reported here are based on samples collected externally, while Khalil's (1947) work was based on urine collected from the bladders of turtles shortly after their death. Therefore, our results are not directly comparable. However, Khalil (1947) refers to work done by Lewis (1918) on urine samples from the bladders of green turtles. In his paper, Lewis (1918) does not identify his study animal as to species, or even to habitat, but only states his work was done on "turtles". Assuming that Khalil (1947) had good reason to assign Lewis' work to *Chelonia mydas*, we can consider Lewis' results here. His data on samples from the bladders of two turtles also conflict with Khalil's (1947) and support mine in that urea was the major component in the urine. However, uric acid and ammonia were found in nearly equal concentrations; the ammonia concentrations were higher and the uric acid concentrations were lower than those values reported here.

There is no clear correlation between the concentration of urine components and the length of time the turtles were out of water. Other studies dealing with urine samples from turtle bladders have shown an increase in uric acid production with dehydration (Dantzler, 1976). However, spontaneously excreted urine samples cannot be used to measure increases in uric acid production with dehydration because the uric acid crystals can be held for long periods of time in the bladder, and thus would not be detected in excreted urine.

An unexpected aspect of my observations is the variation in the color and pH of the urine. The turtles that we had on board the *Alpha Helix* (approx 10 animals) excreted either dark-green, clear urine or pale-yellow, clear urine. There was no correlation between the color of the urine and the sex or size of the turtle, or the length of time it had been out of water. The data in Table 1 suggest a correlation between color and pH, but the sample size is too small to draw definite conclusions. Khalil (1947) also reported variation in the pH of the urine from his four turtles: 4.4, 4.4, 4.5 and 8.5. Unfortunately, he did not record the color of the urine. Although most of our turtles excreted green urine, green urine is not the norm throughout the green turtle's range. During my 18 months' work with green turtles on their feeding grounds in the southern Bahamas, I observed urine from many turtles, and it was always pale-yellow. The color of the urine may be due to diet, but it is unlikely that it results from a major dietary difference. The turtles in the southern Bahamas fed almost entirely on the seagrass *Thalassia testudinum*. A dead turtle that I observed during the *Alpha Helix* trip had green urine in its bladder and had *T. testudinum* throughout the length of its gut. Also, green turtles in the Miskito Cays region are quite consistent in their diets (Mortimer, 1976).

In summary, urea is the major nitrogenous waste product excreted by the green turtle, with uric acid second in importance and ammonia occurring in only minor concentrations. As is common in other reptiles, the nitrogenous products produced by the kidneys and stored in the bladder may have different relative concentrations as compared with excreted urine, because of selective reabsorption in the ureters and bladder. Also of interest is the wide pH range and color variation of the urine.

Acknowledgements—I would like to thank Alan Bolten, Archie Carr and Frank Nordlie for reading this manuscript. I would also like to thank the crew of the R/V *Alpha Helix* for their assistance and the scientific party, especially chief scientist Henry Prange, for their cooperation. This study was supported by the Inagua Project of the Caribbean Conservation Corporation and NSF grant number PCM 77-24919 for the R/V *Alpha Helix* Caribbean/Green Turtle Expedition, August–September 1978.

REFERENCES

CARR A. F. (1954) The passing of the fleet. *A.I.B.S. Bull.* **4**, 17–19.

DANTZLER W. H. (1976) Renal function (with special emphasis on nitrogen excretion). In *Biology of the Reptilia*, Vol. 5A (Edited by GANS C. & DAWSON W. R.). Academic Press, New York.

GAFFNEY E. S. (1975) A phylogeny and classification of the higher categories of turtles. *Bull. Am. Mus. nat. Hist.* **155**(5), 389–436.

KHALIL F. (1947) Excretion in reptiles—1. Non-protein nitrogen constituents of the urine of the sea turtle, *Chelonia mydas* (L.) *J. biol. Chem.* **171**, 611–616.

LEWIS H. B. (1918) Some analyses of the urine of reptiles. *Science* **48**, 376.

MORTIMER J. A. (1976) Observations on the feeding ecology of the green turtle, *Chelonia mydas*, in the Western Caribbean. Masters Thesis, University of Florida.