NITROGENOUS EXCRETION IN CROCODILES

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INTRODUCTION

Animals in general are known to fall into three main groups, ammonoteles, ureoteles or uricoteles according to whether ammonia, urea or uric acid is the main nitrogenous excretory metabolite in the urine. Among reptiles, Lacertilia and Ophidia are known to be uricoteles, chelonian tortoises were found to be ureo-uricoteles (Khalil & Haggag, 1955). Crocodilia—represented by alligators, crocodiles and gavials—is the least-studied reptilian order in respect of its nitrogenous excretion. The data available in the literature are those of Lewis (1918), Hopping (1923) and Coulson, Hernandez & Brazda (1950) on the analysis of urinary excreta of *Alligator mississippiensis*. These authors claim that alligators are ammonoteles. The only work on crocodiles, as the present authors can ascertain, was done by Moore as early as 1851 on *Crocodylus vulgaris* (Winterstein, 1924), but the urine sample he examined was not fresh, since it was taken from an animal 36 hr. after death and was analysed 30 days later, by which time it had a very bad smell. Moore stated that the urine contained a white precipitate of ammonium urate and that urea was absent.

The present work was undertaken on *C. niloticus* to extend knowledge on nitrogenous excretion in Crocodilia.

MATERIAL AND METHODS

Crocodylus niloticus (*Laurenti*) is an amphibious reptile living on the banks of the Nile in the Sudan. It is a very savage carnivore and great difficulties were encountered in transporting it by plane from Khartoum to Cairo; for this reason only three animals were investigated in the present work.

These animals were observed to give their nitrogenous excreta partly as liquid urine and partly as amorphous white thread-like deposits, and so both portions were analysed. Procedures for collection and analysis of both urinary portions are similar to those used by the present authors in tortoises (Khalil & Haggag, 1955).

RESULTS AND DISCUSSION

One urine sample was analysed from animals 1 and 3, and five successive urine samples were analysed from animal 2 (Table 1). Three urinary deposits were analysed from the three animals, that of animal 2 is formed of five successive samples added together (Table 2).

Table 1. *Non-protein nitrogen constituents of urine of* Crocodylus niloticus

Constituents	Nitrogen in 100 ml. urine (mg.)								
	Animal (1, ♂)	Animal (2, ♂)						Animal (3, ♂)	Average
		Five successive samples					Average		
Total N	344·00	222·70	243·60	220·70	250·00	246·20	236·64	314·90	298·50
Ammonia N	228·70	125·30	165·60	130·90	156·30	192·80	154·20	217·50	200·10
Urea N	65·61	53·53	45·24	40·11	23·66	34·26	39·35	5·22	36·74
Uric acid N	7·40	6·00	0·28	0·58	4·56	2·43	2·77	10·93	7·03
Undetermined N	42·29	37·87	32·48	49·11	65·48	16·71	40·32	81·25	54·63
	N-partition, % of total N excreted								
Total N	100	100	100	100	100	100	100	100	100
Ammonia N	66·48	56·24	67·98	59·29	62·52	78·30	64·86	69·08	66·81
Urea N	19·07	24·03	18·57	18·18	9·46	13·92	16·83	1·66	12·52
Uric acid N	2·15	2·69	0·11	0·26	1·80	0·99	1·17	3·47	2·26
Undetermined N	12·30	17·04	13·34	22·27	26·22	6·79	17·14	25·79	18·41

Table 2. *Analysis of urinary deposits of* Crocodylus niloticus (*in 1 g. deposit*)

Animal no. ...	1		2		3		Average	
Components ...	As N	As % to T.N.	as N	As % to T.N.	As N	As % to T.N.	As N	As % to T.N.
Total N (T.N.)	354·20	100	250·20	100	290·90	100	298·40	100
Water soluble N	96·65	27·29	95·02	37·97	108·90	37·44	100·19	34·23
Ammonia N	17·15	4·95	17·90	7·9	17·16	5·90	17·40	5·98
Urea N	0	0	0	0	0	0	0	0
Uric acid N	80·02	22·59	70·22	28·06	88·94	30·58	77·72	27·08
Water insoluble N	257·55	72·71	155·50	62·03	182·00	62·66	198·21	65·77
Uric acid N	211·00	59·61	156·10	62·40	182·00	62·58	183·06	61·53

The samples of liquid urine ranged from 3 to 10 ml. in volume. Each sample was accompanied by an amount of urinary deposit ranging from about 0·1 to 0·3 g. There was no apparent relation between the volume of urine and the weight of deposit associated with it. The pH of the liquid urine was from 7·5 to 8·5 in the samples examined.

The average value of the total nitrogen of the liquid urine in the three animals examined was 298·5 mg./100 ml. Of this value 66·81% was as ammonia, 12·52% as urea and 2·26% as uric acid.

On the other hand, it is clear from table 2 that uric acid nitrogen represents the main nitrogenous component as it formed 88·61% of the total nitrogen of the deposit. The water soluble portion of the deposit consists of ammonia and uric acid in the proportion required for the formation of acid ammonium urate.

If one considers the results in Table 1, without taking into consideration the data of the deposits in Table 2, it would certainly appear that *C. niloticus* is a typical ammonotele excreting ammonia as the main nitrogenous excretory metabolite, this substance forming 66·81% of the excretory nitrogen of the liquid urine, while urea and uric acid formed only 12·52 and 2·26%, respectively. In this respect,

Table 3. *Approximate calculation of the total excretory nitrogen (in the liquid urine + deposit) of* Crocodylus niloticus

Animal no.	Approx. vol. of urine (ml.)	Approx. wt. of deposit (g.)	Nitrogenous constituents for each collection						
			Total N.			Ammonia N			
			Liquid (mg.)	Deposit (mg.)	Total (mg.)	Liquid (mg.)	Deposit (mg.)	Total	
								In mg.	As % of T.N.
1	3·5	0·2	12·0	70·8	82·8	8·0	3·4	11·4	13·8
2*	3·2	0·1	7·1	25·0	32·1	4·0	1·8	5·8	18·1
	10·0	0·1	24·4	25·0	49·4	16·6	1·8	18·4	37·2
	10·5	0·3	23·2	75·1	98·3	13·7	5·4	19·1	19·4
3	10·0	0·1	31·5	29·1	60·6	21·7	1·7	23·4	38·6
Av. % to T.N.			—	—	—	—	—	—	25·4

Animal no.	Approx. vol. of urine (ml.)	Approx. wt. of deposit (g.)	Nitrogenous constituents for each collection							
			Urea N				Uric acid N			
			Liquid (mg.)	Deposit (mg.)	Total		Liquid (mg.)	Deposit (mg.)	Total	
					In mg.	As % of T.N.			In mg.	As % of T.N.
1	3·5	0·2	2·3	0	2·3	2·8	0·3	58·2	58·5	70·7
2*	3·2	0·1	1·7	0	1·7	5·3	0·2	22·6	22·8	71·0
	10·0	0·1	4·5	0	4·5	9·1	Trace	22·6	22·6	45·7
	10·5	0·3	4·2	0	4·2	4·3	0·1	67·9	68·0	69·2
3	10·0	0·1	0·5	0	0·5	0·8	1·1	27·1	28·2	85·9
Av. % to T.N.			—	—	—	4·5	—	—	—	68·5

* Only the first three of the five successive samples were taken into account, as we are not certain of the weight of deposit in the other two.

C. niloticus would be similar to its cousin, *Alligator mississippiensis* which according to Hopping (1923) excretes 75·5% of its excretory nitrogen in the liquid urine as ammonia, while urea and uric acid represent only 4·1 and 11·4 %, respectively. Coulson *et al.* (1950) came to a similar conclusion since they found that the liquid urine of alligators contains 79·1 and 3·7% of the total nitrogen as ammonia and uric acid, respectively, with traces of urea.

Since it was not possible to make accurate quantitative collections of both liquid urine and solid deposit, the distribution of nitrogen in the whole urine (liquid + solid) can only be given approximately. From Table 3 it can be seen that for the whole urine the figures are: ammonia, 25·4%; urea, 4·5%; uric acid, 68·5%. The present authors therefore suggest that crocodiles should be regarded as *ammono-uricoteles*, since they excrete ammonia as the main nitrogenous end metabolite of the liquid urine, together with uric acid in the form of a white urinary deposit. Hopping (1923) and Coulson *et al.* (1950) in their studies on alligators made no mention of these deposits. Notwithstanding this, the present authors, from their

previous experience with reptiles, assume that uric acid deposits are very probably present in alligators, since such deposits have been detected in many representatives of all reptilian orders. These deposits were detected in the order Chelonia represented by turtles (Khalil, 1947) and tortoises (Khalil & Haggag, 1955), in the order Lacertilia (Khalil, 1951 and Haggag, 1954) and in the order Ophidia (Khalil, 1948*a*, *b*). However, previous authors working on alligators may have overlooked the presence of such deposits which are usually found mixed with faeces, as alligators have no urinary bladders and no separate urinary apertures. If such an assumption is correct, alligators will be *ammono-uricoteles* like crocodiles and not ammonoteles as they have been considered until now according to the studies of Hopping (1923) and Coulson *et al.* (1950).

SUMMARY

1. In *Crocodylus niloticus* the liquid urine contains a white deposit. In the present study both the liquid and the deposit have been analysed.

2. For the liquid urine, the following values for percentage of total nitrogen have been found: ammonia, 66·8%; urea, 12·5%; uric acid, 2·3%.

3. For the deposit the corresponding figures are: ammonia, 6·0%; uric acid, 88·6%; urea absent.

4. From the relative proportions of liquid urine and deposit it is calculated that the total excretory nitrogen (liquid + solid) is distributed as follows: ammonia, 25·4%; urea, 4·5%; uric acid, 68·5%.

5. Crocodiles are thus ammono-uricotelic. The view that alligators are ammonotelic derives from analysis of liquid urine only. Uric acid deposits have been noted in the urine of reptiles of many orders and it is probable that they occur also in the urine of alligators.

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