Hamadryad Vol. 31, No. 2, pp. 258 – 264, 2007.

DIET RECORDS FOR THE DWARF CROCODILE, *OSTEOLAEMUS TETRASPIS TETRASPIS* IN RABI OIL FIELDS AND LOANGO NATIONAL PARK, SOUTHWESTERN GABON

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ABSTRACT.– **The objective of this study was to investigate the diets of *Osteolaemus tetraspis tetraspis* from two biotopes in south–western Gabon: inland lowland rainforest (14 samples) and mangrove forest (eight samples). Stomach contents included vegetation (including leaves, fruits, etc.) and animal matter (Gasteropoda, Arachnida, Diplopoda, Insecta, Crustacea, Osteichthyes, Amphibia, Reptilia, Mammalia), and confirm a varied, partly terrestrial, diet. Gastroliths numbered from 0 to 42, and their wet mass did not exceed 0.33% of the crocodile mass, and seem too low to serve a hydrostatic function. Maximal total length observed was 1.8 m.**

KEY WORDS.– **Reptilia, *Osteolaemus tetraspis tetraspis*, diet, gastrolith, Rabi oil fields, Loango National Park, Ogooué-Maritime, Gabon.**

INTRODUCTION

Osteolaemus tetraspis tetraspis Cope, 1861 was described from Gabon where the species is still common and widely distributed. Hunting of *Osteolaemus t. tetraspis* for food consumption has been reported from several provinces of Gabon: Estuaire, Ngounié, Nyanga, Ogooué-Lolo and Woleu-Ntem (Blaney et al., 1997; Gossmann et al., 2002; Pauwels et al., 2002a–c). In Gabon, these crocodiles are hunted mainly at night, through detection by their eye reflection with torch light, and then killed by machete or gun. They are also caught on land in snare traps (as illustrated by Maran, 2002) installed near streams, or entrapped by fishing nets. Specimens are often exported in numbers from remote villages to larger cities in the bush meat trade. The species can regularly be found in the Lambaréné, Libreville, Makokou, Oyem and Port Gentil markets (Gramentz, 1999; Lahm, 1993; Steel, 1994), and may also be kept as a pet (Pauwels et al., 2002a). Despite evidence of intensive human predation on *Osteolaemus* and hence its obvious economic importance in Gabon, little or no data on its biology in this country exists. During a three week expedition to southwestern Gabon, we had the opportunity to collect data on its diet, as well as other ecological observations.

MATERIALS AND METHODS

The stomach contents of 22 subadult and adult specimens were analyzed from two localities: Rabi oil fields (freshwater swamps in inland dense lowland rainforest), and Loango National Park (mangrove/brackish water). Both are in the Gamba Complex of Protected Areas, Ogooué-Maritime Province, southwestern Gabon (Alonso et al., 2006). The survey took place in the second half of June (Rabi) and the first week of July 2003 (Loango), i.e., at the beginning of the dry season. Data on the environment and herpetological communities of these localities were presented by Pauwels et al. (2004, 2006a–b). All crocodiles were captured by the authors by hand at night, using lights to detect their eye-shine. Upon capture, each individual was measured to the nearest cm for total length (TL) and snout-vent length (SVL), sexed, and body mass recorded to the nearest 0.1 g. Within three hours following capture, the stomach of each crocodile was flushed, using the hose-Heimlich method to remove all stomach contents. The hose-Heimlich method involves inserting a hose carefully down the esophagus and into the crocodile's stomach. An electric water pump is used to gently fill the crocodile stomach with water. With the hose still in place and running, a person beside the specimen vigorously squeezes its belly up towards its spine and forward in a motion analogous to the Heimlich maneuver. A mixture of stomach contents and water is expelled, thus emptying the stomach. This procedure was repeated several times until only water free of stomach contents was obtained. Our *Osteolaemus* stomach flushing was illustrated in a National Geographic movie (Anonymous, 2003a). Following stomach flushing, crocodiles were released at their exact capture site unharmed. Recovered stomach contents were preserved in 70% ethanol, sorted, counted, and identified to the lowest possible taxonomic class with the help of a light microscope. Insects were identified using keys in Delvare and Aberlenc (1989). The maximal diameters of gastroliths were measured with a dial-caliper (precision 0.1 mm).

RESULTS

Detailed stomach contents for the 14 Rabi and the eight Loango *Osteolaemus* are presented in Tables 1–2 and 3–4, respectively.

DISCUSSION

Tests have shown that the hose-Heimlich method is 100% effective in removing all food contents from the stomach (Fitzgerald, 1989; Barr,

Table 1. Stomach contents of 14 *Osteolaemus t. tetraspis* from Rabi oil fields (inland lowland forest), south-western Gabon. A = animal preys; P = parasite; V = vegetable matter; G = gastroliths. Rabi gastroliths are detailed in Table 2.

Crocodile #	SVL + Tail L (cm)	Sex	Stomach contents
1	72 + >31	M	A: millipede trunk segments (Julidae); 3 claws of juvenile *Varanus ornatus* (Varanidae); V: 1 small fern leaf (Pteridophyta); 3 pieces of unident. leaves and a 5 cm stick; 1 fruit, prob. *Sacoglottis gabonensis* (Humiriaceae); P: 1 2 cm nematod worm
2	63 + 51	F	A: partly digested shrew (Soricidae)
3	48 + 42	M	A: remains of 1 frog leg bones; G
4	42 + 36	M	A: millipede trunk segments (Julidae); 1 pair of Coleoptera elytra
5	56 + 44	M	A: whole millipede, diameter 1.3 cm (Julidae); 1 whole Coleoptera Dytiscidae, TL 3.5 cm; 1 head of unident. aquatic Coleoptera; G
6	49 + 45	F	A: remains of 1 Julidae; remains of 1 Dytiscidae; G
7	38 + 35	F	A: 4 aquatic snails opercula + remains of 1 snail shell; 1 Dictyoptera Blattellidae; 1 Hydrophilidae, TL 14.5 mm; remains of 1 Dytiscidae; 1 unident. Coleoptera; 1 Formicidae, TL 1.8 mm; remains of 1 unident. insect; remains of 2 small crabs; remains of 1 fish, TL ca 30 mm
8	41 + 37	M	A: remains of 1 aquatic Coleoptera; 1 small crab; V: two 8 mm sticks; G
9	32 + 28	M	A: 1 Ensifera Tettigoniidae; 1 Carabidae, TL 11 mm; 3 pairs of Dytiscidae elytra; 4 pairs of Coleoptera elytra; G
10	66 + >45	F	A: remains of 1 shrimp; elytra of 1 Coleoptera; remains of 4 unident. fishes; remains of 1 Clarias sp. (Clariidae); V: small wood pieces
11	38 + 37	F	A: remains of 1 Julidae; 1 whole caterpillar (Lepidoptera); remains of 1 crab; G
12	36 + 33	M	A: remains of 3 aquatic Coleoptera; part of 1 fish backbone; V: 32 cm long stem; G
13	42 + 42	F	A: remains of 1 Julidae; 1 Araneae; 1 Orthoptera; 1 Orthoptera Tettigoniidae; remains of 1 Lepidoptera; 2 Dytiscidae, LT ca. 2 cm; remains of 2 Dytiscidae, LT > 3 cm; part of 1 fish backbone; remains of 1 frog; P: two 2 cm nematod worms; V: unident. vegetal remains; G
14	78 + 63	M	A: 2 whole Julidae; G

Table 2. Description of the gastroliths sets found in Rabi oil fields *Osteolaemus t. tetraspis* stomachs, south-western Gabon. Ø = diameter.

Crocodile #	Crocodile mass (g)	# gastroliths	Nature of gastroliths	Max. Ø of smallest gastrolith (mm)	Max. Ø of largest gastrolith (mm)	Total wet mass of gastroliths (g)
1	10800	0	/	/	/	0
2	5130	0	/	/	/	0
3	2570	3	Limonite (1) + quartz (2, incl. smallest)	5.6	8.5	0.6
4	1260	0	/	/	/	0
5	3290	8	Limonite	7.8	21.4	2.9
6	3650	15	Limonite	5.4	19.1	11.1
7	1220	0	/	/	/	0
8	1440	5	Limonite	6.0	9.2	0.9
9	500	3	Limonite	6.4	10.3	0.6
10	4190	0	/	/	/	0
11	1080	11	Limonite	4.9	12.3	2.9
12	1030	7	Quartz (1, smallest) + limonite (6)	4.8	13.2	2.5
13	1760	1	Limonite	/	10.5	0.6
14	11700	20	Limonite	6.6	24.7	17.9

Table 3. Stomach contents of eight *Osteolaemus t. tetraspis* from Loango National Park (mangrove), south-western Gabon. A = animal preys; V = vegetal matter; G = gastroliths. Loango gastroliths are detailed in Table 4.

Crocodile #	SVL + Tail L (cm)	Sex	Stomach contents
1	93 + > 60	M	A: 1 whole crab, thorax maximal width 29.1 mm; 1 fish scale; V: 23 wood debris of various sizes, incl. 1 stick of 48 mm long and 7.6 mm diameter; G
2	80 + 66	M	A: remains of 1 crab; remains of 1 insect; V: unident. vegetal matter
3	49 + 43	M	Empty
4	40 + 32	M	A: remains of 1 small crab; G
5	45 + 43	F	G
6	58 + 49	F	G
7	78 + 59	M	A: remains of 2 crabs; remains of 2 shrimps; G
8	98 + > 72	M	A: remains of 1 crab carapace; V: remains of 2 fruits

Table 4. Description of the gastroliths sets found in Loango National Park *Osteolaemus t. tetraspis* stomachs, south-western Gabon. Ø = diameter.

Crocodile #	Crocodile mass (g)	# gastroliths	Nature of gastroliths	Max. Ø of smallest gastrolith (mm)	Max. Ø of largest gastrolith (mm)	Total wet mass of gastroliths (g)
1	18450	2	Quartz	5.6	7.6	0.2
2	11250	0	/	/	/	0
3	2610	0	/	/	/	0
4	11300	14	Quartz	4.8	16.2	3.1
5	2030	8	Limonite (1, smallest) + quartz (7)	5.4	13.7	6.8
6	3690	2	Quartz	12.0	16.3	0.6
7	11250	42	Limonite (11) + quartz (31, incl. smallest and largest)	2.4	16.8	3.1
8	27900	0	/	/	/	0

1997). Only one of the 22 stomachs flushed was empty. Two contained only gastroliths, both from Loango. Our sampling illustrated a varied diet, with a marked difference in prey diversity between Rabi (nine prey classes: Gasteropoda, Arachnida, Diplopoda, Insecta, Crustacea, Osteichthyes, Amphibia, Reptilia, Mammalia) and Loango (three prey classes: Insecta, Crustacea, Osteichthyes). For the Rabi samples (n = 14), percentages of total food mass for prey classes were distributed as follows: Insecta + Diplopoda 70.9%, Osteichthyes 8.7%, Crustacea 8.2%, Mammalia 7.4%, Amphibia 3.8%, others 1% (total food mass recovered from all stomachs = 108.7 g). In Loango, for the 8 samples clustered, Crustacea represented 99.9% of the total prey mass. Frequencies of occurrences for prey items per classes in Rabi samples (*n* stomachs = 14; total number of prey items = 62) was: Insecta 51.6%, Diplopoda 12.9%, Osteichthyes 12.9%, Crustacea 8.1%, Gasteropoda 6.5%, Amphibia 3.2%, Arachnida 1.6%, Reptilia 1.6% and Mammalia 1.6%. Both localities clustered, among the 19 stomachs with contents, 58% contained Insecta (11 samples), 47% Crustacea (9), 37% Diplopoda (7), 26% Osteichthyes (5), 11% Amphibia (2), 5% Gasteropoda (1), 5% Arachnida (1), 5% Reptilia (1) and 5% Mammalia (1). At least part of the insect material in the guts may result from secondary ingestion, via the stomach contents of soft-bodied predators (frogs and fish) that the crocodiles may have eaten, and which were completely digested leaving the hard-bodied insect remains.

Limonite and/or quartz gastroliths were found in 9 out of 14 (64%) of the Rabi samples (see Table 2), and in 5 out of 8 (63%) of the Loango samples (Table 4). Wet mass of the gastroliths represents 0 to 0.33% (n = 22, mean = 0.08%) of the crocodile mass. This mass seems too low to play any role in buoyancy, therefore a possible role in trituration of food or aid against parasites seems more probable, as was also suggested for *Crocodylus cataphractus* (Pauwels et al., 2003). Limonite and quartz are common on the bottom of waters at both localities surveyed. Both minerals had also been found in the stomachs of *Crocodylus cataphractus* from Lake Divangui (Pauwels et al., 2003, 2007), ca. 15 km from Rabi.

Vegetable matter was present in 8 of 22 stomachs (36%). Accidental ingestion during prey capture is probable, but intentional ingestion cannot be ruled out. Hard wood sticks and seeds could serve as substitutes for gastroliths (as was suggested with palm nuts for Congolese *Crocodylus cataphractus* by Eaton and Barr, 2005). Parasitic worms were found in only two stomach contents, both from Rabi (Table 1), and numbered only one or two.

No other data on the diet of *Osteolaemus* in Gabon was previously available, except a report from local fishermen of predation on the aquatic colubrid snake *Grayia ornata* in Ogooué-Lolo Province (Pauwels et al., 2002c). E. Truter (pers. com.) provided additional information about the feeding of *Osteolaemus*. He observed at ca 10 p.m., along Iguéla Lagoon, about 8 km upland from its estuary (Etimboué Dpt, Ogooué-Maritime Prov.), an adult preying on a crab on land, at ca. 2 m from the shore. In another observation (M. Eaton, pers. comm.) at night in late Sept. 2005, a juvenile specimen (TL 48 cm) had a millipede in its mouth. The crocodile was found out of water, in the forest along Echira River, near Akaka village, Ogooué-Maritime Province. Luiselli et al. (1999) recorded Gasteropoda, Crustacea, Osteichthyes, Amphibia and Mammalia from stomachs of *Osteolaemus t. tetraspis* inhabiting swamp rain forest in southeastern Nigeria, crabs being the most abundant resource locally, and the commonest prey item.

Osteolaemus t. tetraspis is the only crocodile species found in the Rabi forest swamps and small streams where our specimens were collected. The closest known locality for another crocodile, *Crocodylus cataphractus*, is Lake Divangui, where a large population exists (Pauwels et al., 2003). The vegetated and swampy littoral zones around the lake also harbour *Osteolaemus* (see Anonymous, 2003b; Barr, 2004), although apparently in small numbers. In these shallow waters it lives syntopically with juvenile *C. cataphractus*, while the subadult and adult *C. cataphractus* occupy deeper waters in the middle of the lake, where no juvenile *C. cataphractus* nor any *Osteolaemus* were observed. In Loango National Park, mangroves are syntopically inhabited by both *Osteolaemus* and *Crocodylus niloticus*. More inland in the park, in the shallow, seasonal ponds, only *Osteolaemus* is found, but it seems absent from the open lagoons and beaches along the sea where *C. niloticus* is locally common (Pauwels et al., 2004; this work). The biotope preferences of *Osteolaemus* thus only partly overlap with those of the two other crocodile species. No diet study for *C. niloticus* is available for Loango N.P.'s mangroves (nor for any locality in Gabon), and at Lake Divangui, while diet data exist for *C. cataphractus*, none is locally available for *Osteolaemus*, so there are currently no comparative diet data for localities where they live in syntopy with *Osteolaemus* in south-western Gabon. Luiselli et al. (1999) showed a wide diet overlap between *Varanus ornatus* and *Osteolaemus t. tetraspis* in southeastern Nigeria. Both species coexist in Loango and Rabi and competition might occur as well, but no data are currently available for the diet of *Varanus ornatus* in these two localities (except a case of predation by *Varanus* on *Dermochelys coriacea* eggs in Loango N. P., see Pauwels et al., 2004).

The sex ratio among the specimens examined was in favor of males (64%, see Table 1 and 3). Rabi and Loango samples clustered, the ratio Tail L/TL ranged from 0.45 to 0.50 in females (n = 7, mean = 0.48) and from 0.43 to 0.48 in males (n = 11, mean = 0.46) (incomplete tails excluded; see Tables 1 and 3). The largest specimen encountered, a male (SVL 98 cm), had an incomplete tail of 72 cm with only 11 single caudal scutes. Through extrapolation, the complete tail should have measured ca. 83 cm, giving a total length of ca. 181 cm.

Riley and Huchzermeyer (2000) suggested a possible role of *Clarias* catfish in the transmission of pentastomid infections in the lungs of *Osteolaemus tetraspis osborni*, but the condition of the fish they found in stomach contents did not allow an identification even at the family level. Our data at least confirm *Clarias* in the diet of *Osteolaemus*. In the Rabi region, only two *Clarias* species are known: *Clarias buthupogon* Sauvage, 1879 and *Clarias* sp. (Mamonekene et al., 2006). During the dry season, when *Osteolaemus* retire in deep holes in the river and swamp banks (as observed in Loango by OSGP and MB), predation on fish, and thus fish-crocodile parasite transmission, may be especially high. Fish entrapped in these water holes represent a food stock for *Osteolaemus* during the dry season, and one of us (OSGP) observed in the dry season in Rabi tracks of *Osteolaemus* that came to visit open, isolated, small drying pools where fish densities were especially high.

CONCLUSION

In Gabon, *Osteolaemus t. tetraspis* inhabits a large variety of habitats, from mangroves, swamps, to forest streams at mid-altitude. In some Gabonese localities it lives in syntopy with *C. cataphractus* (medium-sized forest rivers, lakesides with vegetated shores) or *C. niloticus* (mangroves), but it also inhabits a number of temporary, shallow water body types from which the two other crocodile species are ecologically excluded. Our dietry data show that it has a varied and seemingly opportunistic diet, and that it hunts on land as well as in water. Although commonly hunted in Gabon, its ubiquity in the country, its ecological plasticity, together with its poor quality skin (Abercrombie, 1978; Knoepffler, 1974), contribute to make it the least endangered crocodile species in the country. It is partly protected in Gabon, and has already been recorded from six of the 13 national parks, but should be found in all (Pauwels, 2006; Pauwels et al., 2006b). Gabonese populations are very important in view of the global decline of the species, and their use in bushmeat trade and habitat degradation should be carefully monitored.

ACKNOWLEDGEMENTS

This research was supported by the National Geographic Television, the Smithsonian Institution/Monitoring and Assessment of Biodiversity Program and grants from Shell Foundation and Shell Gabon. This publication is contribution 55 of the Gabon Biodiversity Program (contribution 54 was made by Pauwels et al., 2007). We are grateful to Michelle E. Lee, Alfonso Alonso, Patrick Campbell and Francisco Dallmeier (SI/MAB, Washington), Faustin Bangole, Frank Denelle and Pieter Keemink (Shell Gabon), David Hamlin and Bryan Harvey (NGC) and Jose Luis Bonnin (CBG-Rabi) for working facilities, and to Mitchell Eaton (University of Colorado), Luca Luiselli (Centre of Environmental Studies Demetra, Rome) and Edward Truter (Opération Loango) for useful information or literature. William R. Branch (Port Elizabeth Museum) reviewed the manuscript. Research authorizations were kindly provided by Adèle Sambo (CENAREST, Libreville) and Adrien Noungou (Direction de la Faune et de la Chasse, Libreville).

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Received: 31 December 2005.
Accepted: 21 April 2006.