Morelet's Crocodile (*Crocodylus moreletii*) in the Macal River watershed, Maya Mountains, Belize

PETER J. STAFFORD[1], SCOTT T. McMURRY[2], THOMAS R. RAINWATER[2], DAVID A. RAY[3], LLEWELLYN D. DENSMORE[3], and BRADY BARR[4]

[1] *The Natural History Museum, Cromwell Road, London SW7 5BD, UK* [author for correspondence]

[2] *The Institute of Environmental and Human Health, Texas Tech University, Lubbock, TX 79416, USA*

[3] *Department of Biological Sciences, Texas Tech University, Lubbock, TX 79416, USA*

[4] *National Geographic Society, Washington DC, USA*

ABSTRACT — Results are presented of an investigation into the status of Morelet's Crocodile in the Macal River watershed, a little known upland tributary system in Belize. During spotlight surveys in February 2001 and September 2002, numerous individuals were observed representing a wide range of size classes. Sequence analyses of mtDNA from captured animals show that crocodiles in the area represent a genetically pure strain of *C. moreletii*. No evidence of hybridisation with the American Crocodile (*C. acutus*) was detected, as observed in animals from other sampled localities (northern lowlands). Due to their relative isolation, crocodiles in the Macal watershed may thus function as a regionally important population source for *C. moreletii* should introgression with *C. acutus* spread over time. Differences between *C. moreletii* in the Macal and northern lowlands were apparent also in aspects of ecology.

MORELET'S Crocodile (*Crocodylus moreletii*) is one of two species of crocodilian found in Belize (Lee, 1996; Stafford & Meyer, 2000). It occurs primarily in freshwater habitats, especially in the northern part of the country, a flat limestone shelf dominated by extensive lagoons, alluvial swamps, and flooded sinkholes. The remaining species, *C. acutus*, is restricted to offshore islands and coastal areas of the mainland (Platt & Thorbjarnarson, 2000a). Commercial harvesting for its high quality leather had depleted populations of *C. moreletii* throughout its entire range, and by the late 1960s the species is believed to have been nearly exterminated in Belize (Neill, 1971; Frost, 1974). Following legal protection afforded in 1981, however, its numbers have since recovered significantly.

Surveys undertaken recently of *C. moreletii* in Belize have focused mostly on the northern lowlands (e.g. Abercrombie et al., 1980, 1982; Platt, 1996; Rainwater et al., 1998; Platt & Thorbjarnarson, 2000a), where at some localities the species appears to be common. At Gold Button Lagoon in the Orange Walk District, Platt (1996) counted 159 individuals representing an encounter rate of 22.08 crocodiles per km of the shoreline. More recent observations have confirmed the presence of *C. moreletii* at various localities in southern Belize east of the central mountain divide (Platt et al., 1999). Crocodiles are also known to inhabit some of the larger rivers and streams that drain the western slopes of this little known mountain range (Maya Mountains), particularly the Macal and its larger tributary, the Raspaculo Branch, but with only a small number of records available the occurrence and distribution of populations in the area remain inadequately assessed. In this paper we review the status of *C. moreletii* in the Macal watershed based on recent surveys and other data collected periodically over the last ten years. Much of this system is threatened with flooding should plans to construct a hydro-electric storage dam at Chalillo, a locality on the Macal some 12 km downstream from its

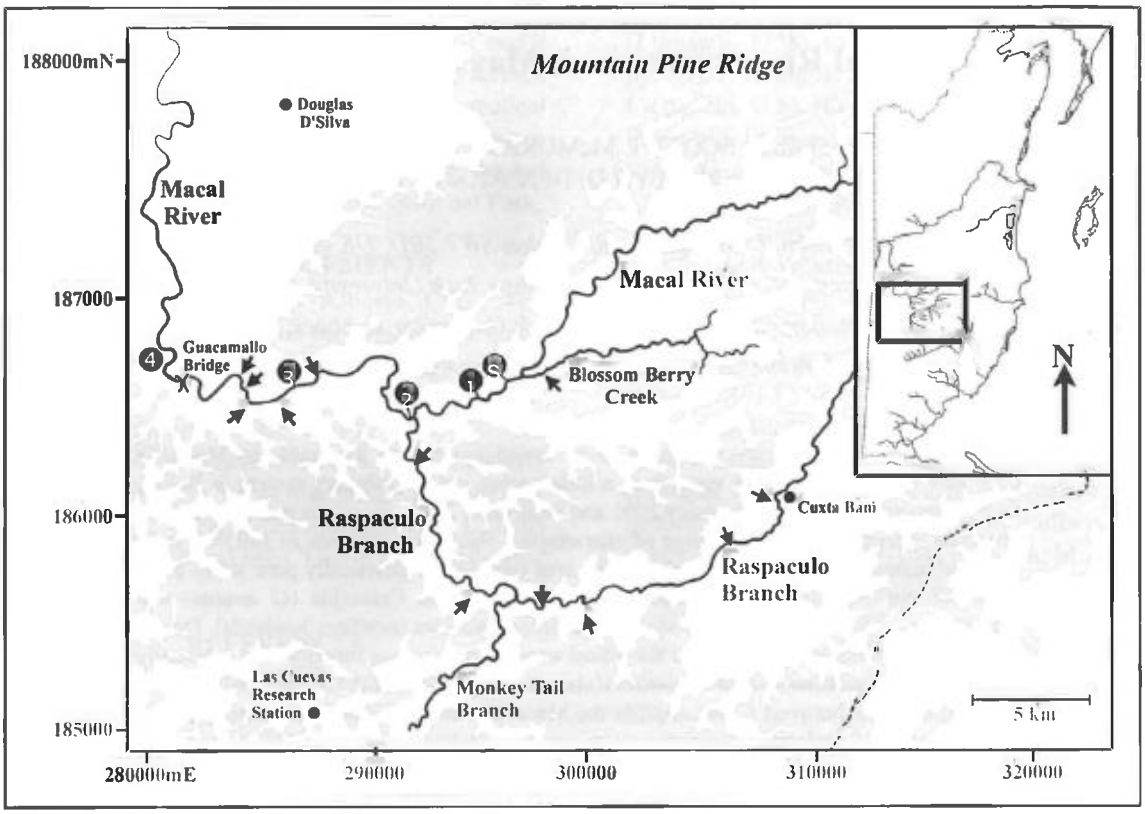

Figure 1. Macal River watershed showing location of survey route. S = start point; 1 = site 1; 2 = site 2 and end point of 2002 survey; 3 = site 3 and end point of 2001 survey; 4 = site 4. For coordinates see text and Appendix 1. Black arrows represent other known distributional records of crocodiles (Stafford, 1991; Rogers, 1994, 2002; J. Meerman, unpublished data; C. Minty, pers. obs.). The dotted line marks the position of the main divide of the Maya Mountains; areas shaded in grey denote elevations above 600 m. Only principal tributaries are shown.

confluence with the Raspaculo Branch, not be repealed.

Survey area

The Macal River is located in west-central Belize in the provincial district of Cayo (Figure 1). From its headwaters in Mountain Pine Ridge it extends for a distance of approximately 80 km, flowing west and then north to its confluence with the Belize River near San Ignacio. Over its wider catchment area the river flows through a region of considerable relief, where much of the flanking ground lies above 600 m. Most of its larger tributaries arise from sources in these highlands. No important tributaries enter from the west, which is probably due to subsurface drainage through porous limestone and highly developed karst topography of the Vaca Plateau (Hartshorn et al., 1984). Rainfall in the area can exceed 2000 mm per year with most (> 80 %) falling during a pronounced wet season extending from June-December. Fluctuations in river levels during this period are often substantial and in parts of the system water levels may rise by up to 5 m or more, occasionally with devastating effects (Figure 2). Hartshorn et al. (1984) described the Macal as 'the most tumultuous river in Belize'.

Although several localities in the watershed have specific colloquial names, there are no major settlements and the entire region remains largely uninhabited. Encompassed within the boundaries of three national parks (Chiquibul Forest Reserve, Chiquibul National Park, and Maya Mountains Biosphere Reserve), the area provides sanctuary

for crocodiles and many other vulnerable species of wildlife, among them the Jaguar (*Panthera onca*), Tapir (*Tapirus bairdii*), Neotropical River Otter (*Lutra longicaudis*) and a recently described subspecies of Scarlet Macaw (*Arao macao cynoptera*).

METHODS

Sightings of crocodiles in the Macal drainage have been recorded on an intermittent basis since 1991 (Stafford, 1991; Rogers et al., 1994, 2001; J. Meerman, pers. data; C. Minty, pers. data). For the purposes of this specific assessment, however, two periods of fieldwork were undertaken, the first for 3 nights between February 20th and 23rd 2001 (McMurry and Barr) and the second for 5 nights between September 4th and 10th 2002 (Stafford, McMurry and Rainwater). On each occasion the same general section of river was surveyed, beginning at GR 0296753E 1864400N (Francelia) and extending downstream to 1864900N in 2001 (approx. 15.5 km), and 1863431N in 2002 (approx. 8 km). In 2002 an additional 1 km section of the Macal was surveyed below Guacamallo Bridge (location 4 on map).

Crocodiles were located from two-man canoes at night using 12-volt headlights to detect eyeshine reflections. All animals sighted or captured were classified by total length (TL) as hatchlings (<35.0 cm), juveniles (35.1 to 75.0 cm), subadults (75.1 to 140.0 cm), or adults (>140.1 cm); individuals that could not be approached close enough to estimate TL were classified as 'eyeshine only' (EO). Following Bayliss (1987), the number of crocodiles encountered per km of survey route was used as a measure of relative density (Platt & Thorbjarnarson, 2000b). Distance traveled on the river was calculated with a Magellan Global Positioning System (GPS) 2000 satellite navigator and confirmed using UTM 1:50,000 topographical maps of the area. At each of the main survey sites we recorded air temperature (AT), water temperature (WT), and an estimation of mid-stream flow rate by measuring the distance covered in 30 seconds by a small rubber ball. Evidence of nesting activity along the route was also investigated by searching suitable sites.

Figure 2. Aerial photograph of upper Macal showing floodwater devastation in May 1990. Photograph © D.A. Sutton.

Small crocodiles (TL < 90 cm) were captured by hand, while larger individuals (> 90.1 cm) were noosed using self-locking breakaway snares. For each captured animal we recorded sex (determined by cloacal examination; Allsteadt & Lang, 1995), TL, scutellation features, cloacal temperature (CT), and evidence of external parasites, injury, or abnormalities. Juveniles captured in 2002 were also stomach flushed for dietary data (Platt, 1996; Platt et al., 2002). Crocodiles were then marked for identification and future monitoring purposes by clipping four of the caudal scutes following the method of Jennings et al. (1991); using the number of the first animal marked as an example (4522), the digits 4 and 5 represent the 4th and 5th scutes of the single row tail series (moving in a posterior direction), the first 2 is the second scute of the double row on the right side, and the second 2 is the second scute of the double row on the left side. Finally, a blood sample was collected from the post-cranial sinus and placed in an extraction

buffer (ACD-B, see White & Densmore, 1992) for DNA analysis, following which the animal was returned to its original capture site and released.

RESULTS

Time constraints and the practical limitations of operating in a remote area precluded us from conducting a detailed survey of the entire watershed. Surveys were therefore restricted to the vicinity of four main localities in the upper Macal and adjoining section of the Raspaculo (Figure 1). Observations recorded at each of these localities are summarised in Appendix 1.

During the 2001 survey a total of 23 crocodiles was observed, representing an encounter rate of 1.48/km. These included 7 juveniles, 4 subadults, 9 adults, and 3 for which size could not be determined (identified by eyeshine only). In 2002, 21 crocodiles were observed, 10 between the survey start point and junction of the Macal and Rapsaculo (1.25/km), and the remainder along a separate 1 km stretch below Guacamallo Bridge (locality 4). Of these, 12 were juveniles, 3 were subadults, 4 were adults, and 2 were detected by eyeshine only. As is the nature of such surveys, many animals will have been overlooked and the number of individuals recorded is therefore likely to represent the minimum number present. Of 14 animals that were captured and marked, 9 were juveniles (3 males and 6 females), 2 were subadults (males), and 3 were adults (1 male and 2 females). None of the animals captured in 2001 were recaptured in 2002.

Species identification

All captured individuals exhibited dorsal and subcaudal scutellation patterns consistent with those of Morelet's Crocodile (Brazaitis, 1973; Ross & Mayer, 1983; Ross & Ross, 1974; Platt, 1996). DNA sequence analyses of 534 bases of mitochondrial (mt) control region DNA, isolated from blood collected from 11 specimens, revealed that haplotype A (Ray et al., in review) is the most common mitochondrial haplotype (9 of 11 animals) in this population. Two rare haplotypes (J and K) are each represented by single individuals. There is no suggestion of any Macal animals having mitochondrial haplotypes resulting from hybridisation with American Crocodiles, as has been found in other populations in Belize (Ray et al., in review). The within-population haplotype diversity for the 11 animals sampled is 0.182; the nucleotide diversity is 0.0003, which is the lowest amount found in any single Morelet's Crocodile population (Ray et al., in review).

Distribution and ecology

The furthest upstream locality at which crocodiles have been recorded in the Macal watershed is Cuxta Bani in the Raspaculo (Stafford, 1991; Rogers et al., 1994, 2001). Crocodiles at this locality and one other observed a short distance further upstream at approximately 450 m a.s.l. represent the highest known elevational records for *C. moreletii*. Crocodiles were encountered mostly at night in slow-flowing water, usually near the bank or in small side pools away from the main current. The largest aggregation of juveniles (5) was observed in a small deep ox-bow with dense reed growth at the edges on 4th September 2002. Three individuals captured at this locality (Site #1) between 19:00 and 21:00 hrs had a cloacal temperature of 27.5°C. Water and air temperatures were 27.5°C and 25.0°C respectively. A large adult (> ca. 210 cm total length) was also observed in the vicinity of this pool, possibly a parent.

Of seven yearlings examined for dietary data, six contained food. Two had eaten damselflies (Zygoptera; Odonata) and orthopterans (Acrididae and Gryllidae), one had eaten an unidentified crustacean, and another contained eight snail opercula, snail flesh, and the limb bones of an unidentified anuran. Other items recovered from stomachs included unidentified tissue remains and, in one individual (#4679), ten nematodes. Gastrolith numbers ranged from 0-61 per stomach, all of them small, rounded, uniformly-sized pieces of gravel. Most crocodiles appeared to be in a good state of general health with no evidence of injury, and also remarkably free of ectoparasites. *Paratrichosoma* spp. (Moravec & Vargas-Vazquez, 1998; Moravec, 2001) were observed on the ventral scales of only two individuals, both yearlings from the same locality (4).

Population size

In the absence of comprehensive survey data it is not possible to provide an accurate estimation of population size of *C. moreletii* in the Macal watershed as a whole. Based on the observed encounter rate, however, a crude approximation of non-hatchling numbers in its two principal tributaries – the Macal and Raspaculo Branch – can be obtained by extrapolating this value over the length of river along which crocodiles are known to occur. Using standard topographical maps (see Methods), we conservatively measured a total distance of 68.5 km from the furthest upstream localities at which crocodiles have been sighted in each river (Cuxta Bani in the Raspaculo, and locality 1 in the Macal to its confluence with the Belize River). Multiplying this value by the average number of crocodiles observed per km of route (1.37 based on combined 2001 and 2002 data) accordingly yields a total non-hatchling population size of 94. This should be considered a minimum estimate as not all individuals are sighted during nocturnal spotlight surveys, and along some parts of the route observations were made only by day (most crocodiles are seen at night). Furthermore, a large section upstream of the known distributional limit of crocodiles in the Macal remains uninvestigated. In our attempt to estimate population size in the area, however, we are aware of the various potential sources for error, and recognise the need for qualitative estimates of abundance throughout the entire watershed.

DISCUSSION

This report is based on observations of crocodiles along a minimal stretch of the Macal River and a limited number of other localities. Nonetheless, the survey data reveal several interesting characteristics of *C. moreletii* in this watershed.

Results of the mtDNA analyses suggest that crocodiles in the area represent a genetically pure strain of *C. moreletii*. This is of potential significance in that analyses of mtDNA from individuals tested elsewhere in Belize (northern lowlands) have shown evidence of introgression with *C. acutus* (Ray et al., in review). Due to their relative isolation, crocodiles in the Macal watershed may thus function as a regionally important population source for *C. moreletii* should introgression with *C. acutus* spread over time. However, given that *C. acutus* is restricted to coastal areas, it may be that *moreletii* is actually the more 'pervasive' of the two species, and introgression between them is proceeding mostly in the other direction (S. Platt, pers. comm.). This is also suggested by the fact that hybrid crocodiles in the northern lowlands are morphologically identical to *C. moreletii* (S. Platt, pers. comm.). That some hybridisation events appear to have taken place so far inland, however, is surprising. Additional data are clearly needed on populations of crocodiles from other areas, but it may be that genetically pure *C. moreletii* are much rarer in Belize than has previously been assumed.

Unlike typical habitat of *C. moreletii*, the Macal watershed is situated in mountainous topography at 400 m or more elevation. Water temperature in the upper Macal recorded during the 2001 trip was consistently at 23 to 24°C (73 to 75°F). In comparison, water temperatures for a lowland lagoon site (New River Lagoon) taken in March averaged 28.6°C (range = 27.7 to 29.7), essentially five degrees warmer than the Macal. As a dynamic mountain river system this habitat is subject also to pronounced seasonal fluctuations in water levels, flow rate, and turbidity. During periods of high floodwater crocodiles are seen infrequently, and their movements on such occasions remain almost completely unknown. It is possible that some disperse into surrounding floodplain areas, perhaps using small ephemeral pools or concealing themselves in submerged vegetation, although we have no direct observations of this. How crocodiles contend with flooding in this system, and to where they apparently 'disappear', would benefit from particular further investigation.

In the northern lagoons of Belize, *C. moreletii* eats a variety of prey, a large part of the adult diet being comprised of Apple Snails (*Pomacea flagellata*) and fish (Platt, 1996; Platt et al., 2002). Other prey items available to populations in this area include a plethora of animals encompassing almost all vertebrate and non-vertebrate groups. In the Macal and Raspaculo rivers, however, we observed relatively few potential prey items. Aquatic river snails were abundant and appear to

comprise one species, but all were probably less than 20 grams in mass. During an earlier survey several fish species were observed (Rogers et al., 1994), but relatively few compared to those in some of the northern lagoons studied, and most were small (<10 cm; e.g. *Astyanax fasciata*, *Gambusia* sp. *Cichlasoma salvini*, *C. spilurum*). Catfish (Pimelodidae; *Rhamdia* sp.?) appear to be the only suitably large fish species available (> 20 mm), at least in some upper sections of the watershed. However, none of our observations on potential prey in either the lagoons or the Macal and Raspaculo rivers were quantified, therefore precluding anything other than anecdotal comparisons. In 2000, a large adult *C. moreletii* near site 2 was observed feeding on a dead adult Tapir purportedly killed by a Jaguar (S. Snider, R. and C. Foster, pers. obs.), and another adult was seen feeding on a Tamandua (*Tamandua mexicana*) (M. Meadows, pers. obs.).

Although no direct evidence of nesting was observed, nests have been seen in the area (S. Matola, M. Meadows, pers. obs.) and the population is clearly breeding. We observed a wide-range of size classes, including several individuals likely to have hatched during the previous year (0.5 m class). These yearlings, coupled with the number of animals in successively larger size classes, indicate successful sustained reproduction. In northern Belize, *C. moreletii* nests during the wet season, but given that water levels at this time of year in the Macal can rise by several metres, it is difficult to envisage how nests survive the incubation period without being flooded. Dry season nests of crocodiles have been found in southern Belize but appear to have been the work of hybrids (S. Platt, unpubl. data).

None of the individuals examined at close quarters showed evidence of scarring or other indications of physical combat, even in the largest adult male. This may reflect a state of low intraspecific competition between males in this river system. In northern Belize, virtually all adult male crocodiles were found to have suffered injury in one form or another (Rainwater, pers. obs.).

The importance of mountain habitat for crocodiles and other wildlife inhabiting the Macal watershed should not be understated. Our observations and those of others (e.g. Rogers et al., 1994, 2002) indicate that this area remains virtually untouched by humans, and its remoteness makes it an invaluable natural resource for wildlife. Projected plans for the Macal include construction of a hydroelectric storage dam that will flood much of the area east of locality #3 (approx. 20 km upstream in the Macal and 10 km in the Raspaculo), the eventual reservoir having a total surface area of 9.53 km^2 (BECOL, 2001). Although one could argue that creation of a 'lake' due to back-flooding would enhance crocodile habitat, in reality the dynamic changes in river levels from water release at the dam will most likely hinder crocodile productivity. Fluctuating water levels not only destroy nesting/nursery habitat and the nests themselves, but also potentially disrupt life cycles of aquatic invertebrates and other organisms required by crocodiles for food. Additionally, the dam itself – a 49.5-metre high wall with power plant and associated installations – is likely to form a barrier to the movement of crocodiles between upstream and downstream areas. Should impoundment of the area go ahead as planned, the impact on crocodiles might to some extent be mitigated by not allowing water levels to rise and fall during the nesting season. In the Mollejon hydro reservoir further downstream in the Macal, such fluctuations appear to have resulted in the loss of shoreline vegetation and increased sedimentation, many of its banks now being coated with mud. These conditions are unlikely to be favourable to nesting crocodiles, and surveys have not revealed a large population in that area (J. Meerman, pers. comm.).

ACKNOWLEDGEMENTS

For practical help received at various stages during this project we thank Chris Minty, Nicodemus Bol, Enrique Saquil and Norberto Coc of the Natural History Museum's field research station at Las Cuevas. Assistance and hospitality during the 2002 survey was also gratefully received from Richard and Carol Foster. Fieldwork was conducted with funding assistance from the Natural History Museum (Las Cuevas Research Station grant scheme), National

Geographic Society, and British Ecological Society, under Ministry of Natural Resources (Belize) research and collection permit number CD/60/3/02(45), and CITES permit number 03US812795/9. Partial funding for the molecular analysis work was provided by a National Geographic Society Grant to LDD (#7007-01). Helpful review comments on an original version of this manuscript were received from Steven Platt (Oglala Lakota College, South Dakota) and J. Perran Ross (Florida Museum of Natural History).

REFERENCES

Abercrombie, C.L., Davidson, D. Hope, C.A. & Scott, D.E. (1980). Status of Morelet's crocodile (*Crocodylus moreletii*) in Belize. *Biol. Conserv.* **17**, 103-113.

Abercrombie, C.L., Davidson, D. Hope, C.A., Scott, D.E. & Lane, J.E. (1982). Investigations into the status of Morelet's crocodile (*Crocodylus moreletii*) in Belize, 1980. In *Crocodiles*. Proceedings of the 5th Working Meeting of the Crocodile Specialist Group, pp. 11-30. Morges, Switzerland: IUCN.

Allsteadt, J. & Lang, J.W. (1995). Sexual dimorphism in the genital morphology of young American alligators, *Alligator mississippiensis*. *Herpetologica* **51**, 314-325.

Belize Electric Company (BECOL). (2001). Macal River Upstream Storage Facility Environmental Impact Assessment. AMEC.

Bayliss, P. (1987). Survey methods and monitoring within crocodile management programmes. In *Wildlife Management: Crocodiles and Alligators*, pp. 157-175. Webb, G.J.W., Manolis, S.C. & Whitehead, P.J. (Eds.). Sydney, Australia: Surrey Beatty and Sons Pty. Ltd.

Brazaitis, P. (1973). The identification of living crocodilians. *Zoologica* **58**, 59-88

Frost, M.D. (1974). A biogeographical analysis of some relationships between man, land, and wildlife in Belize (British Honduras). Unpublished Ph.D. dissertation. Corvallis, Oregon: Oregon State University.

Hartshorn, G.S., Nicolait, L., Hartshorn, L., Bevier, G., Brightman, R., Cal, J., Cawich, A., Davidson, W., Dubois, R., Dyer, C., Gibson, J., Hawley, W., Leonard, J., Nicolait, R., Weyer, D., White, H., & Wright, C. (1984). *Belize: Country environmental profile; a field study*. Belize City, Belize: Robert Nicolait Associates Ltd.

Jennings, M. J., David, D. N. & Portier, K. M. (1991). Effects of marking techniques on growth and survivorship of hatchling alligators. *Wildl. Soc. Bull.* **19**, 204-207.

Lee, J.C. (1996). *The Amphibians and Reptiles of the Yucatán Peninsula*. Ithaca, New York: Comstock Publishing Associates.

Moravec, F. (2001). Some helminth parasites from Morelet's crocodile, *Crocodylus moreletii*, from Yucatan, Mexico. *Folia parasit.* **48**, 47-62.

Moravec, F. & Vargas-Vasquez, J. (1998). First description of the male and redescription of the female of *Paratrichosoma recurvum* (Nematoda: Capallariidae), a skin-invading parasite of crocodiles. *Parasit. Res.* **84**, 499-504.

Neill, W.T. (1971). *The Last of the Ruling Reptiles: Alligators, Crocodiles, and Their Kin*. New York, NY: Columbia University Press. 486 pp.

Platt, S.G. (1996). The Ecology and Status of Morelet's Crocodile in Belize. Unpublished Ph.D. dissertation. Clemson, South Carolina: Clemson University.

Platt, S.G. & Thorbjarnarson, J.B. (2000a). Status and conservation of the American crocodile, *Crocodylus acutus*, in Belize. *Biol. Conserv.* **96**, 13-20.

Platt, S.G. & Thorbjarnarson, J.B. (2000b). Population status and conservation of Morelet's crocodile, *Crocodylus moreletii*, in northern Belize. *Biol. Conserv.* **96**, 21-29.

Platt, S.G., Thorbjarnarson, J.B. & Rainwater, T.R. (1999). Distribution of Morelet's crocodile (*Crocodylus moreletii*) in southern Belize. *Southwest. Nat.* **44**(3), 395-398.

Platt, S.G., Rainwater, T.R. & McMurry, S.T. (2002). Diet, gastrolith acquisition and initiation of feeding among hatchling Morelet's Crocodiles in Belize. *Herp. J.* **12**(2), 81-84.

Rainwater, T.R., Platt, S.G. & McMurry, S.T. (1998). A population study of Morelet's Crocodile (*Crocodylus moreletii*) in the New River watershed of northern Belize. In

Crocodiles. Proceedings of the 14th Working Meeting of the Crocodile Specialist Group, Singapore, pp. 206-220. Gland, Switzerland: IUCN.

Ray, D.A, Dever, J.A., Rainwater, T.R., Finger, A.G., McMurry, S., Platt, S.G., Batzer, M.A., Barr, B., Stafford, P.J. & Densmore, L.D. (in review). Low levels of nucleotide diversity in *Crocodylus moreletii* and evidence of hybridisation with *C. acutus*. *Conserv. Gen.*

Rogers, A.D.F., Sutton, D.A., & Stafford, P.J. (Eds.). (1994). *Report of the Joint Services Scientific Expedition to the Upper Raspaculo River, Belize, Central America*. London: NHM and HMSO.

Rogers, A.D.F., Sutton, D.A., & Stafford, P.J. (Eds.). (2001). *Report of The New Millennium Expedition; The Year 2000 Joint Services Scientific Expedition to Nohoch Ch'en and the Upper Raspaculo, Maya Mountains, Belize*, London: NHM.

Ross, F.D. & G.C. Mayer (1983). On the dorsal armor of the Crocodilia. In *Advances in Herpetology and Evolutionary Biology*, pp. 305-331. Rhodin, A.G.J. & K. Miyata (eds.). *Mus. Comp. Zool.*, Cambridge.

Ross, C.A & Ross, F.D. (1974). Caudal scalation of Central American *Crocodylus*. *Proc. Biol. Soc. Washington* **87**, 231-234.

Stafford P.J. (1991). Amphibians and reptiles of the Joint Services Scientific Expedition to the Upper Raspaculo, Belize, 1991. *Brit. Herpetol. Soc. Bull.* **38**, 10-17.

Stafford, P.J. & Meyer, J.R. (2000). *A Guide to the Reptiles of Belize*. San Diego, California: Academic Press.

Appendix 1. Observations of *C. moreletii* recorded at each of the main survey localities. Confirmed sightings are crocodiles that were seen and for which size could be estimated. Sizes given are total lengths. EO = eyeshine only.

Locality	Date	Number observed	Size (m)	Sex	Comments
Site #1 GR 295850E, 1864290N This locality included a small ox-bow pool approx. 30 m across at its widest point, and adjoining section of the main river channel extending about 100 downstream.	21/02/2001	1	0.5	?	Confirmed sighting
		3	1.0	?	Confirmed sightings
		1	1.62	♀	Captured; #4522
		1	2.0	?	Confirmed sighting
		1	?	?	Heard vocalising
	22/02/2001	1	0.4	♀	Captured; #4524
		1	0.5	?	Confirmed sighting
		1	0.655	♀	Captured; #4526a
		1	0.815	♂	Captured; #4525
		1	1.5	♀	Captured; #4523
		2	1.8	?	Confirmed sightings
	04/09/ 2002	3	0.54	2♂ + 1♀	Captured; #4675, 4676, 4677
		1	2.10	?	Confirmed sighting
		2	0.5	?	Confirmed sightings

Locality	Date	Number observed	Size (m)	Sex	Comments
Site #2	05/09/2002	1	2.54	♂	Captured; #04
		1	0.5	?	Confirmed sighting
GR 292700E, 1863405N Confluence of the Macal and Raspaculo Rivers.		1	?	?	EO
		1	0.51	♀	Captured; #4678
	06/09/2002	1	0.51	♀	Recapture (#4678)
Site #3	23/02/2001	2	0.5	?	Confirmed sightings
		1	0.54	♀	Captured; #4526b
GR 287994E, 1864900N This locality included two pools upstream from camp, and several pools extending to a point approx. 0.5 km downstream.		1	0.815	♂	Recapture (#4525)
		2	1.5	?	Confirmed sightings
		1	1.5	♀	Recapture (#4523)
		1	1.8	?	Confirmed sighting
		1	2.4	?	Confirmed sighting
		1	?	?	EO; possibly >1 m but poor visual
		1	?	?	EO; middle of river; appeared large but poor visual
		1	?	?	EO; appeared large but poor visual
Site #4	09/09/2002	1	0.47	♂	Captured; #4679
		1	0.77	♂	Captured; #4682
GR 282750E 1865600N This site included two small pools and a wide continuous stretch of the Macal between Guacamallo Bridge and a point approx. 1 km downstream.		2	0.60	?	Confirmed sightings
		1	0.90	?	Confirmed sighting
		1	?	?	EO; yearling?
	10/09/2002	1	0.5	♀	Captured; #4683
		1	0.60	?	Confirmed sighting
		1	1.20	?	Confirmed sighting; pool at side of bridge
		1	0.90	?	Confirmed sighting; likely to be same 0.90 m individual observed on previous night
		1	1.50	?	Confirmed sighting
		1	2.10	?	Confirmed sighting