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1. The BHS Bulletin publishes a range of features concerned with herpetology. Emphasis is placed on captive breeding and husbandry, conservation and field notes, general natural history, veterinary and behavioural aspects. These features include major articles and scientific papers (sometimes illustrated), short notes, letters and book reviews.

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The Bulletin is edited and produced by John Pickett and John Spence. Contributions and correspondence arising from the Bulletin should be sent to John Spence, 23 Chase Side Avenue, Enfield, Middx, EN2 6JN (0181-366 8127).

FRONT COVER

Hetrixalus alboguttatus. Most of the adult coloration is showing, the feet are beginning to exhibit the orange colour of the parents. See "An Account of the Care and Breeding of *Hetrixalus alboguttatus*" by Robert and Valerie Davies and Paul Hoskisson, p. 30.

DIVERSITY, OBSERVATIONS, AND CONSERVATION OF THE HERPETOFAUNA OF TURNEFFE, LIGHTHOUSE, AND GLOVERS ATOLLS, BELIZE

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INTRODUCTION

Inventories of species in particular regions are essential data sets for conservation and resource management (Oliver and Beattie, 1993), and the acquisition of baseline data on the distribution and status of even common species is important (Dodd and Franz, 1993). Furthermore, knowledge of local species diversity is fundamental to understanding community and ecosystem dynamics (McDiarmid, 1994). Comprehensive herpetofaunal inventories of the Belizean atolls have yet to be completed (Zisman, 1992), and natural history information on these populations is almost non-existent. We herein review existing biodiversity data, and present additional records and observations gathered during fieldwork in Belize from 1994 to 1997.

Visits were made to Turneffe Atoll in May, June and September 1994, June 1995, August and November 1996, and February, April, May, June and July 1997. Lighthouse Atoll was visited in October 1995, August 1996 and July 1997. Glovers Atoll was visited in September 1994. Voucher photographs of most species were deposited in the Campbell Museum, Clemson University, Clemson, South Carolina, U.S.A. Taxonomy follows Lee (1996). Place names in the text correspond to maps published by the Ordnance Survey, Southampton, England, and obtained from the Department of Lands and Survey, Belmopan, Belize.

STUDY AREA

Three atolls are found in Belize outside of the barrier reef: Turneffe, Lighthouse, and Glovers Atolls (Figure 1). There is only one other such atoll in the Western Hemisphere, Banco Chinchorro on the coast of Quintana Roo, Mexico (Stoddart, 1962). Turneffe Atoll (Figure 2) is located approximately 35 km east of Belize City and is 50 km long and 16 km wide with an estimated surface area of 533 km^2 (Perkins, 1983). This atoll consists of a chain of islands partially enclosing three shallow lagoons: Southern, Central and Northern or Vincent's Lagoon. A near continuous beach ridge extends along the windward shore of the atoll, with a maximum elevation of about 1.5 m above sea level (Stoddart, 1962; Minty et al., 1995).

The vegetation of Turneffe Atoll has been described by Stoddart (1962, 1963), and Minty et al. (1995). Most of the atoll is dominated by Red *(Rhizophora mangle)* and Black Mangrove *(Avicennia germinans)* swamps, with a transition zone of Buttonwood *(Conocarpus erectus)* and White Mangrove *(Laguncularia racemosa)* bordering more elevated habitats. The elevated beach ridge along the eastern shore of the atoll is characterized by cay littoral forest composed of Black Poisonwood *(Metopium brownei)*, Gumbo Limbo *(Bursera simarubra)*, Wild Seagrape (Copcoloba uvifera) and Saltwater Palm *(Thrinax radiata)*. Elsewhere in Belize much of this habitat has been cleared for human settlements or Coconut *(Cocos nucifera)* plantations, and consequently cay littoral forest is now considered the most endangered habitat in the coastal zone (McField et al., 1996). Extensive Turtlegrass *(Thalassia testudinum)* beds occur in shallow water surrounding the atoll.

Turneffe Atoll supported a large coconut industry prior to 1961 (Stoddart, 1962), and plantations were established on many cays along the eastern shoreline with a warehouse and collection centre on Calabash Cay. Most of this infrastructure was destroyed by Hurricane Hattie in October 1961 (Stoddart, 1963), and the industry never recovered. However, many of the trees remain and coconuts are still harvested and sold in Belize City. In some areas the accumulation of palm fronds beneath the trees is inhibiting the regeneration of native vegetation (Minty et al., 1995). A recent (1997) outbreak of lethal yellowing has decimated coconut stands in some parts of the atoll, and may enhance the recovery of native vegetation.

Today Turneffe Atoll is largely undeveloped. Resorts are located on Cay Bokel, and the northern and southern ends of Blackbird Cay. Coral Cay Conservation/University College of Belize has established a Marine Research Center (MRC) on Calabash Cay. There are also many small fishing camps of varying degrees of permanence scattered throughout the atoll, and most are constructed on beach ridges. The atoll is under increasing pressure for development and the construction of several additional tourist facilities has been proposed (Platt and Thorbjarnarson, 1996).

Lighthouse Atoll (Figure 3) is located approximately 75 km east of Belize City and has an estimated surface area of 126 km^2 (Hartshorn et al., 1984). Much of this is underwater, and terrestrial habitat is restricted to Northern, Sandbore, Long, and Half-Moon Cays. The latter is encompassed within the Half-Moon Cay National Monument (Zisman, 1996), while the remainder is privately owned. A resort with an airstrip is located on Northern Cay, while Sandbore and Long Cay remain undeveloped.

The vegetation of Lighthouse Atoll has been described by Stoddart (1962), Fosberg et al. (1982), and Meerman (1996). Mangrove swamps dominate much of Northern, Long, and Sandbore Cays, although some littoral forest is present on the former two cays. The eastern portion of Half-Moon Cay was cleared in the 1920's and a coconut plantation established which remains in existence. The western half of the cay is characterized by Ziricote *(Cordia sebestena)* forest, where a Red-footed Booby *(Sula sula)* nesting colony is found (Verner, 1959). An abundance of introduced *Rattus* sp. on Half-Moon Cay may prejudice the survival of native wildlife (Zisman, 1996).

Figure 1
Map of Belize showing the location of Turneffe, Lighthouse and Glovers Atolls in relation to the mainland

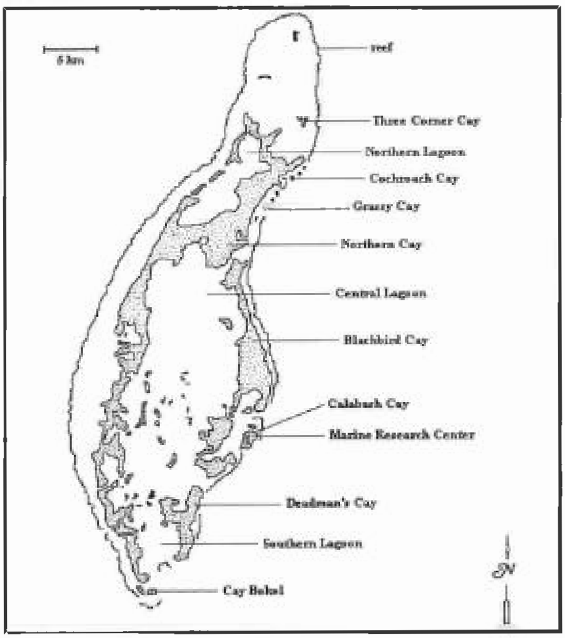

Figure 2
Map of Turneffe Atoll, showing localities mentioned in the text

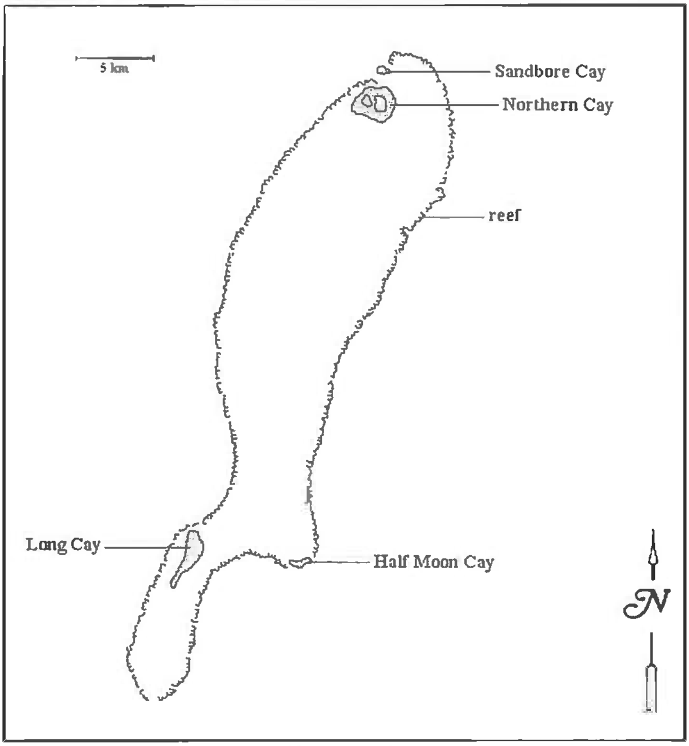

Figure 3
Map of Lighthouse Atoll, showing localities mentioned in the text

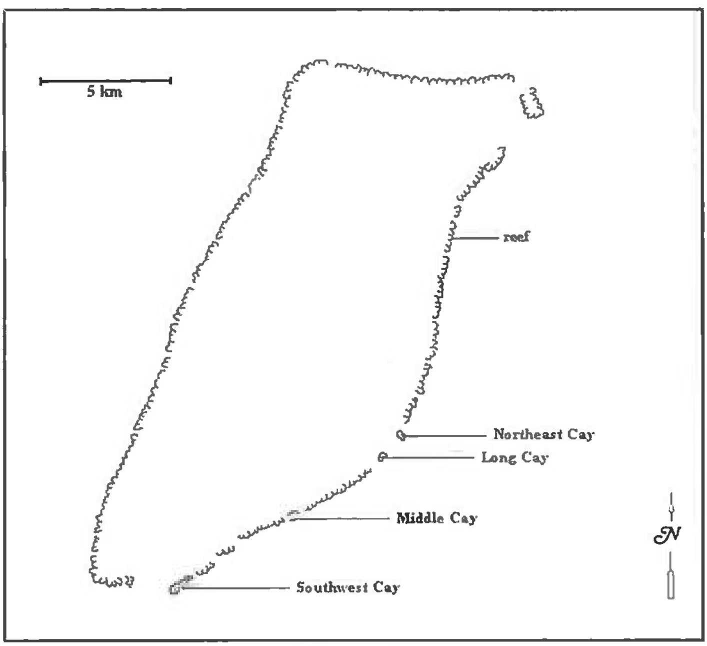

Figure 4
Map of Glovers Atoll, showing localities mentioned in the text

Glovers Atoll is located approximately 50 km southeast of Dangriga, and is 24 km long and about 10 km wide (Stodddart, 1962). Most of the atoll consists of submerged reef, and terrestrial habitat is limited to Northeast, Long, Middle Long, and Southwest Cays (Figure 4). The entire atoll is encompassed within the Glovers Reef Marine Reserve (Zisman, 1996). The vegetation of Long Cay was recently described by Meerman (1995) who found much of the cay had been converted to coconut plantations and the remaining native vegetation was extremely impoverished. Mangrove is virtually absent, although some Saltwater Palms and Ziricote remain. Although a floristic survey of Northeast Cay was not conducted, some native vegetation remains, including Black Mangrove (Meerman, 1995). Human dwellings are present on Long, Middle Long, and Northeast Cays.

The climate of coastal Belize is considered tropical since the average temperature of every month is greater than 18°C. The warmest temperatures occur in April and May, with average daily maximums of 32.8 and 33.1°C respectively. The coastal zone is exposed to southwest trade winds averaging 10 to 13 knots, which moderate daily high temperatures. Mean annual rainfall in the atolls is 1347 mm/year, and this region is among the driest in Belize. There is a pronounced wet season from June through November, and negligible rainfall in April and May, but this may vary annually (Hartshorn et al., 1984). Fresh surface water is scarce to non-existent in the atolls during the dry season (S. Platt, pers. obs.).

SPECIES ACCOUNTS

AMPHIBIA

Bufo marinus: While abundant on the mainland, *B. marinus* appears to be a rare inhabitant of Turneffe Atoll. Two adults were found on Calabash Cay: one in a pile of debris in littoral forest adjacent to the MRC (16 June 1995), and another on the MRC grounds (25 February 1997). These constitute the first records of *B. marinus* on any offshore island in Belize (Lee, 1996), and are the only amphibian records from the atolls. No evidence of reproduction has been found, but ephemeral rain-filled pools available during the wet season may serve as breeding habitat. Elsewhere in Central America *B.marinus* exhibits a bimodal reproductive cycle with peaks in the dry and wet season (Lee, 1996). However, dry season reproduction is unlikely in the Turneffe Atoll owing to a paucity of fresh surface water.

REPTILIA

Crocodylidae

Crocodylus acutus: The American Crocodile is present in both Turneffe and Lighthouse Atolls (Platt and Thorbjarnarson, 1996, 1997). An earlier report (Stoddart, 1962) that Morelet's Crocodile (*C. moreletii*) occurred in Lighthouse Atoll is believed erroneous, and probably resulted from confusion with *C. acutus*, a mistake common even among professional herpetologists (Thorbjarnarson, 1989). Based on nest counts and demographic data obtained in spotlight surveys, an estimated 200 to 300 non-hatchling crocodiles are believed to inhabit Turneffe Atoll, the largest population in Belize (Platt and Thorbjarnarson, 1997). Population estimates are unavailable for Lighthouse Atoll. Nesting has been documented on Deadmans, Blackbird, and Northern Cays in Turneffe Atoll, and Northern Cay in Lighthouse Atoll (Platt and Thorbjarnarson, 1996, 1997). Fifteen nests were found in the Turneffe Atoll in 1997, the largest concentration of nesting activity in Belize. Crocodiles require a well-drained sandy substrate for successful nesting, and thus nesting is generally restricted to elevated beach ridges (Platt and Thorbjarnarson, 1997). Furthermore, shallow freshwater or brackish pools located adjacent to nesting beaches provide essential nursery habitat and are a vital source of water for hatchlings and juveniles, the size classes most vulnerable to osmotic stress (Platt and Thorbjarnarson, 1997). The American Crocodile is considered threatened in Belize due to opportunistic killing, habitat loss, and past over-exploitation by commercial skin hunters (McField et al., 1996).

Testudines

Caretta caretta: Loggerhead Turtles are reported to nest from May to August on all islands in Lighthouse Atoll (Miller, 1984; Moll, 1985; Smith 1990; Smith et al., 1992).. According to Smith et al. (1992) the largest number of nests are deposited on Half-Moon Cay (4-12 nests/year), followed by Long Cay (7 nest/year), Sandbore Cay (ca. 6 nests/year), and Northern Cay (1 nest/year). On 11 July 1997 we found abundant evidence of nesting activity on Northern Cay, and a nest of emerging Loggerhead hatchlings. Loggerheads are also reported to nest on Northeast and Long Cays, Glovers Atoll (Smith et al., 1992; Meerman, 1995). Nesting has not been reported in Turneffe Atoll, but juvenile and adult turtles are occasionally encountered by divers.. The Loggerhead is listed as vulnerable in the IUCN red data book (Groombridge, 1982).

Chelonia mydas: The Green Sea Turtle once nested by the "hundreds" from June to August on Northern and Half-Moon Cays, Lighthouse Atoll and in Glovers Atoll, but these historical rookeries were decimated by over-harvesting, and consequently few nests are found today (Smith, 1990; Smith et al., 1992). Large numbers of adults migrate through Belizean coastal waters, arriving in November and departing in March (Smith et al., 1992). Green Turtles have been observed foraging in turtlegrass beds surrounding Turneffe Atoll, but nesting has not been reported. This species is listed as endangered in the IUCN red data book (Groombridge, 1982).

Eretomochelys imbricata: Hawksbill Turtles remain in Belizean coastal waters throughout the year. Females are solitary nesters, depositing clutches from May to October. Nesting has been reported from Long Cay, Lighthouse Atoll, and Calabash Cay, Turneffe Atoll (Smith et al., 1992). We observed shells of adults taken by fishermen near Calabash Cay, and divers occasionally report encounters with Hawksbill Turtles in this area. The past trade in tortoise-shell is believed to have resulted in serious declines among Belizean Hawksbill populations (Moll, 1985). The Hawksbill is listed as endangered in the IUCN red data book (Groombridge, 1982), and half of the known nesting populations in the Caribbean are suspected to be declining (Smith et al., 1992).

Dermochelys coriacea: The Leatherback is rarely encountered in Belize and nesting has not been reported (Smith et al., 1992; Lee, 1996). A dead adult was found washed ashore in Turneffe Atoll (Smith et al., 1992). Smith et al. (1992) suggested that because the pliable shell is easily abraded and injured, the fringing reefs encircling atolls and the barrier reef along the coastline may deter Leatherbacks from entering Belizean waters.

Marine Turtles (general): Smith et al. (1992) list a number of sites in Turneffe Atoll where evidence of sea turtle nesting was noted, but the species could not be determined. These include Three Corner, Grassy, and Cockroach Cays, and beaches around Cockroach Bogue. Additionally, an extensive nesting beach once occurred on Blackbird Cay (near the present site of Blackbird Resort), but has since been destroyed by development (Perkins, 1983). It is uncertain which species formerly nested at this site. The beaches north of Blackboard Resort appear to offer excellent habitat, but we found no evidence of turtle nesting during searches in 1994, 1996 and 1997. We found an excavation (25 June 1997) on Northern Cay, Turneffe Atoll, but did not open the nest to determine the presence of eggs.

Rhinoclemmys areolata: The occurrence of the Furrowed Wood Turtle in the Turneffe Atoll has been discussed by Platt et al. (submitted). *R. areolata* was initially reported in the Turneffe Atoll by Zisman (1992), but no details concerning the collection or deposition of this specimen were provided. Other sight records were reported from Blackbird Cay by Belize Fisheries Department personnel, and in November 1996 we recovered the fresh remains of a Furrowed Wood Turtle while flushing the stomach (Taylor et al., 1978) of a subadult American Crocodile captured in Northern Lagoon (Platt and Thorbjarnarson, 1997). Based on these records we consider the Furrowed Wood Turtle a rare member of the atolls' fauna. While nothing is known concerning the ecology of this insular population, *R. areolata* on the mainland feed extensively on various fruits (S. Platt, unpubl. data), and are probably dependent on littoral forest as a source of fruit for both food and water in Turneffe Atoll.

Serpentes
Boa constrictor: This snake is a common inhabitant of many Belizean Cays, including islands in Turneffe Atoll (Zisman, 1992). We frequently encountered *Boa constrictor* on Calabash Cay, Lee (1996) examined specimens from Cockroach Cay and Grand Point, and according to the staff at Blackbird Resort these snakes are common on Blackbird Cay. Likewise Schmidt (1941) reported *Boa constrictor* from Turneffe Atoll, but gave no specific locality. Boas probably occur in mangrove and littoral forest habitats throughout the atoll. On 17 June 1995 a *Boa constrictor* (total length ca. 1.2 m) was observed swallowing a *Ctenosaura similis* on Calabash Cay. These abundant lizards probably constitute a significant portion of the diet in Turneffe Atoll.

Leptophis mexicanus hoeversi: This subspecies, originally described by Henderson (1976) from specimens collected on Cay Bokel, is endemic to the Turneffe Atoll. We found these snakes on Deadmans, Blackbird, Calabash, and Northern Cays, where they are common in both littoral and mangrove forests. *L. mexicanus hoeversi* differs from mainland subspecies in having a uniform green dorsum with only a faint indication of a post ocular stripe (Henderson, 1976). We also encountered numerous blue morphs, which have not been previously reported. Although mistakenly identified as *Leptophis ahaetulla*, a photograph of blue and green *L. maxicanus hoeversi* morphs we collected on Calabash Cay appears in Garel and Matola (1996: page 78). *L. mexicanus* were frequently observed pursuing *Anolis sagrei* on Calabash Cay.

[*Ramphotyphlops braminus*]: In 1994 Coral Cay Conservation Volunteers found a Blind Snake under beach debris on Calabash Cay. The snake was photographed and released. Our subsequent attempts to locate a specimen for positive identification were unsuccessful. According to Lee (1996) this snake was most likely *R. braminus*, a parthenogenetic species which has become widely established through inadvertent human transport. This species has been provisionally included on the Turneffe Atoll checklist pending collection of a specimen for verification.

Sauria
Anolis allisoni: Allison's Anole was previously known in Belize only from Half-Moon Cay, Lighthouse Atoll (Schmidt, 1941; Verner, 1959; Ruibal and Williams, 1961). Recently Meerman (1996) collected specimens on Long Cay, and Greg Smith (pers. comm.) reported observations from Northern and Sandbore Cays, Lighthouse Atoll. The nearest populations to Lighthouse Atoll are found in the Bay Islands of Honduras (Ruibal and Williams, 1961). Notable morphological differences occur between these populations, but Ruibal and Williams (1961) declined to accord them subspecific status. Allison's Anoles are common on Half-Moon Cay where the preferred habitat appears to be the crowns of coconut palms (Meerman, 1996).

[*Anolis carolinensis]*: The Carolina Anole is reported from Belize based on a single specimen collected on Half-Moon Cay in 1966 (Lee, 1996). Subsequent searches have failed to locate additional specimens (Lee, 1996), although Meeman (1996) observed several small adult anoles which appeared to be *A. carolinensis*. However, Lee (1996) stated "it is difficult to believe that two [*A. allisoni* and *A. carolinensis*] such closely related species could occur together. . ." and concluded that *A. carolinensis* is no longer present on Half-Moon Cay. We provisionally included the Carolina Anole on our checklist, but suggest further collecting is warranted to resolve this question.

Anolis sagrei: Brown Anoles were previously reported in Turneffe (Schmidt, 1941; Henderson, 1976; Lee, 1996), Lighthouse (Verner, 1959; Stoddart, 1962; Lee, 1996; Meerman, 1996), and Glovers (Schmidt, 1941; Stoddart, 1962; Meerman, 1995; Lee, 1996) Atolls. Our observations indicate they are extremely abundant in littoral forest, mangrove, and coconut plantations. In the latter, Brown Anoles were often the only lizards encountered. In addition to being taken by *Leptophis mexicanus*, predation by Great-Tailed Grackles (*Quiscalus mexicanus*) was also observed.

Basiliscus vittatus: These lizards are common on Calabash and Blackbird Cays, Turneffe Atoll, where they appear confined to beach scrub and littoral forest. Basilisk Lizards probably occur in similar habitat on other cays in the atoll. These observations constitute the first record of Basilisk Lizards in Turneffe Atoll.

Ctenosaura similis: Spiny-tailed Iguanas are abundant in Turneffe, Lighthouse (Schmidt, 1941; Stoddart, 1962; Lee, 1996), and Glovers (Schmidt, 1941; Stoddart, 1962; Lee, 1996) Atolls. In Turneffe Atoll we found Spiny-tailed Iguanas on Deadmans, Calabash, Blackbird, and Northern Cays, and Cay Bokel. These lizards have not been previously reported from Turneffe Atoll (Lee, 1996), although what Bond (1954) described "as an iguana-like lizard . . . with black bands across the back . . ." was undoubtedly *C. similis*. Numerous old nests and eggshells were found along beach ridges on Blackbird Cay, and a nest containing 18 eggs was inadvertently unearthed during a search for crocodile nests on Northern Cay. Two eggs were opened and contained well-developed hatchlings beginning to absorb the remaining yolk. Many nests appeared to have been unearthed by Raccoons (*Procyon lotor*), which occur throughout the atoll and probably represent a major nest predator. In addition to predation by *Boa constrictor* (see above), the remains of a juvenile *C. similis* were flushed from the stomach of an American Crocodile (Platt and Thorbjarnarson, 1997).

On Half-Moon Cay, Lighthouse Atoll *C. similis* are restricted to remnants of native vegetation on the western half of the island (Meerman, 1996). Mostly adults, and few juveniles and subadults were observed. Meerman (1996) concluded this age distribution may be due to rat pradation on the smaller size classes. In contrast, on nearby Long Cay where rats, although present, are less numerous, many subadults and juveniles were observed and the age distribution appeared normal (Meerman, 1996).

Iguana iguana: Green Iguanas have only been reported from Half-Moon Cay, Lighthouse Atoll and do not occur on any other offshore island in Belize (Schmidt, 1941; Verner, 1959; Lee, 1996). The origin of the Half-Moon Cay population is speculative. Arrival by natural means, such as swimming or rafting is possible, but given the absence of Green Iguanas on cays closer to the mainland, it is generally believed this population resulted from human introduction. The highly esteemed flesh is known locally as "bamboo chicken", and Green Iguanas may have been introduced as a food source, perhaps by British privateers in the 1800's, to be utilized by passing ships. Green Iguanas now occur only in Ziricote forest on the western half of the island, and are absent from coconut plantations. Meerman (1996) found only large adults; juveniles and subadults were absent, possibly due to rat predation.

Mabuya unimarginata: Lee (1996) examined specimens of *M. unimarginata* from Cay Boke. We encountered two skinks on Calabash Cay: the first under a pile of palm fronds (20 May 1994), and the second inside an arboreal termite nest (16 June 1995). Neither skink could be captured, but both appeared to be *M. unimarginata.*

Phyllodactylus insularis: This species was originally described by Dixon (1960) from specimens collected on Half-Moon Cay, Lighthouse Atoll. These geckos also occur on Long Cay, Lighthouse Atoll (Meerman, 1996), and Long Cay, Lighthouse Atoll (Meerman, 1996), and Long Cay, Glovers Atoll (Meerman, 1995). Island Leaf-toed Geckos are common on Lighthouse Atoll beneath rocks and woody debris, and in coconut palms (Lee, 1996; Meerman, 1996). *P. insularis* in Glovers Atoll were found inside of decaying and hollow coconut trees and beneath fallen palm fronds (Meerman, 1995). According to Lee (1996) subadults occur exclusively beneath surface objects, while adults are found only on palm trunks, suggesting ecological segregation by age or size class. Meerman (1996) observed predation by rats, which may constitute a significant source of mortality for Half-Moon Cay populations.

Phyllodactylus tuberculosus: Lee (1996) reported Leaf-toed Geckos from Cay Bokel, Turneffe Atoll, and we found them to be common in the MRC buildings on Calabash Cay in 1997. Additionally, Lee (1996) reported *P. tuberculosus* from Long Cay, Glovers Reef, although Meerman (1995) did not record this species.

In addition to four species of marine turtles found in Belizean coastal waters, Lee (1996) lists six species of reptile (1 crocodilian, 2 snakes, and 3 lizards) occurring in Turneffe Atoll, five species of lizards from Lighthouse Atoll, and three species of lizards from Glovers Atoll. No amphibians were reported from any atoll. Our efforts have added one amphibian, one terrestrial turtle, and two lizards to the species list for Turneffe Atoll, and a lizard to the known herpetofauna of Glovers Atoll (Table 1). Future efforts will likely yield additional species.

CONSERVATION

While Turneffe Atoll remains under increasing pressure for development, there has been considerable recent interest in designating parts of the atoll as a national park (Zisman, 1996). Destruction of terrestrial habitat is the greatest threat to the herpetofauna of Turneffe Atoll. Platt and Thorbjarnarson (1997) stressed the need to protect known crocodile nesting beaches and associated brackish and freshwater lagoons which provide nursery habitat for hatchlings. In the absence of habitat protection, development will deprive crocodiles of suitable nesting sites and recruitment may drastically decline and perhaps cease. Protection of crocodile nesting beaches will also ensure the future availability of nesting sites for marine turtles. Thus, every effort should be made to include known and potential nesting crocodile nesting sites within the boundaries of any proposed national park.

Moreover, efforts should also be made to extend protection to the littoral forest remaining in Turneffe Atoll. Because littoral forest is confined to beach ridges, which are often the only elevated sites in an area otherwise at or only slightly above sea level, this habitat has been extensively cleared for development and is now considered critically endangered (McField et al., 1996). However, significant tracts remain on Blackbird, Calabash, and Deadmans Cays. It is likely that most terrestrial species in the atoll, including invertebrates, birds, and mammals, are dependent to some extent on littoral forest, and without protection a major loss of species can be expected to occur.

Half-Moon Cay is a National Monument managed by the Belize Audubon Society for the protection of the Red-footed Booby nesting colony and endemic lizards. Because introduced rats may constitute a threat to booby chicks and lizards, a campaign of rat eradication is urgently needed. Past attempts to reduce rather than eradicate rats have proven unsuccessful because of their high reproductive potential, and abundant food and water provided by coconuts. The number of rats present on this small island is phenomenal, and during short nocturnal walks literally hundreds were observed by headlight. To ensure success, however, any eradication program must have the goal of total elimination. If even a few rats remain on the island the population will certainly recover in several years.

The immediate removal of all Coconut Palms in the Ziricote forest, and a gradual elimination of Coconut Palms from the rest of the national monument is also recommended. While Coconut Palms do have some scenic value in the atoll, they are an exotic species common elsewhere, displace and prevent regeneration of native vegetation, and are responsible for the presence of excessive numbers of rats. Thus, Coconut Palm removal on Half-Moon Cay should be accorded high priority. Removal should be gradual, as an aggressive program could result in immediate famine among the rats, which may increase predation on birds and lizards. A program of sustained rat eradication coupled with Coconut Palm removal would be most likely to reduce risks to native wildlife. As Coconut Palms are removed, Saltwater Palms should be re-established to provide replacement habitat for geckos and anoles.

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Table 1
Checklist and status of amphibian and reptile species found in the Turneffe, Lighthouse, and Glovers Atolls, Belize.
Asterisk denotes locality records not previously reported

Species	Turneffe Atoll	Lighthouse Atoll	Glovers Atoll	Status/Comments
AMPHIBIA				
Bufo marinus	X*			Rare
REPTILIA				
Crocodylia				
Crocodylus acutus	X	X*		Uncommon; nesting Turneffe and Lighthouse Atolls
Testudines				
Caretta caretta	X	X	X	Rare; nesting Lighthouse and Glovers Atolls
Chelonia mydas	X	X	X	Rare; nesting Lighthouse and Glovers Atolls
Eretmochelys imbricata	X	X		Declining; nesting Turneffe and Lighthouse Single record
Rhinoclemmys areolata	X*			Rare
Serpentes				
Boa constrictor	X			Common
Leptophis mexicanus	X			
[*Ramphotyphlops braminus*]	?			Unconfirmed
Sauria				
Anolis allisoni		X		Common
[*Anolis carolinensis*]		X		Extinct?; Single record
Anolis sagrei	X	X	X	Abundant
Basiliscus vittatus	X*			Common
Ctenosaura similis	X*	X	X	Common
Iguana iguana		X		Declining?; Half-Moon Cay only
Mabuya unimarginata	X			Rare
Phyllodactylus insularis		X	X*	Common
Phyllodactylus tuberculosus	X		X	Common

HERPETOFAUNA OF THASSOS, NORTH AEGEAN SEA, GREECE

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In a recent paper an account was given of the amphibians and reptiles of Thassos (Clark 1993). Further investigations undertaken by me in June and early October 1997, as well as exchange of correspondence with Kevin Hingley in 1995, indicate the need for a revision. Some former identifications are open to doubt and two further species can be included. There have been no forest fires on Thassos since 1993 and the scars of fire damage in the 1980s have largely healed, partly due to a re-forestation project and the natural reclaiming of burnt areas by secondary growth – bracken and scrub. In 1990 the devastated forests presented a tragic sight.

Part 1 is a result of field work carried out in 1997 and Part 2 a review. The localities mentioned in the text can be located on any good map of Greece.

PART 1

BUFONIDAE

Bufo bufo spinosus Daudin 1803 Common Toad. On June 27th two adult specimens were found dead on the gravel road above the village of Maries. This seems to be the first record from Thassos.

Bufo v. viridis Laurenti, 1768 Green Toad. Several adults in a stream bed at Skala Potamias along with numerous larvae. These were repeatedly seen during the summer visit. Tadpoles were observed feeding on a dead adult. Baby toads were found in roadside ditches and damp areas. In October four adults were found as road casualties.

HYLIDAE

Hyla a. arborea (Linnæus, 1758) Tree Frog. This species was identified from two examples heard calling at Skala Potamias in October.

RANIDAE

Rana dalmatina (Bonaparte, 1840) Agile Frog. The most interesting find in 1997. One specimen was seen in October amongst light undergrowth on the edge of a track at Skala Potamias. The weather had been cooler with rain shortly before my arrival but then turned warmer and drier. Buttle (1989) records it on the nearby mainland.

Rana graeca Boulenger, 1891 Stream Frog. In the summer larvae were found in a mountain stream above Prinos and in roadside ditches in the same region at around 700-800m. Both partly and completely metamorphosed froglets were also seen. A revisit to the same localities in October was negative.

Rana r. ridibunda (Pallas, 1771) Marsh Frog. Not found in the summer but common in October in the river running from Theologos to Potos, both juveniles of the current year and adults, the largest being about 12cm in length. The colouration varied: brown to brilliant green; none had a light vertebral stripe. In a mountain stream one adult was seen which was dull olive in colour with black bars on the limbs and dorsum.

TESTUDINIDAE
Testudo graeca ibera (Linnæus, 1758) Spur-thighed Tortoise. Six adults were found in the summer: three adults on a track between the villages of Panayia and Potamia and two near a river amongst thick vegetation above the village of Maries. At Skala Potamias tortoise tracks were found on the sand dunes behind the beach. One tortoise had heavy tick infestation. None were found in October.

ANGUIDAE
Ophisaurus apodus thracius (Obst, 1978) Glass Snake. Common in the summer when 12 adults were found, five living, the others either as road casualties or deliberately killed. The largest measured 90 cm in total length but this was the only live example caught. Not found above about 300m altitude.

LACERTIDAE
Lacerta v. viridis (Laurenti, 1768) Green Lizard. Abundant both in the summer and the autumn. In October juveniles greatly exceeded the number of adults. Most young were plain brown though some had a trace of dorso-lateral striping. The adults varied in coloration and markings: males often brilliant green with black stippling, females green, olive, brown or green on the first half of the body, brown on the latter either with or without the dorso-lateral striping. Found in the lowlands and well in to the mountains but generally where there was vegetation and often near water. Open rocky and dry habitats were shunned.

Ophisops elegans macrodactylus (Berthold, 1842) Snake-eyed Lizard. This species was only found in October and then in small numbers. Seven were seen at Alyki, two at Potos and one close to Theologos. This lizard prefers dry, well-exposed sites with broken ground in the vicinity of low scrub and isolated bushes. Damp localities, dense vegetation and heavily shaded regions are avoided. These habitat requirements restrict its distribution on Thassos.

COLUBRIDAE
Coluber jugularis caspius (Gmelin, 1789) Whip Snake. Four specimens were seen in the summer, three of which had been killed. The single living example measured 135 cm and was found at Skala Potamias, the others in low-lying localities in the same region. In October a further three dead specimens were encountered and a freshly cast skin about 100cm in length, also near Skala Potamias.

Malpolon monspessulanus insignitus (Hermann 1758) Montpellier Snake. Seven examples found in the summer, but only two alive. Five of these, including three juveniles, were seen between Kinara and Astris. The remaining two were observed in the central mountains at over 700 m.

Natrix n.persa (Linnæus, 1758) Grass Snake. An interesting find since records of this snake on Thassos are few. Two specimens were seen in a mountain stream, at the same locality as *R.graeca* tadpoles, in late June. The neck patches were a deep yellow, and the body barring dark. Total lengths around 50 cm.

PART 2

The checklist is divided into two parts: **A** – confirmed records, **B** – dubious records. It is evident that Thassos has been neglected compared with other islands (groups) and much of the information listed in Ondrias (1968) and Chondropoulos (1986, 1989) is based on old records, in many cases pre-war. Some species are seldom encountered, either due to seasonal preferences, or scarcity. Especially can be mentioned *Typhlops vermicularis* representing the first case and *Tenuidactylus kotschyi* the second. In recent years significant contributions have been made by Yeomans and Laister who visited Thassos in May 1989 and 1990, probably the optimum month. Comments are given for species which are of special interest or where there lingers doubt as to identity.

LIST A

BUFONIDAE *Bufo bufo spinosus* Common Toad. *Bufo v. viridis* Green Toad.
HYLIDAE *Hyla a. arborea* Tree Frog;
RANIDAE *Rana. dalmatina* Agile Frog. *Rana graeca* Stream Frog. *Rana r. ridibunda* Marsh Frog
EMYDIDAE *Mauremys caspica rivulata* Stripe-necked Terrapin
TESTUDINIDAE *Testudo graeca ibera* Spur-thighed Tortoise
GEKKONIDAE *Hemidactylus t. turcicus* Turkish Gecko. *Tenuidactylus kotschyi bibroni* Naked-fingered Gecko. Both these species seem uncommon.
ANGUIDAE *Anguis fragilis colchicus* Slow Worm – listed by Chondropoulos (1986) quoting Cyren (1993) and Werner (1938) but not found in recent years. *Ophisaurus apodus thracius* Glass Snake.
LACERTIDAE *Lacerta v. viridis* Green Lizard; *Ophisops elegans macrodactylus* Snake-eyed Lizard.
TYPHLOPIDAE *Typhlops vermicularis* Worm Snake – first recorded in 1989 by Andrew Laister (Clark 1993).
VIPERIDAE *Vipera ammodytes meridionalis* Long-nosed Viper.

LIST B

TESTUDINIDAE *Testudo marginata* Marginated Tortoise. The inclusion of this species rests on the identification of a single specimen, agreeing with the description given in Arnold, Burton & Overton (1978), found by Laister in 1989. In deciding whether Laister's identification is correct one should remember a) old examples of *T.graeca* resemble *T.marginata* b) Thassos lies outside the known range of *T.marginata.* The most northerly and easterly locality is from Mt. Vermion near Veroia in central Macedonia, at least 200 km. west of Thassos (Loumbourdis & Kattoulas 1983). However there are isolated reports of *T.marginata* from scattered localities outside the established range: the Cycladean islands of Paros (Clark, 1970), Milos (Cattaneo, 1984), Syros and Naxos as well as Chios (Dimitropoulos, 1987). The fact that these tortoises are fairly common on Chios led Dimitropoulos to the conclusion that they could have been deliberately introduced in historical times and managed to establish themselves. The occasional specimen that turns up on the Cyclades is more likely to have escaped from captivity or been released by its owner. If one accepts Laister's diagnosis then the occurrence of this species on Thassos is due to introduction.

SCINCIIDAE *Chalcides o.ocellatus* Eyed Skink. This species is not included in the herpetofauna of Thassos by Chondropoulos (1986). The species was supposedly sight-identified by Yeomans (Laister, pers.comm.) and also by a companion to Kevin Hingley in 1995. Hingley (pers.comm.) doubts this latter identification, suspecting confusion with

Lacerta viridis which is quite variable in coloration, sometimes even orange in ground colour. On the unsatisfactory nature of these observations I feel that more evidence is needed to establish the occurrence of this lizard on Thassos.

LACERTIDAE *Podarcis t.taurica* Balkan Wall Lizard. According to Yeomans (1993), Laister (pers.comm.) and Hingley (pers.comm.) this species is common on Thassos. Again I suspect misidentification and confusion with young and half-grown *L.viridis.* Despite several visits to Thassos I have never seen it although it occurs on the mainland (Buttle, 1989; Clark unpublished). A subspecies. *L.t. thassopoulae,* occurs on Thassopoula island between Thassos and the mainland port of Keramoti.

COLUBRIDAE *Coronella austriaca* Smooth Snake. Gruber (1979) states that this species "could with certainty be expected also on Thassos" based on the occurrence of this snake on neighbouring Samothraki. Since Samothraki has some species which do not occur on Thassos viz. *Lacerta trilineata, Podarcis muralis, Podarcis erhardii,* and *Elaphe longissima* it seems unwise to make assumptions.

Elaphe quatuorlineata sauromates Four-lined Snake. Listed by Chondropoulos (1989) who quotes Gruber (1979). If this species occurs it is rare. This is so on the mainland Kordges & Hemmer, (1987), a fact that I can confirm. Despite many investigations in northern Greece I have only found one specimen and that was just over the border in Turkish Thrace (Clark, 1973). In the summer of 1997 I found one example of the nominate form in the foothills of Vrontou mountain, village of Orini. Gruber's paper contains certain distributional errors, e.g. that *E.quatuorlineata* exists on the eastern Aegean islands. Here *Coluber nummifer* (*C.ravergieri*) has a wide distribution and has sometimes been mistakenly identified as *E.quatuorlineata*, e.g. on Kos (Lotze, 1977).

SUMMARY

The herpetofauna of Thassos consists of 5 amphibians (2 toads, 3 frogs) and 14 reptiles (1 tortoise, 1 terrapin, 6 lizards, 6 snakes), a total of 19 species. The possibility that some of the species mentioned in List B may also occur brings the total to a potential 24. In addition a further two species need to be considered: *Ablepharus kitaibelli,* Snake-eyed Skink, and *Emys orbicularis,* European Pond Tortoise. As I have indicated (Clark, 1993) the apparent absence of the former species is curious considering its otherwise ubiquitous range. This little skink prefers cool, dampish situations and is most commonly found in the early spring and autumn. *E.orbicularis* has recently been recorded from Samothraki (Broggi, 1988) where it is sympatric with *Mauremys caspica.*

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REPRODUCTION OF THE RUFOUS-BEAKED SNAKE, *RHAMPHIOPHIS OXYRHYNCHUS* (COLUBRIDAE, LAMPHROPHIINAE)

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INTRODUCTION

Data are generally lacking for most aspects of the reproductive biology of an African rearfanged snake, the Rufous-Beaked Snake (*Rhamphiophis oxyrhynchus*). Oviposition has been reported to occur in the wild during December-January (Sweeney 1959, 1961, Branch 1988, Marais 1992) and August (Loveridge 1928). Pitman (1974) found a gravid female on 27 October and reported the duration of incubation as about "3 months". Clutch size has been recorded as between six (Sweeney 1961) and eighteen (Marais 1992) eggs.

The only details report covering a clutch incubated to term and producing viable hatchlings was that of a female *Rhamphiophis oxyrhynchus rostratus* at the National Zoological Park (NZP, Washington, D.C.) by Walsh and Davis (1978). Subsequently, additional clutches have been recorded at the NZP. Data concerning these clutches, eggs, and hatchlings, as well as courtship and mating, the period between copulation and oviposition, incubation period, and female reproductive output are presented below.

METHODS AND MATERIALS

Two female *Rhamphiophis oxyrhynchus rostratus* produced 27 clutches containing a total of 314 eggs during an 18-year period (June 1976-March 1994) at the NZP. The first female (no. 301586) was wild hatched in South Africa and was received 9 June 1976. A second female (no. 303644) was a daughter of female 301586 that hatched at the NZP on 4 June 1983.

Three males were involved in all but one of the 27 recorded clutches (female 301586 laid a clutch of nine infertile eggs on 16 June 1976 during quarantine before being placed on display with a male). Male (no. 301215) was wild-hatched in South Africa and was obtained 11 March 1976. The second male (no. 303645) was an offspring of male 301215 and female 301586 hatched at the NZP on 6 June 1983, and a clutch sibling of female 303644. The third male (no. 304943) was a backcross offspring of male 301215 and female 303644 that hatched at the NZP on 2 July 1986.

The various pairings (one male with one female) of *R. oxyrhynchus* were housed on exhibition in a glass-fronted 84 x 63 x 100 cm ventilated cage. The floor of the cage was covered with 10 cm of peagravel, and a hollow log provided shelter for the snakes. Plastic plants simulated a natural habitat. Temperature in the exhibit cage was maintained with a heat lamp and fluctuated about 6.0°C between day and night, averaging 26.7°C diurnally and 21.0°C nocturnally. Extreme temperatures recorded were 32.2°C and 17.0°C. Overhead skylights provided a natural photoperiod. An ultraviolet light was suspended above the screened top of the cage. The cage was misted with water daily, and a bowl of drinking water was constantly available for the snakes. Diet generally included one mouse (*Mus musculus*) per snake per week.

Females used their snout to rake out and make a depression in the peagravel, typically under the hollow log, in which they deposited eggs. The date of oviposition was recorded for each egg, and the eggs were carefully removed from the cage, weighed, and measured for length and width to the nearest 0.1 mm with a dial calipers. Total egg mass was recorded for each clutch. Selected eggs were then placed either in a 60 x 60 x 30 cm styrofoam box or in 4.4 litre (gallon) jars on sphagnum moss. Eggs were positioned on 4 cm of potting soil in 15 x 10.5 x 17.5 cm plastic containers, and then incubated at 28.0-29.0°C on a 30-cm layer of peagravel covering two lengths of subterranean 125 W heat tape.

Periodically the eggs were candled to determine fertility and monitor embryonic development. Collapse of the eggs, indicating water loss was noted; shell collapse is a normal event during incubation. The hatching date of each egg was recorded, and, within hours of emergence from the egg, the neonate body mass and total length (TBL) of each hatchling were recorded. Egg and hatchling weights were recorded on a triple beam balance. the snout-vent length (SVL), tail length (TL), head length (HL), and head width (HW) were also recorded for a litter of 15 hatchlings after preservation.

Egg, hatchling, and female body size measurements were compared descriptively, as well as with linear regressions. Assumptions for the regressions were analyzed graphically (Cleveland 1993). All regression results are stated with the independent variable given first. A few two-sample t-tests were also employed. All regressions and t-tests were performed using the SAS system (SAS Institute, Inc. 1990). The level of alpha was 0.05 for all statistical tests.

RESULTS AND DISCUSSION

COURTSHIP, MATING AND OVIPOSITION

Both courtship and mating behaviours by *Rhamphiophis oxyrhynchus* have been observed at the NZP. Reproductively ready males repeatedly pursued females. Courtship involved swaying the head and anterior neck from side to side in a jerky manner while peering about by both sexes, and much tongue flicking by the male. During copulation, the bodies of both sexes were usually stretched out on the floor of the cage with the male lying on the female's back.. His head was placed on top of her's, and their bodies pulsated in a jerky manner every few seconds. The male's tail was loosely wrapped around that of the female, with their cloacal vents in contact and one hemipenis inserted into the female's cloaca. The two copulations observed lasted from 20 minutes to 2-3 hours. Periods of inactivity alternated with periods of intense activity, and after separating the snakes usually retreated into the cover of the hollow log.

Three matings were observed in 1977 on 15 February, 22 March, and 19 April. Courtship activity also was recorded on 28 March 1982. A clutch of seven eggs (five fertile, two infertile) was laid on 21 April 1977. If these eggs were fertilized on 15 February, the interval between copulation and oviposition was 65 days, but, if fertilization occurred on 22 March the interval was only 30 days. After the courtship activity on 28 March 1982, a clutch of 10 eggs (not incubated) was laid 29 days later on 26 April. A second clutch

Rufous Beaked Snake, *Rhamphiophis oxyrhynchus*

Rufous Beaked Snake, *Rhamphiophis oxyrhynchus*

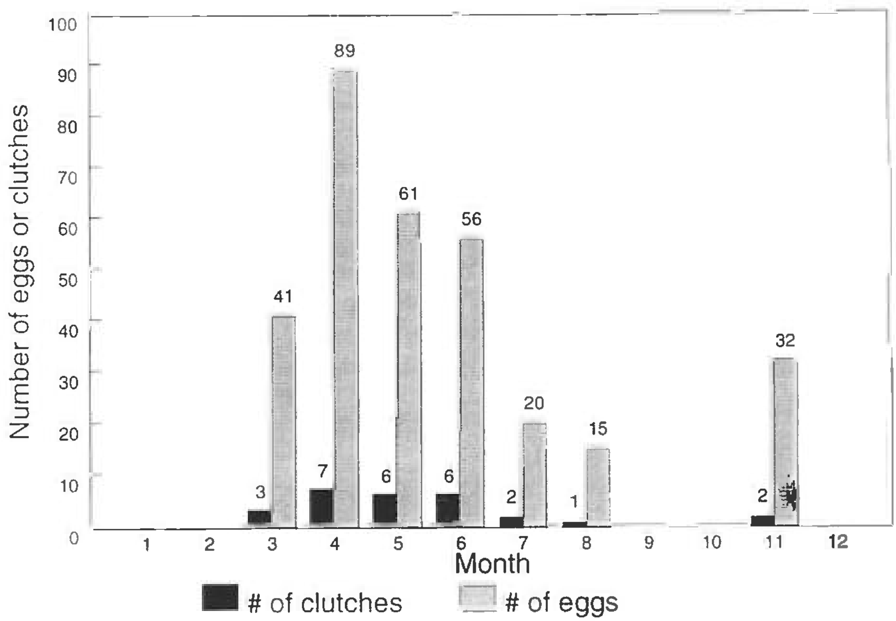

Fig. 1. Number of clutches and total eggs produced by *Rhamphiophis oxyrhynchus* per month

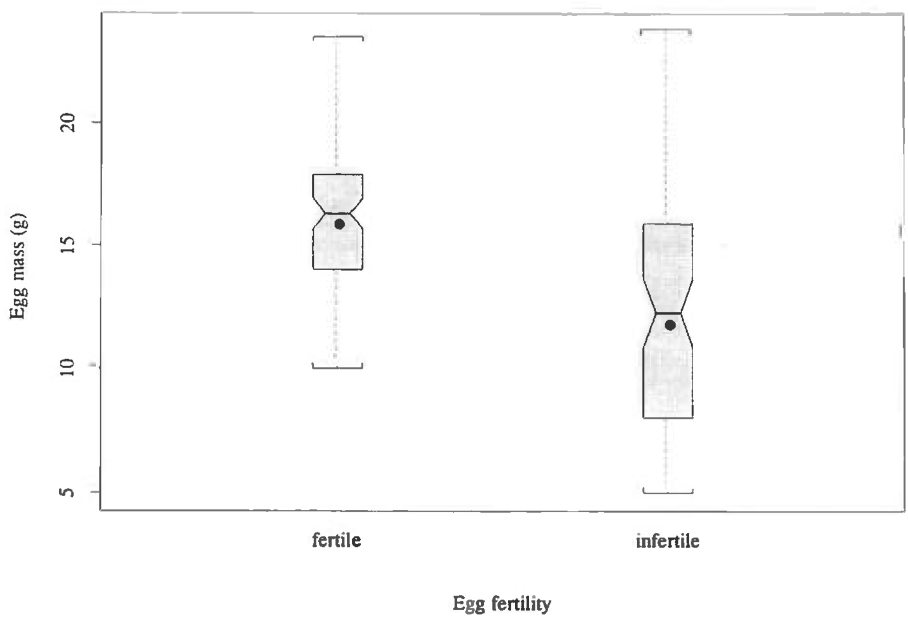

Fig. 2. Comparison of egg mass in fertile and infertile eggs of *Rhamphiophis oxyrhynchus.*

composed of 9 eggs (laid 12-13 June 1982) was oviposited 76-77 days after the 28 March courtship behaviour was noted. If the above clutches were produced from the observed reproductive activities, an average interval between copulation and oviposition would be 55.4 days (29-77 days); however, unobserved matings may have occurred. It is also possible that the clutch laid 12-13 June may indicate sperm storage ability by female *Rhamphiophis oxyrhynchus.*

Clutches were laid from March through August and in November, with most oviposition in April (7 clutches), May (6 clutches) and June (6 clutches) (Fig. 1). Multiple clutches were laid in some years. Female 303644 produced four clutches totalling 62 eggs within an eleven-month period: 16 April 1989 (18 eggs), 12 June 1989 (14 eggs), 14 November 1989 (15 eggs), and 5 March 1990 (15 eggs). She also laid three clutches (43 eggs) in another seven month period: 7 November 1986 (17 eggs), 13 April 1987 (15 eggs), and 29 May 1990 (11 eggs). In each series there was a decrease in the number of eggs laid after an initial large clutch. An average of 54.7 days (48.5-68.0) elapsed between ovipositions by female 301586 during the years she laid more than one clutch. Duration between ovipositions by female 303644 averaged 125.4 days (44-217)), but several of these clutches were laid at mean intervals of only 50.5 days (44-57). Disregarding the two longest intervals between ovipositions by female 303644, the mean duration between the laying of clutches by both females was 53.5 days. Based on these durations, we believe a period of 50-55 days between clutches to be normal. This closely matches the 55.4 days between copulation and oviposition calculated above.

Mean clutch size and clutch mass were significantly different between females 301586 and 303644 (t-test, $p<.001$). Difference in the clutch masses oviposited by the two females is explained by the fewer eggs per clutch by female 301586, mean = 8.5 (6-11), versus a mean of 15.0 eggs (11-18) for female 303644. The discrepancy between the numbers of eggs per clutch is not easily explained.

Shine and Seigel (1996) showed that clutch size differs more in snake species with relatively variable adult female body lengths, and that there is a high rate of increase in clutch size with increasing female length. The two factors act to magnify the extent of clutch size variability brought about by differences in maternal body sizes. Unfortunately, lengths of the two females were not recorded, so no body length/clutch size relationships could be determined. (The literature also is devoid of such data for this species, but a record exists. Field notes accompanying a female in the reptile collection of the United States Museum of Natural History [USNM 206944] collected 27 December 1977 in Tanzania state that she had a TBL of 133 cm [SVL 91.5 cm], was very fat, especially in the area of the oviducts, and contained "16 (?)" eggs, each approximately 32 x 10 mm). In addition, although the age of female 303644 was known since she had been hatched at NZP, that of the wild caught 301586 was unknown, so no age/clutch size comparisons could be made between the two females; however, the relationship of clutch size to female age was not significant in female 303644.

Clutch size and mass in oviparous snakes are known to differ with variance in available resources (Seigel and Fitch 1985, Ford and Seigel 1989b, Seigel and Ford 1991). Since both female *Rhamphiophis* were maintained under the same habitat conditions and feeding regime, resource variance can not explain the difference in clutch sizes between the two individuals.

Most likely the difference in mean clutch size between the two females is simply an indication of the normal variance (phenotypic plasticity, Seigel and Ford 1991) in fecundity within *Rhamphiophis oxyrhynchus.*

REPRODUCTIVE CAPACITY

An idea of reproductive capacity can be determined by examining the individual egg output of the two female *Rhamphiophis*. Female 301586 lived until 20 March 1985 and laid 14 clutches, totalling 119 eggs during her confinement at the NZP, 13 clutches were sired by male 301215 (110 eggs). Forty-four young hatched from these eggs, including female 303644, who, herself, laid 13 additional clutches between 1985 and her death on 26 May 1994 (195 eggs, 44 hatchlings). Three of these clutches were sired by male 301215 (48 eggs); nine clutches were fathered by her F_1 litter mate 303645 (131 eggs), and one clutch of 16 eggs was sired by male 304943. Combined mean clutch size for the two females was 11.6 eggs (6-18) (see above).

EGGS

Mean measurements for eggs were: length 46.5 mm (28.6-71.0, n = 270), width 22.2 mm (14.1-29.1, n = 263), mass 14.8 g (5.0-23.7, n = 270), and clutch mass 171.16 g (62.8-321.8, n = 25). Mean egg mass vs. mean egg length, and clutch mass vs. mean egg length were not significant, but mean egg mass vs. mean egg width ($p<.0001$, $R^2 = 0.69$), clutch mass vs. mean egg mass ($p<0.0002$, $R^2 = 0.48$), and clutch mass/mean egg width ($p<.0001$, $R^2 = 0.67$) were. In addition, female age vs. mean egg width was significant ($p<.01$, $R^2 = 0.54$).. Ford and Seigel (1989a) found that when adjusted for female length increasing clutch size in snakes is negatively correlated with egg length and usually egg mass.

No significant differences were found between the lengths and widths of 90 fertile eggs and 61 infertile eggs (condition of most eggs not recorded); but the masses of fertile and infertile eggs were significantly different (t-test, $p<0.02$; Fig. 2). The average mass of fertile eggs was 16.6 g (12.7-21.7), whereas that of infertile eggs was 12.3 g (6.9-16.3).

HATCHLINGS

In contrast to the plain tan dorsal body colouration of adults, hatchlings were darker brown with light flecks. They had the following mensural characteristics: mean TBL 35.0 cm (28.0-41.2, n = 60), mean SVL 26.9 cm (24.6-29.4, n = 15), mean TL 10.3 cm (8.6-11.9, n = 15), mean HL 1.5 cm (1.3-1.7, n = 15), mean HW 0.7 cm (0.6-0.8, n = 15), and mean mass 11.7 g (6.2-14.5, n = 45). Both SVL ($p<0.001$) and TL ($p<0.0358$) were significantly related to TBL.

The relationships of hatchling TBL to female age and clutch mass, and hatchling mass to female age and clutch size were not significant. However, hatchling TBL was significantly related to clutch mass ($p<0.04$, $R^2 = 0.52$), as was also hatchling mass ($p<0.04$, $R^2 = 0.47$). Heaviest clutches produce the largest offspring.

Reproductive biology of most lamprophine snakes is unknown. Comparative studies similar to this would be very helpful in determining management programs and proper captive husbandry. Especially needed are reproductive data on the other species of *Rhamphiophis*, and on wild populations of *R. oxyrhynchus*.

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AN ACCOUNT OF THE CARE AND BREEDING OF *HETRIXALUS ALBOGUTTATUS* (BOULENGER, 1882), ALONG WITH A DESCRIPTION OF THE TADPOLE

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The Genus *Hetrixalus* are small to medium sized (18-40 mm), brightly coloured Madagascan treefrogs belonging to the large African family *Hyperoliidae* (Glaw & Vences, 1992).

Glaw & Vences (1992), give a full diagnostic description of this endemic genus. It is speculated that *Hetrixalus*, along with other endemic Malagasy Anuran sub-families, evolved in-situ after the island separated from mainland Africa (Duellman & Trueb, 1986).

Hetrixalus occur outside of forest, being adapted to open savannah habitats, in eastern Madagascar (Glaw & Vences, 1992), with the climate being warm and humid, with annual rainfall being 1500-3000 mm, distributed throughout the year (Preston-Mafham, 1991).

It appears that this particular species has been (or is) seldom imported. The first authors were lucky enough to purchase two pairs in October 1995. Glaw & Vences (1992), in their introduction on the genus, state that males possess a yellow throat patch, this was not apparent in these specimens, however the sexes became distinguishable by the more rotund appearance of the females.

HOUSING

All four specimens were housed in a front-opening glass vivarium 45 x 45 x 60cm high. A glass strip sealed across the base provided a water area 45 x 12 x 12cm at the front; the rear land section was formed as follows:– a 2cm layer of large aquarium gravel 1cm of activated aquarium charcoal, covered by soil-based potting compost and topped with medium aquarium gravel which is finished off just below the level of glass strip. The land area sloped slightly towards the rear. The rear wall was covered with a slab of compressed cork granules, which had been roughened to provide a natural appearance. Furnishing consisted of driftwood, well soaked, and cork bark 'logs'. The land area was planted with Sweetheart vine (*Philodendron scandens*), Peace lilies (*Spathyphyllum spp*) and Ribbon plants (*Dracena sanderiana*) in the substrate and two Bromeliads set into the cork logs. (N.B. Planting should be done before adding the final layer of gravel). The water level was maintained approximately 1 cm below the top of the glass strip. Although the water area was planted with *Elodea spp.* regular water changes were required due to crickets drowning, in spite of a Styrofoam raft and overhanging leaves. As the plants thickened up the *Philodendron* leaves were positioned so they actually hung in the water.

The vivarium was situated in a warm room, which meant that additional heating was unnecessary. A 45cm full-spectrum tube, fixed inside the vivarium provided sufficient light for the plants – this had to be switched off in hot weather to prevent the temperature rising above the desired maximum. It is not claimed that full-spectrum light is essential for these frogs, which are strictly nocturnal but the authors use it for diurnal frogs such as *Dendrobatidae* and frogs which 'bask' in hot sunlight e.g. *Hylidae* and *Chiromantis spp.* A daytime temperature of around 26°C, dropped to around 18°C (with slight variations) at night. A photoperiod of 13 hours was maintained.

BREEDING

Regular spraying kept the land area wet with resultant high humidity (80-85%). Around the beginning of August 1997 spraying was withheld until the 20th September 1997. The water level gradually dropped to 1.5 cm but the land area retained sufficient moisture to prevent the plants from wilting. During this period, the previous daily feeding was reduced to once every five days or less if uneaten crickets were observed. The dry spell coincided with hot weather – the light was frequently switched off, but temperatures frequently rose to 28-29°C. Regular heavy spraying and feeding resumed on 22nd September 1997, by which time the temperatures were back to normal and the water level had been restored. From 30th September sporadic calling occurred overnight, especially in the early hours of the morning. Calling increased in frequency from 6th October and the first spawn was observed on the 11th October 1997. Most of the black eggs were adhering to *Philodendron* leaves below the water level – those above the water rapidly developed fungus, and a substantial number which had sunk to the bottom of the water were greyish in appearance and did not develop.

Hatching occurred around three to five days later. Tadpoles were difficult to spot due to being only 5-6 mm in length and remaining motionless during the day unless disturbed. Finely ground tropical fish flake food was provided daily but the large numbers of tadpoles soon necessitated removal of some to plastic aquaria containing 10 cm of water. The other tadpoles eventually had to be removed due to fouling of the water area in spite of regular water changes. Metamorphosis took between 112 and 120 days; the froglets measured on average 12 mm snout to vent (SVL) and a head width of 4.5 mm (n=5). Although Styrofoam rafts were provided the froglets preferred to climb up the aquarium sides. Those which remained longer in the main vivarium tended to be stunted, probably due to inadequate nutrition – because of the fouling less food had been supplied. Any surviving young exhibited poor growth rates and did not attain full size.

The majority of the froglets thrived in a moist vivarium feeding on *Drosophila* and small crickets dusted with multivitamin/calcium supplement.

At metamorphosis the coloration of the froglets was light cream, the dorsum having a 'pearly sheen', with a pale-greenish dorso-lateral stripe outlined in darker coloration running from each nostril to the posterior end. As growth progressed the line began to break up to become uneven. The body darkened slightly and large numbers of tiny black dots appeared. Gradually the adult coloration of gold spots on a black background was assumed. This was first observed on the 19th March 1998, although the orange areas, exhibited by the adults, remains pale at the time of writing (Mid-May 1998).

Periodic calling from the young frogs commenced on 15th March 1998, usually after spraying. Glaw & Vences (1992) noted that sexual maturity in wild specimens can be achieved in 4 months, for the closely related *Hetrixalus boettgeri*. However in *H. alboguttatus* this is considerably quicker, between four and six weeks in captivity for male specimens.

Table 1.
Measurements in mm for tadpoles of *Heterixalis alboguttatus*, raised in an aquarium

CHARACTER	Mean Measurement (mm) at Stage 25	Mean Measurement (mm) at Stage 38
	(n=4)	(n=9)
Total Length	11.5	38
Body Length	4	11.5
Internarial Distance	1	2.5
Interorbital Distance	1.5	4
Eye-nostril Distance	1	1.5
Dorsal Caudal Fin Height	0.5	2
Caudal Musculature Height	0.5	3

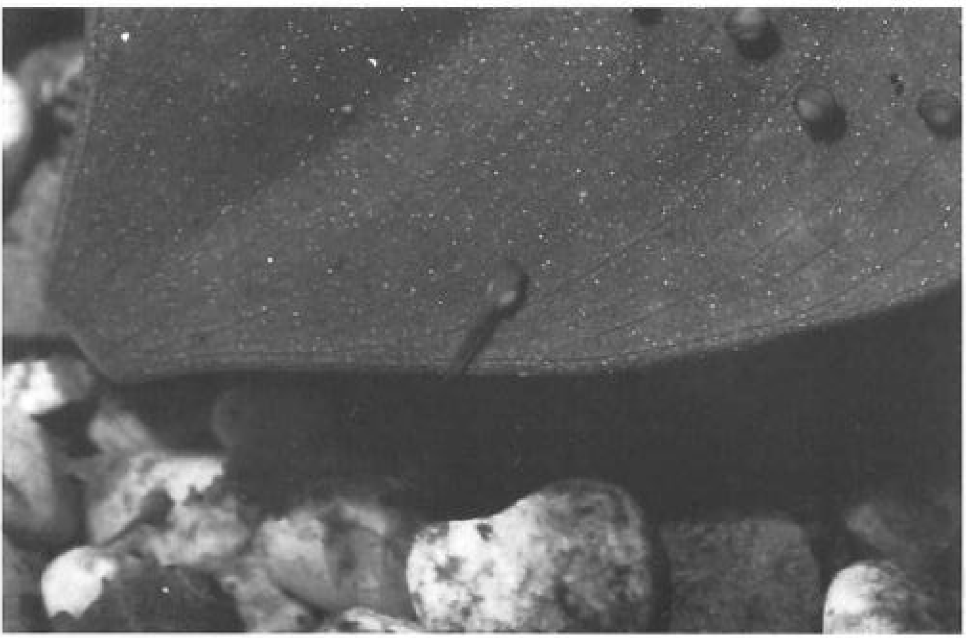

Plate 1. *Hetrixalus alboguttatus* eggs and tadpole.

Plate 2. ***Hetrixalus alboguttatus***, a newly metamorphosed froglet, note the lack of dorsal markings

Plate 3. ***Hetrixalus alboguttatus***, adult coloration just beginning to show behind the eye

Although the adults are strictly nocturnal the young specimens come out at feeding time, sometimes even waiting for food. However, this could be due to increased competition as several are housed together.

THE TADPOLE OF *HETRIXALUS ALBOGUTTATUS*

The tadpole of *Hetrixalus alboguttatus* is unknown, (Glaw & Vences, 1992). Following successful captive reproduction of this species, by the first authors, the following description was made. It is based on 4 tadpoles of *Hetrixalus alboguttatus* at stage 25 of Gosner (1960).

BODY MORPHOLOGY

Body oval in dorsal view, moderately depressed (wider than deep), body is deepest and widest at about 50% length of body; body length about 35% of total length; eyes dorsolateral, directed laterally; nostrils dorsolateral, directed anterolaterally, equidistance between snout and eyes; internarial distance is less than interorbital distance; chondrocranial elements visible through the skin of head; spiracle sinistral (left), spiracle opening directed posterolaterally, at about mid-length of the body; dorsal fin arises prior to the body-tail juncture, at 50% of tail length dorsal fin height is equal to caudal musculature depth, ventral fin about 50% of caudal musculature; tip of tail rounded.

COLORATION IN LIFE

The coloration was recorded in stage 25 larvae. Dorsum is dark fawn in colour with numerous darker brown stippling, Caudal musculature is pale fawn, with the caudal fin lacking pigmentation. Venter is pale and semitransparent, with heart, intestines, and oral musculature visible.

OVAL MORPHOLOGY

The following description is based on a stage 38 (Gosner, 1960) tadpole. This was chosen in preference to those at stage 25 because at the lower stages of development the oral structure was less well developed.

Mouth is small (18% of maximum body width), ventral, directed anteroventrally. One upper and three lower tooth rows. Rows on posterior labium shorter than the anterior. All tooth rows uninterrupted, third posterior row approximately 2/3 of second row, second row with medial V-shaped arrangement, equivalent in size to first posterior tooth row. Anterior tooth row larger than beak, with broad terminal V-shapes.

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SOME NOTES ON *GASTROPHOLIS PRASINA*

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Little was known about these lizards until one was brought in on 13 XII 85. Unable to identify it we wrote to Dr. E.N. Arnold of the British Museum with a brief description. Dr. Arnold suggested that it may be an example of *Gastropholis prasina* and he sent us a photograph of a sub-adult one taken in the Jalori Forest some weeks before. This we considered a reasonable confirmation. Our single specimen remained the only one for five years. During this time it laid a clutch of five infertile eggs. Regrettably it died within five days of our having a second specimen, a male, brought in. Since that time a number of specimens have been brought to us.

It appears that our first specimen was the first ever collected in Kenya and only the fourth one ever collected over the last 90 years. (Dr. E.N. Arnold).

SUPERFICIAL DESCRIPTION:

These are medium sized lizards. The normal adult size appears to be about 350 mm. long. Much of this is tail. They are a brilliant green dorsally fading to a more yellowish green ventrally in the body. There are fine black spots dorso-laterally along the tail. The femoral portions of the rear limbs are grey. The inside of the mouth and the tongue are a bright orange. These lizards are irascible and difficult to handle, proving resistant to accurate measurement when alive. Recently we had a female die so we were able to provide the following measurements and scale counts.

Length Total:	326 mm		This means that the tail is two and a half times the body length.
Nose to vent:	94 mm		
Vent to tail end:	232 mm		
Mid-body dorsal scales:	(tranverse)	29	
Mid-body ventral scales:	(tranverse)	15	
Caudal Scales:	(longitudinal)	142	
Ventral scales: Gular fold to vent:		38	
Femoral pores	Left:	13	
	Right:	14	

Gular fold. This is a fold ventrally on the neck which in this specimen consisted of 12 transverse enlarged scales, the largest in the centre and decreasing in size to each side. When the head is lifted a line bare of scales across the neck is exposed.

Dorsal scales are imbricate on the rear margins but appear not to be so. Ventral scales are oblong in unstaggered rows resembling schoolbook illustrations of the Roman military *testudo.*

There appears to be no sexual dimorphism apart from that the tail root of males appears to be slightly larger than that of females. Examination of a series could well provide other differences. At present all our other specimens are alive so close scrutiny is difficult.

These lizards are slender and bear a superficial resemblance to *Varanus niloticus* (Quoting Karl Schmidt. *The Herpetology of the Belgian Congo*).

OBSERVATIONS IN CAPTIVITY

Disposition

These are active, fierce little lizards and will not hesitate to attack anything they deem to be attackable. One determinedly attacked a ruler I put into a cage to measure it. A gecko, *Hemidactylus* Sp. was put in a vivarium with one of these lizards and was chased around until it dropped its tail. The green lizard promptly ate the wriggling discarded tail. A bite can draw blood from a human hand. Observation shows that these lizards are probably quite intelligent and can learn about feeding routines and watch carefully what is happening on the other side of the glass and will give any addition to the contents of the vivarium a thorough inspection. Males put together will behave aggressively towards each other and this usually results in a truncated tail in one or both.

Breeding in captivity

"A pair collected from the same hole in a tree were accidentally disturbed when the door was opened for feeding. I saw a movement, two lizards dropping from the higher branches of the vivarium furnishings. When I checked, the female was climbing back with difficulty because the male was on her back and the twigs on the cage furnishings were thin. The male had a grip with his mouth on the female's neck and his partly truncated but regrowing tail was twined around her. She came to rest on a thin twig with her neck and forelimbs over it and her body hanging to one side with only the toes of the upper hind foot holding on to the twig. The male suddenly shifted, his head going down to her groin and his vent opposite hers, his tail curling up and past her temporal region so he was encircling her pelvis. I could not see if copulation was actually taking place, nor could I see whether he was licking her vent but his head appeared to be doing so. After one minute his rear end dropped away while he held her with his mouth across the pelvis. She hauled herself up and he released her" – (S.R. Ashe).

FIELD OBSERVATIONS

Below are extracts from an account of observations sponsored by Bio-Ken, made by Peter Mashauri between 28 VII 96 and 11 VIII 96. & 12 VIII 96.

General observations

"28 VII 96, 7 am. I watched a hole about seven meters up a *Combretum scharmantii* tree, (Swahili & Giriyama name, Mugurure, Sanyo name Mugulule) I knew these lizards lived here but saw none until about 7.30 am when one came out of it's hole. The holes are usually small and narrow, but only about only half an inch of its head appeared. It saw me at once and went in again. I went elsewhere where it could not see me and it came out again. I saw it eat some insects around the hole but the distance was too great to see what the insects were. I noted that these lizards are so shy that they would stay in their hole a whole day if they could see that they were being watched. I did discover that they only leave their home in sunny weather, and then from about 7.30 to 11 am returning to

Fig 1. *Gastropholis prasina.* Line drawing by Lorna Depew

their hole about 1 pm, where they stay until about 3 pm when they go hunting until around 6 pm, when they go back to their hole for the night. They do not emerge if there are heavy clouds or rain.

Two further inhabitated holes were discovered where there were more than one lizard living in each. These are in *Dailium oriantale* trees, (Mpepita in Swahili, Mutsungwi in Giriama and in the Sanya language, Shoshole). One was four metres up and the other is six. These are not far from the main road and the lizards appear to be watching people passing between 100 and 300 metres distant, in one case five individuals.

Two nests which were under observation were seen to be taken over by Forest Cobras, *Naja melanoleuca.* Whether the previous occupants had been eaten by the cobra is not known but it may well be a new record of these snakes living five or seven metres up trees."

Mating

"Realising that there was much that I was missing because of the distance, I was lent a pair of binoculars and observed these lizards in the field from 12 VIII 96 to 20 VIII 96. The result was as below:

On the morning of 20 VIII 96 at 11 am, I saw a male come out of a hole and climb round the hole several times with his head in it and the female just looking out. I watched until 4 pm when the female came out. The male at once got onto her back and got a grip on her neck with his mouth. She slowly moved away from the hole and then the male bit the back of the female. They stayed like this for five minutes or so, then the male squeezed his tail under the female's and the female responded by lifting her tail and copulation started. They remained like this for about 20 minutes while I kept watching through binoculars. Then she showed signs of wanting to go by moving and lifting her head up and down. The male let her go and the female returned to the hole in the tree. The male watched her and then went in himself. I watched for five minutes and saw one head looking out of the hole. The time was 4.30 pm. I kept watching and at 5 pm the head vanished into the hole and did not come out again until I left at dark." – (Peter D. Mashauri).

INCUBATION AND YOUNG

Two specimens brought from the same location were placed in the same cage. They had not been seen to mate but may well have done so unobserved. On 20 IX 94 the female produced five eggs that were scattered in the cage, all but two were badly damaged. The undamaged ones were placed in a makeshift incubator in our laboratory. Incubation was at normal seasonal ambient temperatures, namely 26 to 29 degrees C with high humidity. On the morning of 24 XII 94 the two sound eggs were found to have hatched. The young lizards were found to be very active and their basic measurements were as follows:

Nose to tail: 115 mm. Nose to Vent: 78 mm. Tail 78 mm. I can only assume that the disparity between the body and tail ratios between the adults and the young is the proportionally larger heads of the neonates. The colour of the newly hatched specimens is the same as that of the adults except that the black spots along the tail are less visible in the newly hatched ones.
Unfortunately the eggs were not measured on being laid but they seemed to increase in size during incubation. After hatching they were 16 mms long and shaped like a bird's egg with one end tending to be more acute than the other. Clutches of eggs vary from 5 to 7 in number.

DIET

This is not precisely known in the wild though they were observed eating ants. In captivity they ate a wide variety of insects like cockroaches, grasshoppers, crickets termites, flying ants and beetles, both adult and larval. Their food of choice seems to wasp grubs. When food is scarce we feed out captive ones on eggs, boiled, raw or scrambled.

CONCLUSION

In the past there has been some discussion as to whether these lizards are arboreal or terrestrial. Our study has confirmed that they definitely are an arboreal form. They can infrequently be seen on the ground but always are moving from one tree or patch of forest to another (per. com. Mashauri). The tail is partly prehensile and the lizard can sometimes be seen depending solely by it. Although before these lizards were discovered in the Kenya Coastal Forest only three specimens were ever collected, they are perhaps more common than believed because their habitat is in and only just below the forest canopy.

ACKNOWLEDGEMENTS

Firstly we would like to thank local villagers for their help and for bringing in two specimens from their orchards bordering the forest. We owe a particular vote of thanks to the officials of The Forest Department and Kenya Wildlife Services, Mr. Mwashaha and Mr. Kirui for their sporting view and without their co-operation this paper would never have been written.

Mrs. Lorna Depew kindly volunteered to make a line drawing of the lizard for us (Fig 1). We owe particular thanks to Dr. E.N. Arnold of the British Museum for the information and help he has given us. We also thank Dr. Drewes of the California Academy of Sciences, Dr. Howell of the University of Dar es Salaam and Mr. Duff Mackay of the National Museums of Kenya for their interest and advice. We have presumed on their time and hope to do so more in the future.

CROCODILE FARMING WITH PARTICULAR REFERENCE TO EAST AFRICA

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INTRODUCTION

The Class Crocodilia consists of the crocodiles, alligators, caimans and gharials. There are twenty-three extant species but, in the past, many more existed (Frye, 1994).

Crocodiles are reptiles that are well adapted to life in water. While most are freshwater, one species is partly marine. The anatomy of crocodiles is dominated by their tough integument which, on the dorsum, is protected by plates of osteoderm. Internally, crocodiles have a well developed palate, a four chambered heart and a right aortic arch.

All crocodilians are oviparous. In many species the female constructs a nest of decaying vegetable matter and as this decomposes, the temperature rises and assists in incubation. Sex determination in crocodilians is temperature-related. Crocodilians are unusual amongst reptiles in that the nests are guarded by the mother (possibly the father) who also protects the young, often for a considerable period of time.

The Nile Crocodile *(Crocodylus niloticus)* is the most widespread of the three species of crocodile that are found in Africa. The Nile Crocodile is biologically similar to other crocodilians. It is an ectothermic vertebrate. The free-living crocodile reaches sexual maturity at between 20 and 35 years of age when the male is 3-3.3 m in length and the female is 2.4-2.8 m (Revol, 1995). The Nile Crocodile has one breeding season per year and eggs are laid in a hole made in the ground.

The legal status of the Nile Crocodile is relevant. It is listed on Appendix II of CITES. Therefore international trade is controlled (Cooper, 1987) and this influences farming and other commercial enterprises. Until fifteen years ago, Nile Crocodiles were hunted extensively in most parts of their range in Africa. More recently, controls on this have been introduced in many countries and crocodile farming has become popular. Much of the research to date on the farming of the Nile crocodile has been carried out in Zimbabwe (formerly Rhodesia) (Blake, 1974).

BREEDING TECHNIQUES

Eggs of crocodiles can be collected from the wild or produced (laid) in captivity. The former are usually detected using light aircraft, which locate the females, or by probing the ground with a rod. As a general rule, in East Africa, eggs are not collected until about 50 days after laying. The hatchability is then higher and the eggs are easier to monitor: predation before this time is, however, common. Eggs are transported carefully and, after cleaning and disinfection, are placed in incubation boxes, taking care that the eggs are not turned in the process. There are two main methods of incubating eggs, 1. using an artificial nest and 2. an incubation box. In both cases, hatching rates of 80-90% can be obtained. In the artificial nest, the eggs are placed in humid sand or similar substrate with complete reliance on solar heat. It is important to protect the incubation area from predators, using fences or walls. Hatching is obvious because of the noise made by the young crocodiles at this stage. The insulation box is an insulated container, filled with san, soil or vermiculite, in which eggs are buried. The box is then placed in an incubator maintained at 30-32°C, the approximate temperature in the wild. Relative humidity is kept high (above 60% and nearer 90-100%), usually by running through water.

The production of animals from eggs collected from the wild as described above, is termed "ranching". Crocodile "farming" implies that the animals are bred in captivity, in which case animals are allowed to mature and captive breeding is encouraged. Most Nile Crocodiles will not breed successfully until they are 8-10 years of age – this is considerably earlier than in the wild and is probably related to the higher rate of growth in captivity. In Africa, breeding crocodiles are usually kept in large pens. There are two methods of breeding, either using small pens with one male to 6-8 females or a larger pen with a maximum of 60 males and 300 females (Revol, 1995). The former is the more popular.

Rearing techniques contribute greatly to the success of a crocodile farming enterprise. Young crocodiles must be offered both water and dry land. Blake (1974) recommended a minimum surface area for hatchlings of $0.09 m^2$ per animal which is increased to $0.18 m^2$ for a yearling and $0.3 m^2$ for an animal of 2-3 years of age. The water must be kept warm, again preferably around 32°C; a gradient is advisable, produced by shading. Hygiene is always of great importance, particularly in the prevention of water-borne infections, and some enterprises in East Africa routinely add oxytetracycline to suppress bacterial growth. This is not a satisfactory practice – neither bacteriologically nor environmentally sound. Huchzermeyer (personal communication) recommends cleaning with a detergent and a disinfectant at each water change.

Various factors influence growth rate, including temperature and food intake. On average, a Nile Crocodile is 55 cm long at three months, 85 cm at six months and 110 cm at one year. In Zimbabwe, crocodiles are slaughtered when they are 2-3 years of age and approximately 1.2-1.5 m long (Hutton and Webb, 1990): in East Africa they are killed earlier, at 10-14 months.

Hatchlings are fed once a day with meat, fish or similar animal material. It is important to supplement with vitamins and minerals, especially when meat is used. Deaths at this stage can be associated with infectious agents (see later) or be stress-related. Stressed crocodiles tend to show behavioural changes, particularly excitability, and may have a reduced appetite and lose weight. One way of minimising this is to separate young animals into groups of comparable size and to rear them as such. "Premature" or poorly developed hatchlings may need special care.

Various management strategies can be followed as the young crocodiles grow. In East Africa they are usually handled and checked at 2-3 months of age and then moved outdoors.

Slaughter of crocodiles involves shooting or severance of the spinal cord. The former is to be preferred on welfare grounds (Cooper, 1987).

CROCODILE PRODUCTS

The most valuable part of the crocodile is the skin (hide), especially that of the belly. It is most important that skinning is carried out carefully and correctly in order to avoid damage. Grading is adversely influenced by the presence of holes, scars or other lesions and for this reason fighting amongst captive crocodiles must be kept to a minimum. The meat is usually a secondary product and, while increasingly sold as a human food, is often used primarily to feed other animals, including other crocodiles. A crocodile 1.2-1.4 m in length will yield 2.7-6.8 kg carcass weight, of which 1.4-3.4 kg is boneless meat. Crocodile meat is white and similar in taste to chicken, fish or veal. Other products from the crocodile include heads, feet, claws and teeth which can be used for a variety of purposes, mainly curios.

DISEASES

A variety of infectious and non-infectious diseases can occur when Nile Crocodiles are kept in captivity. The maintenance of water quality is essential. The rearing environment is particularly conducive to the spread of bacteria including salmonella, other enteric organisms and viruses including *Adenovirus* (Foggin, 1992) and *Poxvirus* (Buoro, 1992: Foggin, 1992). Chlamydiosis has been diagnosed in Southern Africa but not yet reported in East Africa.

Other bacteria that are important in crocodile farming are mainly Gram-negative organisms and control of these hinges upon good management. Sterilisation (with heat) is advisable for food being given to hatchlings. Vitamins must be added after heat treatment, not before.

Non-infectious diseases include fight wounds (which may become infected), stress-related disorders (see earlier) and osteodystrophy, which can include both calcium and vitamin D3 deficiencies.

Handling of crocodiles must be carried out with care. Even young animals can inflict wounds on themselves and humans; these can readily become infected. Anaesthesia may be carried out using ketamine or etorphine by injection or isoflurane or halothane by inhalation. Gallamine, not an anaesthetic but a neuromuscular blocking agent, has been used extensively to capture, transport and facilitate handling of the Nile Crocodile (Blake, 1993).

Health monitoring of captive crocodiles is important and haematology can be particularly useful in this respect (Cooper and Mbassa, 1993).

CONCLUSIONS

Crocodile farming is becoming increasingly popular and important in Africa. In East Africa (Kenya, Tanzania and Uganda) it is still at a relatively early stage and much remains to be learned. Improved management is essential on health and welfare grounds. In Zimbabwe and other Southern African countries, considerable expertise exists (Blake, 1974, 1993). A particularly encouraging development has been to link crocodile ranching or farming with the conservation of the Nile Crocodile in the wild. In the case of ranching, collection of eggs is carried out by the local community who, in the past, would probably have destroyed crocodile nests.

The return of captive-reared crocodiles to the wild is practised in many African countries: in Uganda, for example, once youngsters reach 2.3 metres in length, at least 5% must be released – a regulation that is strictly enforced. Crocodile farming that is linked with educational visits and research provides opportunities to teach local people about the value and importance of these reptiles and to encourage their conservation in the wild. Crocodile farming faces many challenges, both economic and practical, but has considerable potential in Africa as a form of sustainable utilisation.

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CENSUSING INLAND ROAD-CROSSING YEARLING NATTERJACKS

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The critical importance of correct vehicle speed in censusing road crossing yearly natterjack toads is demonstrated. Excellent 1997 breeding successes at the recently discovered, inland, flooded-meadow, breeding site are reported.

INTRODUCTION AND METHODS

July 26th 1998 was a warm, humid evening. Following heavy rain earlier it was dark at 10.30 pm. Between 10.30 pm and 11.30 pm [similar times to a previous traverse of this identical stretch of road several weeks earlier under similar weather conditions on 8th July (Bustard 1998a)] the Priestside road was checked for toads crossing.

On the previous occasion John Buckley, the driver of an HCT Peugeot, drove rather fast and I felt we *might* be missing smaller Natterjacks. On this second occasion Gwen Soutar drove an Austin Metro and I asked her to select a uniform speed which we were both sure would allow us to see all toads crossing, including the smallest. As on the previous occasion, we drove the length of Priestside from the Cummertrees turn-off to the junction and back again counting toads in both directions. At each sighting a brief stop was made while the toad was examined. It was then placed on the verge on the roadside verge in the direction it was facing. As on the previous occasion, and as observed nightly at Powfoot, toads were invariably crossing in a definite direction not moving *along* the road. During, and at the end of each traverse we carefully noted the speed at which the vehicle travelled to enable us to see all toads with certainty and in good time (Natterjacks may run off the road if not seen in advance and be lost in roadside vegetation). Once the vehicle has passed by they are very difficult to find. The ideal was found to be precisely 4 mph (6.4 kmph.) on both outward and return journeys.

On the previous occasion on 8th July we saw and checked a total of only five Natterjack Toads. On 26th July, under very similar weather conditions, the total was 16 Natterjacks. This confirms my view that at the higher speed on 8th July we were probably missing yearling toads. The 1997 yearlings were smaller than many of the larger moths attracted to the road by the car headlights reflecting off the wet surface, and we were convinced that at any faster speed we would have missed smaller toads. We feel confident, therefore, in stating that 4 mph. is the required speed to be sure of recording all yearling toads on a country road such as this.

These data refer to inland sites; the road running at between approximately 350m and 550m inland from the merse.

RESULTS AND DISCUSSION

Unless all toads are definitely recorded, breakdowns between year classes are valueless – the more especially if smaller toads are selectively missed. The distribution of Natterjack year classes on 26th July is extremely interesting. The sixteen toads recorded comprise: 1 adult female, 2 second year (1996) toads, and 13 yearling (1997) toads. In percentage terms these (rounded up to the nearest first decimal point) are:
adults 6.3%, 2nd years 12.6%, yearling 81.3%. We have no reason to believe that yearling Natterjacks are more likely to cross roads than adults or second year toads, so these figures, with 81% of the toads being yearlings, suggest a very dynamic breeding population in this area with excellent breeding success in 1997. This discovery would have been completely missed at an inappropriate, faster speed. Indeed, this result was lost in the earlier 8th July traverses when only five toads were observed, of which only two or 40% (compared to 81% here) were yearlings.

The location of the toads is most interesting, especially in view of the newly reported breeding sites recently discovered in this area (Bustard 1998b & c). With one exception – a yearling Natterjack seen 1 mile (1.6 km) west of all the others and near Priestside farm – all the Natterjacks were recorded in a 0.65 mile (1.04 km) length of road and 13 of them were on 0.5 mile (0.8 km) of road between Moss-side and Nethertown farms. Seven were seen crossing directly opposite the flooded-meadow site [recorded as a new breeding site by Bustard (1998c)] and a further seven were recorded within 0.2 miles (0.32 km) or less of this site – well within the movement of a yearling Natterjack from its site of metamorphosis. This provides excellent corroborative data on the importance of the flooded-meadow site at Moss-side farm for Natterjack breeding.

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