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The International Varanid Interest Group is a volunteer-based organization established to advance varanid research, conservation, and husbandry, and to promote scientific literacy among varanid enthusiasts. Membership to the IVIG is free, and open to anyone with an interest in monitor lizards and the advancement of varanid research. Membership includes subscription to *Biawak*, a quarterly journal of varanid biology and husbandry, and is available online through the IVIG website.

On the Cover: *Varanus salvator*

The adult *V. salvator* depicted in combat on the cover and inset of this issue were photographed at Punggol Park, north-eastern Singapore by **Jay Tan** (jayquix@hotmail.com) on 30 September 2007. The lizards (each ca. 1.2 - 1.5 m in total length) were first observed while photographing birds at the edge of a large man-made canal beside the park. The monitors were wrestling on the sloping cement embankment of the canal, where one maintained a strong hold over the other until it managed to overturn its opponent into the water. The entire event lasted ca. 2 - 3 minutes.

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ARTICLES

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Juvenile Perentie *Varanus giganteus*. Ormiston Gorge, NT
Photographed by **Patrick Ingremeau**

EDITOR'S NOTE

For the amateur varanid enthusiast…

It is well understood that documentation of observations and the results of research are necessary for the advancement of any scientific discipline. Contrary to popular belief, the ability to report such information is not limited exclusively to academics and professional scientists. In fact over the past several decades, there have been numerous contributions made to the study of monitor lizards by private keepers, hobbyists, students, amateur naturalists, and even vacationing tourists; published in various herpetological journals, magazines, books, and newsletters. However, despite these valuable contributions, there still exists an overwhelming amount of first-hand observations and information which go unreported each year, leaving gaps in what is currently known about the biology and husbandry of lizards which could have potentially been filled.

There have been numerous studies which have used data and observations collected and presented by amateur varanid enthusiasts (e.g., Horn and Visser, 1989, 1991, 1997; Thompson and Pianka, 2001). While not all varanid enthusiasts are fortunate enough to live in areas with wild monitors, captivity offers an excellent alternative opportunity to learn about, and report on various aspects of varanid biology. Although not all observations and data gathered from captivity can be assignable to wild populations, many can provide valuable insight into the reproductive biology, physiology, and ethology of monitors. Additionally, for those residing in areas with native (or feral) monitors, observational notes reporting on their behavior or occurrence can be just as, if not even more valuable.

As one of its most important goals, the International Varanid Interest Group seeks to promote scientific literacy and awareness among varanid enthusiasts. The IVIG encourages all enthusiasts, regardless of educational or scientific background, to carefully take note of, and record behavioral observations, captive breedings, and data on captive varanids, as well as those encountered in the wild. Not only will recording such information help further one's own understanding of monitor lizards, it can also help benefit the study, collectively. If you have observations or data which you would like to contribute to *Biawak*, or

Copulating Yellow-spotted monitors *Varanus panoptes*. Fogg Dam, NT. 14 April 2006
Photographed by **Stephen Barnett** stephenmichaelbarnett@gmail.com

have questions about what you can do to contribute, please contact the editor. Contributions from amateur varanid enthusiasts are always welcomed and encouraged, and can help make a huge difference!

In addition to publishing articles and notes pertaining to the biology and husbandry of monitor lizards, *Biawak* also welcomes critical reviews of recently-published books which deal with, or relate to monitor lizards. Given the recent release of Eidenmüller's (2007) ***Monitor Lizards: Natural History, Captive Care and Breeding***, and Philippen and Eidenmüller's (2007) ***Terralog Vol. 6: Varanoid Lizards of the World***, *Biawak* is currently accepting reviews of these two new varanid books. If you are interested in submitting a review of either of these books to be published in an upcoming issue of *Biawak*, please contact the editor.

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Nile monitor *Varanus niloticus*. Lake Manyara National Park, Tanzania.
Photographed by **Sharon Nardo** snardo@gmail.com

NEWS NOTES

Varanid Attacks

Attacks by wild monitors on humans are very rare. When they occur they are newsworthy stories. The following are two incidents that occurred this decade and are worth having in your file.

The first incident occurred in Tanjung Lumpur, Pahang, Malaysia. In August of 1999 7-yr old Mohd Azarul Ruhaidi was taking a bath with his nine-year-old brother on a wooden platform in the village of Teluk Baru at about 0830. According to Mohd, he saw the monitor which "was as big as a coconut tree trunk" through gaps in the wooden platform. "I had seen about three lizards near my house previously but they would run away when they saw people," he said. "I never dreamt it would attack me". The monitor lizard, locally known as *biawak*, bit his leg through one of the gaps in the wooden platform, "almost separating the flesh from the bone". "It happened so suddenly and I screamed. The lizard then let go of my leg and ran away."

The boy was rushed to the Tengku Ampuan Afzan Hospital for treatment, which included 18 stitches. The boy's father said that in his two years' living in the village, there had never been an incident of a monitor attacking humans. This was also the first such bite case handled by the hospital. The monitor was undoubtedly an Asian Water Monitor, *Varanus s. salvator.*

The second incident took place in Komodo village, Komodo Island, East Nusa Tenggara, Indonesia in June, 2007. An 8-year-old boy was mauled by a Komodo Monitor (*Varanus komodoensis*) when he went to defecate behind a bush. The monitor grabbed the boy on his waist and tossed him from side to side, as it would any mammalian prey of similar size. A nearby villager heard the boy's screams and threw rocks at the lizard until it let the boy go and fled. Komodo village is in a remote area with a minimum of an hour's boat ride to the nearest clinic. The boy died from massive bleeding within half an hour of the attack.

Wardens on Komodo National Park launched a hunt for the monitor. It was not reported whether they found the offending animal.

The monitors have been living in close proximity to the village of 1200 people for centuries. This was the first fatal incident in 33 years.

Submitted by:
HAROLD F. DE LISLE
Associate Editor

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Observations on *Varanus s. salvator* in North Sulawesi

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Abstract: Asian Water Monitors (*Varanus s. salvator*) are widespread on the main island of Sulawesi, Indonesia, but rather rare in the province of North Sulawesi because of human predation. This study documents observations on the daily behavior of a small coastal population over a two week period. Observations of aquatic behavior led to discussion of the possibility that this population is able to catch live fish in a particular coastal lagoon.

Introduction

The Asian Water Monitor (*Varanus salvator salvator*) is perhaps the most wide-spread of all varanids. It is found from Sri Lanka, northern India, Bangladesh, Burma, Vietnam and Hainan (China) through Malaysia east to the Indonesian islands of Sulawesi and Wetar (De Lisle, 1996). Its ability to colonize the remote islands of Malaysia and Indonesia might be due to its adaptability towards freshwater and saltwater (Traeholt, 1994a), and also its large size is an advantage, giving both the energy reserves and power to survive an extended sea voyage and a greater potential to actually achieve a landfall. Backwash from tsunamis could start this process frequently enough.

Figures 1A and B. Remnant primary forest on North Sulawesi

Figure 2. Coastal stream, North Sulawesi

Figure 3. Coast of the Moluccan Sea

In March 2001, a month was spent in North Sulawesi Province, Indonesia (island of Sulawesi) to observe the northeastern-most populations of the Asian Water Monitor (*V. s. salvator*). It proved difficult to find observable populations. Most of the wildlife of North Sulawesi has been extirpated outside national parks and private reserves. The Minahasa people of North Sulawesi consider *biawak air* a favorite delicacy. Local inquiries to find monitors were often met with "Oh yes, whenever I see one I grab it to take home for dinner."

A population was located in Tangkoko National Park. However, there are no accommodations of any kind within the park, and logistics of travel made observations impractical. A second population was located in a private preserve at Bentenan, approximately 75 km SW of Tangkoko.

Methods

Bentenan Preserve (1º00'49"N, 124º54'06"E) is a privately owned nature reserve of some 200 ha located on the shore of the Moluccan Sea. It consists mostly of secondary lowland tropical forest, with a lagoon between the beach and the forest. Bentenan lagoon is approximately 200 m by 50 m. There are two

Figure 4. Bentenan Lagoon

Figure 5. Map of region

small streams entering the lagoon from the forest, one at the north end and one at the south end. There is a 5 m wide channel connecting the lagoon to the sea. The water in the lagoon is brackish. The lagoon is a major part of the habitat of *Varanus salvator.*

Bentenan Lagoon must serve as a nursery for several kinds of fish. It is the most densely populated natural body of water ever seen by this author. A small dip net will bring up 10-15 small (2-5 mm) fish any place around the lagoon. Larger fish, probably mullet (*Mugil* sp.) also inhabit the lagoon.

Monitors frequented this lagoon, especially in the early morning. They proved very wary, and close approach was usually impossible. Gaulke et al. (1999) found similar flighty behavior in North Sumatra. Fortunately our cabin was perched on a knoll directly above the lagoon so that observations with binoculars (7 x 50 mm) were possible, although from a distance of 50-100 m. Such observations were made each morning from 0530-0800 h. Monitors were already in the water when it became light enough to see them. They were not seen to enter the lagoon before dark. Notes were taken on the number of lizards active

Figure 6. Satellite view of study site

Figure 7. Sunrise at Bentenan Lagoon, a time when water monitors are most active in the water.

and on specific behaviors. Walks around the lagoon were also made daily later in the morning to find any monitors that might be basking. Observations in the forest were only possible from an established trail because of thick undergrowth.

The observation period was at the end of the northwest monsoon. Only a few afternoon showers occurred, but the early morning along the coast was mostly overcast.

Results

It was not possible to get a reliable estimate of the monitor population in Bentenan Lagoon, but it was probably fewer than 25 adults, perhaps as few as 15. Table 1 summarizes the daily observations during the hours when monitors were seen in the water. No monitors were ever seen in the water after 0900 h, and most had left by 0800 h. The monitors observed actively swam up and down the lagoon. The significance of this aquatic behavior will be discussed below.

Table 1. Summary of aquatic activity data of *Varanus salvator* in Bentenan lagoon
*Days on which monitors were actually observed with caught fish

Date – March	Number of monitors in water
16	5
17	7
18	6
19	8*
20	6
21	9*
22	10
23	8
24	5*
25	11
26	4
27	7

Figure 8. *Varanus salvator* swimming

<u>*Swimming.*</u> Typically monitors trolled the longitudinal axis of the lagoon. They swam both near shore and well out toward the center of the lagoon. No particular path pattern was observed. Generally only the head was visible (Fig. 8), and a wake made by the tail.

Only monitors of >1 m could be observed reliably from our platform. The water was also roiled during the early morning hours by the thousands of small fish surface feeding. Thus it is not known whether juveniles were also swimming. The only juveniles observed were on shore on the seaward side of the lagoon.

Traeholt (1993) is of the opinion that *V. salvator* is unable to catch fish. This conclusion is drawn from experiments he conducted with captive juveniles who were unable to catch small fish in a tub. However, he leaves open the question that some populations may well have developed the ability to catch fish where other food sources are scarce. The observations made at Bentenan do not indicate how often or even if, the lizards caught the small fish in the lagoon. It probably would not have required the 'open pursuit' technique outlined by Traeholt (1994a), nor would vision have to be employed. Just opening their mouths could probably snare a few fish. Three times monitors were observed exiting the water with a large fish (*Mugil*?) in their jaws. All monitors exited the lagoon on the forest side. No adults were ever seen on the beach side which had a ca. 2 m border of salt grass between the water and sand.

<u>*Basking*</u>. After departing the lagoon into the forest, most monitors were not seen again until the next day. One large (ca. 2 m) lizard did, however, have a favored basking site near the point (see Fig. 6) on the forest side of the lagoon. There was a large snag that pointed out about 1 m above the water at that point. This could not be seen from the observation platform, but when approached cautiously from the beach side, the monitor could be seen basking almost daily between 0900-1000 h. Standing up or any sudden movement by the observer would cause the lizard to immediately dive into the water, even though we were more than 50 m distant. Attempts were made to approach from the landward side, but crawling through the brush made noise and the lizard could be heard hitting the water before we ever got within sight.

Rathnayake et al. (2003), in Sri Lanka, found that most of the water monitors there basked in trees over

15 m above ground. No monitors were observed in the forest at Bentenan, but they were obviously there, perhaps spending much of the day up in the trees.

Three juvenile *V. salvator* were observed during walks around the lagoon. They were all partially concealed in the salt grass on the beach side of the lagoon. Times of observation were ca. 1000, 1100, and 1300 h respectively.

Discussion

Varanus salvator inhabits a wide range of habitats across its wide distribution – from highlands (1100 m in south Sumatra; Erdelen, 1991) to coral islands devoid of substantive aquatic habitat (Pulau Tulai; Traeholt, 1994b) to mangrove swamps (Pardav and Chondhury, 1996). It is thus to be expected that behavioral ecology is equally divergent.

There are no mammalian predators in North Sulawesi larger than a civet (Whitten et al., 2003). The only animal (excepting humans) posing a threat to adult monitors is the Reticulated python (*Python reticulatus*). So it is quite possible for the monitors at Bentenan to spend the night in trees rather than in burrows as is more typical on the Asian mainland. There were no burrows observed any place around the shore of the lagoon.

A night spent up in the trees could explain the early hour of rising at Bentenan, presumably at dawn, since they were already in the water by 0600 h. Wickramanayake and Green (1989) and Rathnayake et al. (2003) found monitors on their study sites in Sri Lanka also swimming at 0600 h. On the other extreme, Traeholt's (1995) population did not become active until 1000 h.

Fish have rarely been found in diet analyses of *V. salvator.* However, most stomach analyses have been done of specimens trapped in palm plantations where small streams are the aquatic habitat (Shine et al. 1998). Most people of southeast Asia familiar with this monitor insist it does catch fish (Traeholt 1994a). Harrison and Lim (1957), Deraniyagala (1931), Smith (1932), and Gaulke (1991) all state it can catch fish. Gaulke is the only one to have reported actually seeing *V. salvator* ssp. in the Philippines eating fish trapped in pools at low tide. This study may be the first report of direct sighting of water monitors catching fish in an open body of water.

What is the significance of this early morning swimming behavior? The swimming did not appear to be random, but a kind of trolling up and down the lagoon. Several hypotheses present themselves: (1) The monitors were taking their morning exercise (I am sure that this hypothesis may be favored by certain amateur reptile keepers.). But anthropomorphisms aside, (2) The monitors were thermoregulating. At 0600 h surface water temperature in the lagoon was 29º C; air temperature was 23º-24º C. This explanation seems to be favored by Rathnayake et al. (2003) in their study of thermal behavior. However, most lizards engaged in thermoregulation find a spot with favorable temperatures and remain there. They do not expend energy running (or swimming) around. (3) The monitors are foraging. Direct evidence for this is slight. Three fish in 12 days hardly seems energy efficient. Indirect evidence, however, is substantial. The trolling-like swimming indicates some purposeful activity. It occurs only in the early morning. As every fisherman knows, fish feed near the surface in the early morning. The fish population in Benentan lagoon is so dense it would seem possible that fish could be caught without the "open pursuit" technique outlined by Traeholt (1994a). They possibly swallowed large numbers of smaller fish unobserved, but for some reason took larger fish to shore. It is also possible that the fish caught and observed were already dead, although no dead fish were ever seen floating near shore.

It should be mentioned that the thermoregulatory and foraging hypotheses are not necessarily mutually exclusive

Few conclusions can be drawn about basking behavior. Most of the population spends most of the day in the forest, presumably using the canopy for basking. We observed a number of fruiting trees in the forest and signs of rodent activity. There are 43 species of rats on Sulawesi (Whitten et al., 2002). There should be abundant prey for monitors in the forest and much of their time there may be taken up with foraging.

Acknowledgements

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Addendum: In the just-published revision of the *Varanus salvator* complex (Koch et al., 2007. Mertensiella 16:109-180) the nominotypic form, *V. s. salvator*, is now restricted to Sri Lanka. The Bentenan, Sulawesi population belongs to Koch's "typically-colored"(spotted) phenotype, presently listed by him as *Varanus salvator* ssp.

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A Revised List of Ixodid Ticks Known to the Yemen Monitor (*Varanus yemenensis*); with a Review of the Ixodid Tick (Ixodoidea) Species Known to African and Arabian Monitor Lizards [Varanidae: *Polydaedalus*]

MARK K. BAYLESS
**deceased*

Abstract: Through a literature review of the African savannah monitor lizards (*Varanus*: *Polydaedalus*), it has been discovered that an overlooked ixodid tick (*Amblyomma gervaisi*) parasite identified with the east African Eyed Monitor (*V. ocellatus*), is in fact a parasite of the Arabian Yemen Monitor (*V. yemenensis*). The ixodid ticks known to the African savannah monitor lizards (*Varanus: Polydaedalus*) are reviewed for clarity.

On 04 September 1986, a television nature program entitled "*Unter Gansegeiern und Hammerkopfen*", on the Republic of Yemen; prepared by Wieland Lippoldmüller and originated from Bavarian Television (W.v. Lossow, pers. com.), aired in Germany (Greenwell, 1989; Böhme, 1990). The Yemen Monitor was first seen on this television program, and subsequently it was collected and described in 1989 as *Varanus yemenensis* (Böhme et al., 1989).

During its initial description, two parasites were reported from *V. yemenensis*; the ixodid ticks *Amblyomma sparsum* and *A.* (formerly *Aponomma*) *flavomaculatum* (Böhme et al., 1989).

While conducting a recent cross-referencing of African *Varanus* [*Polydaedalus*] and related parasite literature review, the author stumbled onto an as of yet unrecognized tick species known to *V. yemenensis*. In 1903, an ixodid tick, *A. gervaisi*, was found on an Eyed Monitor *V. ocellatus* collected from Al Khobar, Saudi Arabia (Hoogstraal and Kaiser, 1959). In 1986, this Al Khobar monitor was identified as *V. exanthematicus* by Arnold (1986). This specimen [BMNH 1903.6.26.9-10] would later be identified as a paratype of the newly-discovered and described *V. yemenensis* (Böhme et al., 1989), hence this monitor lizard once-identified as *V. ocellatus,* was in fact an example of *V. yemenensis*, and its associated tick parasite, *A. gervaisi* is a parasite to *V. yemenensis*.

Amblyomma gervaisi is known to Arabian reptiles including *V. griseus*, as well as other *Varanus* species in southeastern Asia and Asia-minor (Kaufman, 1972). To confirm that *A. gervaisi* has not been associated with *V. yemenensis* before, a review of the ixodid tick species associated with each of the African savannah monitor species: *V. exanthematicus*, *V. albigularis*, and *V. yemenensis* has been compared and depicted in Table 1.

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Table 1. Ixodid tick parasites known to African *Varanus* [*Polydaedelus*] species

Tick Species	*V. exanthematicus*	*V. albigularis*	*V. yemenensis*	References
Amblyomma arcanum	**X**			Dias, 1958
A. exornatum	**X**	**X**		Trommsdorf, 1914; Neumann, 1922; King, 1926; Schwetz, 1927; Rondelli, 1930; Wilson, 1950; Bedford, 1932, 1936; Rouseelot, 1951, 1953; Heisch, 1954; Hoogstraal, 1954, 1956; Villers, 1956; Pienar, 1962; Theiler, 1962; Young, 1965; Elb & Anastos, 1966; Yeoman & Walker, 1967; Avery, 1971; Bourgquin, 1971; Kaufman, 1972; Walker, 1974; Paine, 1982; Keirans, 1984; Mattysse & Colbo, 1987; Branch, 1991, 1992; Broadley (pers. comm.); Bayless & Simmons, 2000; Burridge, 2000, 2001; Flach et al., 2000; Bayless, 2006
A. falsomarmoreum		**X**		Theiler, 1962; Walker, 1974;
A. flavomaculatum	**X**	**X**	**X**	Morel & Mouchet, 1958; Morel, 1961; Kaufman, 1972; Walker, 1974; Keirans, 1984; Hesse, 1985; Mattysse & Colbo, 1987; Bohme et al., 1989; Bayless & Simmons, 2000; Burridge, 2000, 2001
				Kaufman, 1972; Walker, 1974; Keirans, 1984;
A. gervaisi			**X**	Hoogstraal & Kaiser, 1959; Kaufman, 1972
A. hali	**X**			Tendeiro, 1948, 1950, 1952
A. hebraeum		**X**		Theiler, 1962
A. inopinatum	**X**			Keirans & Robins, 1999
A. latum	**X**	**X**		Hoogstraal, 1954; Theiler, 1962; Kaufman, 1972;mattysse & Colbo, 1987; Bayless & Simmons, 2000; Burridge, 2000, 2001
A. marmoreum		**X**		Theiler & Salisbury, 1959; Theiler, 1962; Norval, 1975; Burridge, 2001
A. neglectum		**X**		Hirst & Hirst, 1910

Table 1. *continued*

Tick Species	*V. exanthematicus*	*V. albigularis*	*V. yemenensis*	References
A. nuttalli	**X**	**X**		Tendiero, 1952; Hoogstraal, 1956; Villiers, 1956; Dias, 1958; Theiler & Salisbury, 1959; Morel, 1961, 1963; Theiler, 1962; Yeoman & Walker, 1967; Walker, 1974; Elb, 1977; Keirans, 1984; Burridge, 2000
A. paulopunctatum		**X**		Keirans, 1984
A. sparsum		**X**	**X**	Theiler, 1962; Walker, 1974; Bohme et al., 1989
A. variegatum	**X**			Elb, 1977
Ornithodoros erraticus	**X**			Theiler, 1962

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****Editor's Comments***: Prior to his death in November 2006, Mark K. Bayless submitted several manuscripts resulting from extensive literature reviews for publication within *Biawak*. In addition to the current article, as intended, these submissions will be published in forthcoming issues. For a detailed obituary of Mark K. Bayless, including an annotated bibliography of his published *Varanus* works, please refer to:

Mendyk, R.W. and B. Aller. 2007. Remembering Mark K. Bayless (1960-2006). Biawak 1(1): 4-12.

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Notes on Breeding *Varanus albigularis* in Captivity

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This account describes two successful captive breeding attempts for *Varanus albigularis*; the first occurring in 2000, and the second in 2006. Different lizards were involved in each event.

The two *V. albigularis* involved in the first breeding attempt (2000) were a 7 year old male and a 4 year old female, both of which were originally wild-caught and unrelated. The monitors were maintained in an apartment where they were free to roam the different rooms. Their primary room offered a shallow layer (ca. 1 cm deep) of substrate consisting of a sand and soil mixture atop a concrete floor. Furnishings consisted of large stones and several thick tree branches. Heat and light were provided by six 150 watt reflector bulbs and four full spectrum bulbs (*Zoo Med Laboratories, Inc. San Luis Obispo, CA, USA*). This room's daytime ambient temperature was ca. 24-26 °C, and basking temperatures ranged between 35 and 40 °C. Night-time ambient temperature varied between 19 and 21 °C, depending on the season. The monitors were fed five times a week on a diet of mice, day-old chicks, rats, locusts, and occasionally hard-boiled eggs. This diet has proven to be successful after several years, and none of the monitors have ever become obese or lethargic. It is felt that feeding quantity and quality are crucial in the reproduction of monitors. Vitamin supplementation was added to the food twice weekly, and water was provided daily.

In the first week of May 2000, the male showed typical varanid courtship behavior, consisting of spasmodic head movements when approaching the female, and tongue-flicking around the female's body, especially on the neck and head. This courtship behavior lasted for a week. Intense copulation began on 12 May, and ended 15 May. Copulation did not occur in the primary room, but instead took place in the adjacent rooms where temperatures were lower, around 20 °C (Figures 1 & 2). On average, mating occurred four times a day, with short breaks in between where both lizards rested close to each other. After this three day period, both monitors were observed sheltering together in the same hide spot, and showed no further mating activity. Both used this area as their primary shelter during this period, but also spent


Figures 1 & 2. Copulation of *Varanus albigularis* nights together in various other locations such as beneath slabs of tree bark positioned in various rooms of the apartment, and in closets. One week later, a large wooden nesting box measuring 180 x 90 x 40 cm, was placed in the primary room. The box was filled with a sand and soil mixture to a depth of ca. 35 cm, and was left open for easy viewing. A 100 watt heat lamp suspended from the ceiling to a height of ca. 30 cm above the nest box was directed down onto the nesting substrate, and the substrate moisture levels were monitored daily. Approximately 4 weeks after the last observed copulation, the female showed a special interest in the nest box by repeatedly digging in it. This behavior lasted for several days, as she searched for a suitable place to lay. During this time, her appetite decreased, and she refused to feed four days prior to oviposition.

Overnight, between 17 and 18 June 2000, the female deposited a clutch of 21 eggs atop the sand and soil substrate covering the concrete floor, ignoring the nest box provided (possibly not deep enough). During oviposition, the female positioned herself inside a hollow tree trunk with only her hind limbs and tail exposed, allowing for perfect viewing of the laying process. The female laid her first egg on 17 June at 2400 h, and her 21st egg on 18 June at 0900 h. An additional 3 eggs were laid between 19 June and 20 June atop the substrate covering the cement floor. By using her rear limbs, she carefully pushed each egg into a pile between her hind limbs. Eggs averaged 7 cm in length and 4 cm in width. No nest guarding behavior or aggression was observed in the female towards the male.

All eggs were removed from their site of deposition, and set up for incubation in two separate incubators in order to accommodate the entire clutch. Eleven eggs were incubated in a Brinsea Hatchmaster (*Brinsea Products Ltd. North Somerset, England, UK*), maintained at 30 °C with a humidity of ca. 70-80%. The other 13 eggs were placed in a plastic container inside an aquarium partially filled with water and heated with a 40 watt heat lamp connected to a thermostat. The temperatures within the aquarium incubator ranged between 28-31 °C, and the humidity ranged between 70-95 % . All eggs were partially buried in a water and vermiculite mixture prepared at a ratio of 1:1 by weight (Figure 3).

Of the 24 eggs incubated, 7 successfully hatched; 4 in the aquarium incubator after 150 days of incubation, and 3 in the commercial incubator after 180 days of incubation. The 17 eggs which did not hatch began to look bad towards the end of incubation, and were dissected. One egg contained a dead embryo, and, the others appeared to be infertile; each containing a gelatinous, reddish-colored mass. All seven surviving hatchlings emerged from their eggs on their own without any assistance over the course

Figure 3. (Partial) Clutch of eggs.

Figure 4. Hatchling emerging from egg

of several days, mostly during the night or in the early morning (Figures 4 & 5). Upon emerging, two hatchlings had residual yolk sacs and umbilical stalks attached, which soon fell off after rubbing their abdomens on the substrate.

All seven hatchlings (Figure 6) were set up in a plexiglass enclosure which offered a floor space area of 100 x 40 cm. At night, hatchlings sheltered clustered together under a slab of tree bark. Hatchings began feeding on crickets after 48 h.

The next successful breeding began in May 2006. Two unrelated lizards were involved in this breeding; a 6 year old captive-bred female originating from the 2000 successful breeding, and an 8 year old male of wild-caught origin. Both lizards were kept together with eight other adult monitor lizards (7 *V. albigularis:* 4 females and 3 males; and one female *V. salvator*) in a spacious cellar measuring ca. 18.5 m^2, which was furnished specifically for the lizards. Shelters, branches, and stones to climb on were provided, as well as a water container large enough to allow the monitors to fully submerge their bodies when needed. As in the previous breeding, lighting and heating were provided by five 150 watt reflector bulbs and one 160 watt full-spectrum Power Sun reflector lamp (*Zoo Med Laboratories, Inc. San Luis Obispo, CA, USA*). The room's temperatures were comparable to those offered in the 2000 breeding. All copulation occurred in this cellar. Courtship was similar to the 2000 breeding, and lasted for two weeks.

Deposition of 16 eggs occurred at night on 2 June 2006, after a gestation period of 30 days from the last observed copulation. As in the previous breeding, the eggs were laid atop the sand substrate, however no nesting box was provided for this event, based upon the previous female's taking to laying atop the substrate. All 16 eggs were incubated in the same Brinsea incubator, maintained at 30 °C and 90 % humidity. This increase in humidity from that used in the 2000 breeding was not intentional.

The first egg hatched on the night of 19 November 2006, after 180 days of incubation, and by morning, the hatchling had fully emerged from its egg. By 3 December 2006, six more hatchlings had emerged from their eggs. The remaining nine eggs failed to hatch, and dissection once again revealed that these eggs were infertile, containing no developing embryos.

Although involving different individuals, both breeding events were very similar with respect to observed reproductive behavior and hatching results. Seven monitors hatched from clutches of 24 and 16 eggs, respectively. A clutch of 25 eggs, laid on 24 May 2007, resulting from the same pair involved in the 2006 breeding, is currently incubating in both incubators used in the 2000 breeding. As with previous

Figure 5. Emerging hatchling in hand

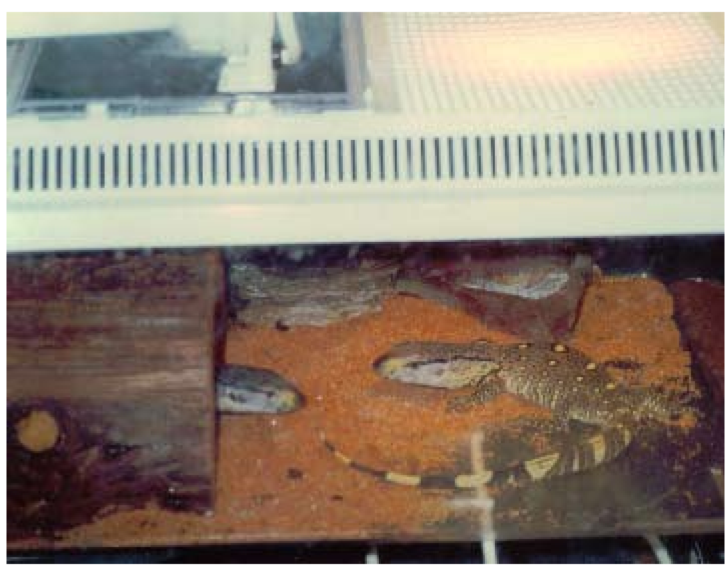

Figure 6. Captive-bred offspring

clutches, oviposition occurred at night, and once again the female made use of a hollow tree trunk as cover while she deposited the eggs atop the substrate.

Despite receiving healthy hatchlings from each breeding, the cause for the poor egg viability and hatch rates experienced in both clutches remains unknown. In the wild, it would be expected that female monitors deposit their eggs in safe, secure areas protected from extreme climatic conditions and potential predators. Therefore, depositing eggs on the surface of the substrate is unlikely normal nesting behavior, and suggests that the nesting options provided may be insufficient. Further testing of different nesting media, depths of media, temperature ranges, and moisture content may help resolve this issue, and provide further insight into the nesting preferences of captive *V. albigularis*.

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The Monitor Twins: A Bugis and Makassarese Tradition from SW Sulawesi, Indonesia

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Despite increasing investigations on the herpetofauna of Sulawesi (Iskandar & Tjan, 1996; de Lang and Vogel, 2005; Gillespie et al., 2005; Koch and Böhme, 2005; Koch et al., 2007a), and particularly the monitor lizards of this island and surrounding areas (Koch et al., 2007b; unpubl. data), the senior author only recently came across an astonishing zoo-ethnological phenomenon which involves the black Sulawesi water monitor lizard, *Varanus* cf. *togianus* (resurrected to specific status by Koch et al., 2007b; Figure 1), and the Bugis and Makassarese, Sulawesian agrarian and seafaring peoples who played a significant role in maritime exploration and the East Indies spice and sandalwood trades prior to European domination in the 1600's (Whitten et al., 2002).

A French television documentary of 1999 entitled, "Les hommes varans" – the monitor men of Sulawesi – directed by Jean Michel Corillion, was broadcasted on 21 and 28 August 2006 on ARTE channel in Germany, reporting an extraordinary relationship between these traditional people of the south-western peninsula of Sulawesi and the local endemic monitor lizards. A trailer of the story, here called "Messengers of Sulawesi", can be seen at the company's homepage (see www.zed.fr). However, when asked for a copy of the whole documentary, the senior author was told that ZED productions are only available for broadcasting stations.

According to Bugis tradition, a long time ago on the Island of Sulawesi, the queen of the kingdom Gowa (sometimes spelled Goa) gave birth to twins**,** one of which was a monitor lizard. Unfortunately, the infant died at birth, but the reptile survived. A week later, the monitor lizard left and went far away from man. The tradition recounts that the water monitor was to let people know through a dream when he intended to return to the company of humans. Since that time, Bugis tradition holds the view that some monitor lizards have an animal's body but a human spirit.

Corillion's television documentary tells the story of Alhim, who lives with his family on a floating house on Lake Tempe, Wajo regency, Southwest Sulawesi, during the rainy season from November to February (Figure 2). Alhim has a son, Suardi, and a four-year-old daughter, Ali Douyoung, who has the scaly body of a monitor lizard, living somewhere around Lake Tempe. One night, Alhim has a dream and the next morning he goes out with his son to bring home his sister, a gentle monitor lizard. Back home, they all live together in peace and harmony, until one day, the monitor lizard disappears. To regain his daughter and to console his cheerless son, Alhim starts on a long journey to the former Kingdom of Gowa, once located around Makassar (formerly known as Ujung Pandang), the capital of South Sulawesi province. There lives Ali Mohammed, a descendent of the former monarch, and he too, is a monitor lizard. On the day when Alhim arrives at the royal reptile's village Todotora (Figure 2), hundreds of devotees have come to celebrate Ali Mohammed's 34th birth day. They all praise and worship him because they believe he is the secular representative of Allah, the God of Islam [Remark by the authors: This information was only

Figure 1. A dark-colored monitor lizard (*Varanus* cf. *togianus*) from the southwestern peninsula of Sulawesi. In Bugis culture, some of these monitor lizards are believed to have a human spirit.

given in the German translation of the documentary.]! Now Alhim hopes that the supernatural power of the royal monitor lizard will help to bring back his daughter.

Facing the remarkable story presented in Corillion's documentary, some aspects will be discussed below.

Firstly, despite comprehensive studies of Bugis culture and religion (e.g. Harvey, 1974; Pelras, 1993; Pelras, 1996; Acciaioli, 2004), so far as the authors could determine, and except for the TV production reported herein, this is the first zoo-ethnological literature record about the special relationship between monitor lizards and humans in Sulawesi. Secondly, although Islam is omnipresent in Indonesia and Sulawesi (more than 85% of the Indonesian population is Muslim), the retention of earlier traditional elements and syncretism, i.e. the fusion of distinct religions, has prevailed among many traditionally minded Bugis (Pelras, 1996; Whitten et al., 2002). According to Pelras (1996), Bugis' religion in practice is marked by: "…the astonishing survival of elements of pre-Islamic religion, manifested in popular rituals, beliefs in pre-Islamic myths, the worshipping of regalia and sacred places, and the active role still played by a number of the pagan transvestite priests, the bissu – all of which are radically incompatible with Islam." Thirdly, it is known, that other ethnic groups of Sulawesi, particularly the Minahassa of the northern peninsula who are predominantly Christians, eat a variety of unusual meat like dogs, rats or bats. As a consequence, they also hunt and eat monitor lizards. Moreover, monitor lizards of the southwestern peninsula of Sulawesi are chased for the international pet and reptile leather trades (pers. observ.). It remains unknown, however, if or how the reptile hunters distinguish between monitor specimens with and without a human spirit. Fourthly, assuming the age of the monitor lizard in the village Todotora was correctly documented, this would represent the highest age of a monitor lizard hitherto reported. The oldest specimen known thus far was a water monitor (*V. salvator*) kept in a German school terrarium for 26 years (Böhme, 2003). Only a specimen of the Komodo dragon, *V. komodoensis*, maintained in a zoo in Sydney, Australia, might have attained a higher age. This specimen reached the zoo as an adult and was kept for 24.5 years (Auffenberg, 1981).

Other observations among Sulawesi Bugis people revealed that it is common to believe that a child is born with a twin who is a 'buaja' (buaya = crocodile in Bahasa Indonesian language). However, one time when visiting Soppeng, South Sulawesi, such a twin sitting in a tree was pointed out to one of the authors (GA); the animal was actually a juvenile monitor lizard. The term 'buaja' in Bugis must thus denote not only crocodiles, but also 'biawak'- the word for monitor lizard in Bahasa Indonesia.

However, the association described above for Southwest Sulawesi seems not to be unique in Indonesia's manifold ethnic groups. For instance, it is known that people from a restricted part of the Lesser Sunda Islands (Nusa Tenggara) south of Sulawesi have a similar relationship to another monitor lizard, the

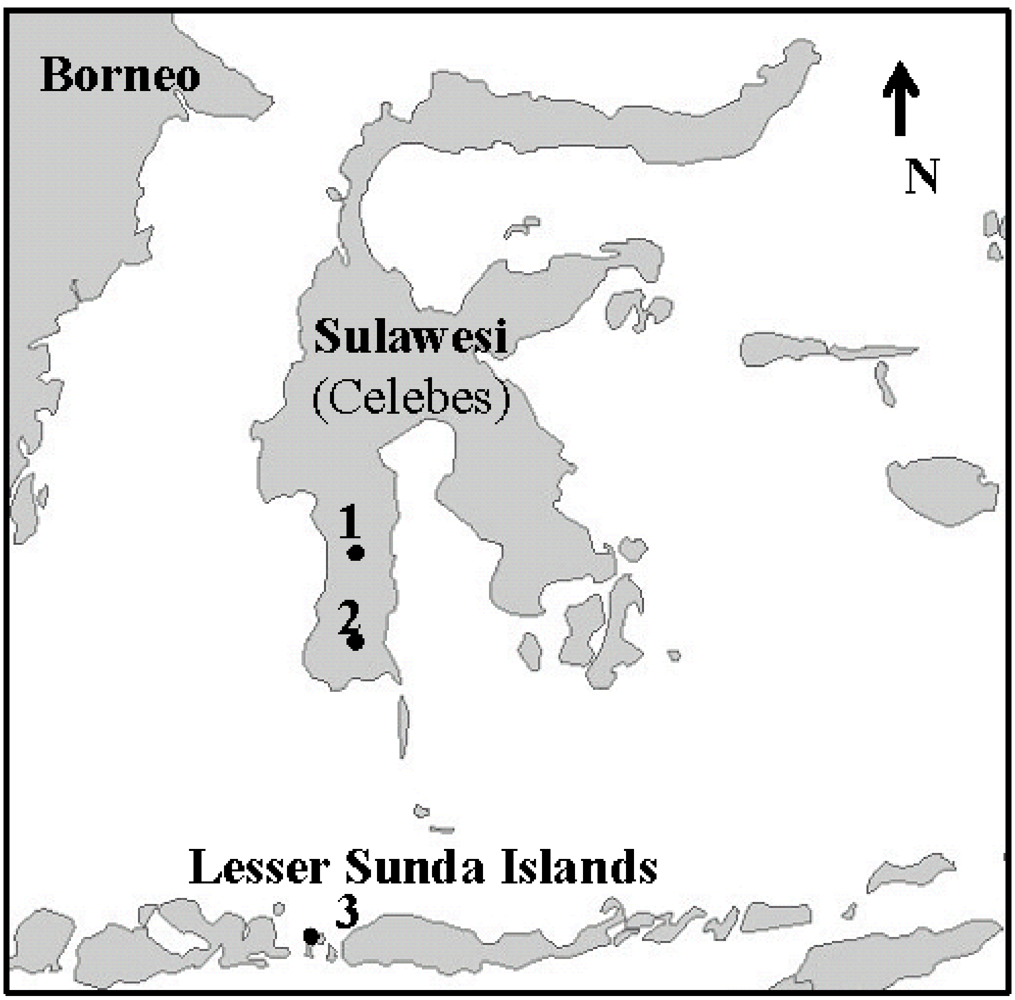

Figure 2. Map of Sulawesi and the Lesser Sunda Islands showing (1) Lake Tempe, the home of Alhim and his family on the southwestern peninsula of Sulawesi; (2) the approximate position of the village Todotora (which could not be traced on any map), where the royal monitor lizard Ali Mohammed lives; and (3) Komodo Island, the type locality of *V. komodoensis*.

Komodo dragon or Ora, *V. komodoensis* (P. Hien, pers. comm.). This monitor species is the largest lizard in the world, reaching a total length of up to 3 m and a weight over 70 kg (Ciofi, 2004). Their natural prey are deer, goats and buffalos (Auffenberg, 1981). Therefore, unlike the Sulawesi water monitor, the Komodo dragon is potentially dangerous to humans and attacks, sometimes lethal, occur from time to time.

The traditional view of the original Ata Modo people from the area around Komodo Island holds that some of the monitor lizards are their relatives (Anonymous, 1981: 47-53; Ellis, 1998), viz. specimens with different numbers of toes are considered to have a human spirit (M. Erb, pers. comm.). As in Bugis tradition, it is also believed that a woman on Komodo Island gave birth to twins of whom one was a monitor lizard. Since that time, Komodo people and dragons are siblings (C. Ciofi, pers. comm.). Auffenberg (1981), however, who studied the ecology of Komodo dragons for many months in the wild, did not mention such an intimate relationship between local inhabitants and monitor lizards.

In general, it is supposed that claiming kinship with crocodiles and monitor lizards is a way of attempting to lessen the danger from these animals. These extraordinary associations may represent a variant of other beliefs regarding guardian spirits, as practiced by many indigenous peoples (e.g. Swanson, 1973; Geertz, 1976; Marshall, 1999).

Altogether, it seems to be not by chance that such remarkable tradition as that of the monitor twins is held in the area around Southwest Sulawesi, Flores, and Komodo Island where large monitor lizards are found. However, it is unknown whether the phenetic resemblance of the two species involved – both unrelated monitor lizards are dark brown to blackish lacking any distinct pattern as adults – had any crucial influence on the origin of the tradition. It seems more reasonable to suggest that people of Southwest Sulawesi and Komodo Island have the same ancestors and/or origin, respectively, and therefore similar traditions. Early contracts by traders with natives of the Lesser Sunda Islands, as elaborated by MacKnight (1983), might be another explanation for the common spirituality.

As this report is merely based upon observations from a TV documentary, zoo-ethnological field studies are urgently required to investigate and understand the close relationship between Sulawesi monitor lizards and local Bugis people. Due to the scarcity of information about the Monitor Twins of Sulawesi and adjacent islands, the authors would appreciate additional information about the above described phenomenon.

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NATURAL HISTORY NOTES

VARANUS BENGALENSIS (Bengal Monitor) **PREY.**

On 24 June 2007 at 0815 h, a sub-adult Bengal Monitor, *Varanus bengalensis* (ca. 50-60 cm total length [TL]) was observed preying on an adult *Calotes* (possibly *C. versicolor*; ca. 20-25 cm TL) in Bundala National Park, southeastern Sri Lanka. Observations occurred on the southeastern side of the park in a coastal area dominated by low shrubs and bushes.

The *V. bengalensis* and *Calotes* were first seen in an open clearing between some bushes less than 100 m from the beach. The monitor was seen with the *Calotes* grasped by the underside of the neck, and was dragging it around in the open for ca. 5 min (Figure 1). Although capture was not witnessed, the *Calotes* was likely recently captured, due to minor twitching seen in the restrained lizard. Aside from dragging the *Calotes*, no other significant handling behaviors by the *V. bengalensis*, such as shaking, or raking with the claws were observed. It finally disappeared with the lizard into a nearby bush, where observations were unable to be continued (Figure 2). It is unknown whether or not the *V. bengalensis* was able to consume the *Calotes*.

Several adult *V. bengalensis* were encountered in Bundala National Park during the morning of the same day. All adult monitor sightings occurred in densely forested areas near the coastline, with many of the monitors observed resting up in trees.

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Figure 1. *Varanus bengalensis* grasps *Calotes sp*.

Figure 2. *V. bengalensis* drags *Calotes sp.* to bushes

VARANUS SALVATOR (Asian Water Monitor) **MIGRATION.**

At 1600 h on 5 July 2007, a large Asian Water Monitor, *Varanus salvator* (ca. 1.8-2.1 m total length) was seen swimming between two small, uninhabited islands located off the southern coast of Railay, Krabi Province, southern Thailand (Figure 1). Observations were made ca. 2.4 km out from the coast of Railay while traveling through the archipelago in a long-tail boat. There are many small islands in the region, most of which are bordered by sheer limestone cliffs (see Figure 2).

The *V. salvator* was first seen approaching a small island from another island ca. 900 m away. When its path became obstructed by the boat, it swam around the boat and then cut back towards the island. It was clear that the monitor was determined to get to this island, rather than swimming out in the open water randomly. The *V. salvator* was a very strong swimmer and did not appear fatigued despite the relatively turbulent waters experienced that day, or the distance traveled.

ROSS BORDEN

Figure 1. *Varanus salvator* swimming in open water between islands

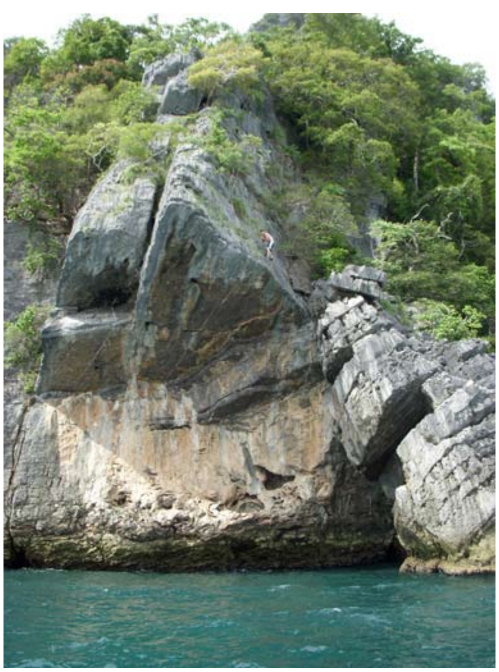

Figure 2. Example of the limestone cliffs which border many of the small, uninhabited islands off the coast of Railay

VARANUS ACANTHURUS (Ridge-tailed Monitor) **SPONTANEOUS PNEUMOPERITONEUM.**

Although well documented in mammalian veterinary literature (e.g., Williams et al., 1983; Probst et al., 1984; Lonsdale and Richardson, 1999; Mellanby et al., 2002; Lykken et al., 2003; Saunders and Tobias, 2003; Itoh et al., 2005), pneumoperitoneum, the retention of gases within the abdominal cavity, has not received much if any attention in reptiles. Furthermore, when compared to other squamate groups frequently maintained in captivity, particularly iguanids, few veterinary reports on afflictions affecting monitor lizards exist (e.g., Zwart and Harshbarger, 1972; Friend and Russel, 1979; Jacobson and Kollias, 1986; Gamble and Hartdegen, 2000; Arnbjerg et al., 2002; Hetzel et al., 2003; Bertelsen and Weese, 2006). Documentation of health complications in captivity may therefore be valuable to the advancement of herpetological husbandry, medicine and surgery. A case of spontaneous pneumoperitoneum in a captive-bred juvenile Ridge-tailed monitor *Varanus acanthurus* is reported here.

Three juvenile Ridge-tailed Monitors, *V. acanthurus* were delivered to the author via overnight domestic shipping. Despite being cold, upon initial inspection all three monitors appeared to be in good physical condition. The group was immediately set up in an enclosure which offered a temperature gradient ranging from 24° C to a basking temperature in excess of 54° C. Once their body temperatures had warmed up, all three monitors became very active, inspecting their surroundings, digging burrows, defecating, and even exhibiting pseudo-copulatory behavior with one another.

Approximately ten hours after arrival one of the juveniles (8.6 cm SVL; 21.4 cm total length) had become noticeably distended in the abdomen, and was seen basking for extended periods (> 5 min at a time). Upon closer inspection, it was evident that the monitor was bloated with gas, rather than food or fluid (Figures 1 & 2). The distention become so pronounced that the monitor was unable to rest in a natural position, and all roaming activity ceased. Likely an effect of the pressure buildup within the

Figure 1. Lateral view of abdominal bloating ca. 10 h after arrival

Figure 2. Dorsal view of abdominal bloating ca. 10 h after arrival

Figure 3. Detail of abdominal bloating in recently-deceased *V. acanthurus* prior to perforation of peritoneum

Figure 4. Deflated abdomen immediately after perforation of peritoneum

abdominal cavity, the *V. acanthurus* appeared to be experiencing difficulty breathing, occasionally gasping or 'gulping' air (ca. once per minute). No attempts to relieve the pressure buildup were made that day. The basking light was left on overnight to provide continuous access to a basking spot, in hopes that the monitor could recover from this malady.

The monitor was found dead the following morning, rolled over onto its side. The abdomen was turgid (Figure 3). Judging by the limpness of the limbs, the monitor had apparently died shortly before its detection that morning, and rigor mortis had yet to set in.

Using a scalpel, a small, shallow incision made through the skin and musculature of the abdomen resulted in immediate deflation of the abdomen (Figure 4). Upon dissection, no noticeable signs of stretching, blockage, ulceration, or damage to the intestines or stomach were detected, suggesting that the gases were retained within the peritoneum and not the intestines. No perforations in the intestinal lining were noticed. Despite being fed three days prior to its delivery, the stomach contained a substrantial amount of undigested food matter (crickets), and little digested material was present within the intestines. Based on observations of the rapid digestive rates (usually within 24 h of ingestion) of healthy juvenile *V. acanthurus* in captivity, it would appear as though the digestive system of the deceased monitor had been compromised. Whether this had any bearing on the pneumoperitoneum remains unknown.

Pneumoperitoneum is a generalized term used to describe the buildup of gases within the peritoneum. Acute, or spontaneous pneumoperitoneum, as seen in this *V. acanthurus*, can have many possible underlying causes in mammals, including bacterial infection (Probst et al., 1984), gastric ulcer (Lykken et al., 2003), bladder rupture (Saunders and Tobias, 2003), neoplasia (Saunders and Tobias, 2003), and gastric perforation (Mellanby et al., 2002; Itoh et al., 2005). It remains to be seen whether reptiles, and more specifically squamates, have the same susceptibilities to pneumoperitoneum as mammals. Although the dissection carried out was inconclusive in determining the causative agent or source of the gases retained by the *V. acanthurus*, it is possible, given the diminutive size of the individual, that a bacterial infection or minor perforation may have been overlooked.

Of interest was the acute onset of symptoms which intensified over the course of several hours. Earlier surgical intervention by perforating the perineum may have temporarily alleviated symptoms, particularly breathing difficulties, however it is unlikely that simple alleviation of the pressure within the abdominal cavity would have remedied the underlying cause of the pneumoperitoneum, especially if bacterial infection or severe perforation of the stomach or intestines were responsible.

Despite being raised and shipped together with the afflicted individual, and housed together while symptoms appeared, the two accompanying *V. acanthurus* remain unaffected and healthy.

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VARANUS SALVATOR KOMAINI (Black Water monitor) REPRODUCTION.

The first documented captive breeding of *Varanus salvator komaini* occurred in 2007, resulting from a single adult pair maintained outdoors year-round in a large exhibit in Costa Rica (Dwyer and Perez, 2007). As a follow-up to this initial report, additional data on a subsequent group of hatchlings and clutch of eggs are presented.

Twelve eggs were laid by the female on 27 January 2007 (Dwyer and Perez, 2007), of which ten successfully hatched after a period of 252 days, incubated at a temperature of 25-26° C. Hatchling measurements are presented in Table 1.

A clutch of 14 eggs was deposited by the female on 22 October 2007 (Table 2) at a depth of ca. 30 cm; the same depth as previous clutches (Dwyer and Perez, 2007). Interestingly, all five clutches of eggs laid by the female have been deposited within a meter of each other. Judging from the nature of the site: full sun on a slight incline, both temperature and drainage of the nesting site seem to be very important. Whether or not females in the wild are faithful to a particular nest site remains to be seen.

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Table 1. Hatchling measurements

No.	Mass (g)	SVL (cm)	TL (cm)	Total Length (cm)
1	38.1	12.5	17.0	29.5
2	37.0	12.5	16.0	28.5
3	39.5	12.5	16.0	28.5
4	41.0	12.5	17.7	30.2
5	34.6	12.7	17.7	30.4
6	40.4	13.5	19.0	32.5
7	38.0	13.5	18.2	31.7
8	37.0	13.7	19.2	32.9
9	39.1	12.2	17.0	29.2
10	39.2	12.7	17.5	30.2

Table 2. Egg measurements

No.	Mass (g)	Length (cm)	Width (cm)
1	52.7	6.5	3.5
2	51.9	6.6	3.5
3	54.2	6.5	3.5
4	54.2	6.4	3.5
5	53.9	6.4	3.5
6	55.3	6.5	3.5
7	53.4	6.8	3.4
8	53.5	6.6	3.4
9	51.7	6.5	3.3
10	52.5	6.4	3.5
11	56.3	6.5	3.8
12	55.3	6.8	3.4
13	55.3	6.8	3.5
14	54.7	6.4	3.6

GEOGRAPHICAL DISTRIBUTION NOTES

VARANUS INDICUS (Mangrove Monitor) **LIAPARI ISLAND**

While living on Vella Lavella, an island within the Western Province, Solomon Islands, between January 1996 and December 1997, several Mangrove Monitors, *Varanus indicus* were observed during visits to the neighboring Liapari island. Liapari is a small, flat island ca. 1 km in diameter, situated off the southern coast of Vella Lavella, and separated from Vella Lavella by a very shallow passage ca. 30 m wide. Liapari is sparsely vegetated, and is comprised primarily of coconut plantations, which made observation of monitor lizards easier through stands of palm trunks than in dense rainforest encountered on Vella Lavella. Mangroves occur along the northern coastline which faces Vella Lavella, with beaches and reefs along the southern coast. There are very few, if any densely-vegetated areas on the island.

On Liapari, *V. indicus* was observed primarily in coconut plantations (Figure 1), either traveling on the ground or climbing the trunks of palms (Figure 2.). All observations took place in the mornings, before 1200 h. As many as 10 individuals were seen on Liapari, all of which were adults. Two *V. indicus* were also observed in coconut plantations in southwestern Vella Lavella, near the village of Sambora.

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Figure 1. Coconut plantation on Liapari

Figure 2. *Varanus indicus* climbing trunk of coconut palm on Liapari

Effects of Environmental Enrichment on the Behavioral and Cognitive Development of Captive Black Throated Monitor Lizards (*Varanus albigularis*)

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While it is generally accepted that stimulus enrichment plays an important role in the behavioral and physical health of mammals, significantly less attention has been focused on non-avian reptiles, especially in relationship to cognitive development. The Dallas Zoo, in conjunction with the University of Tennessee, studied the effects of environmental enrichment on the behavioral and cognitive development of a group of captive Black-throated monitor lizards, *Varanus albigularis*. Analysis is continuing on the behavioral tests of a group of monitors reared in enriched, rather than standard, environments. The former contained more structure, the animals were fed live rather than dead prey, and they were given novel objects, problems, and social stimuli. Clutchmates reared in standard environments were compared with those in enriched environments and tentative results show that the latter had larger forebrain growth. The effects of habituation and individual differences in response to object introductions and performance tasks will allow further understanding of learning processes in monitors.

The project goals include:

1) Determine if environmental enrichment has an effect on behavioral development of captive monitor lizards.

2) Determine if environmental enrichment has an effect on the cognitive development of captive monitor lizards.

3) Shed light on the learning processes of monitor lizards.

Restoring Vitamin D in Monitor Lizards: Are Dietary and UVB Sources Equivalent?

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Project Background

Vitamin D is an essential nutrient involved in the regulation of calcium and phosphorous in the vertebrate body. Vitamin D-deficiency and pathology related to that condition (e.g. nutritional metabolic bone disease, reproductive failure) can be improved in many vertebrates by increasing vitamin D from two sources: dietary supplementation of vitamin D and UVB-mediated endogenous synthesis of vitamin D. However, the natural importance and relative efficiency of these two sources of vitamin D remain largely unknown.

Research so far has suggested considerable variation among species in the importance of the two sources. Species with naturally high levels of vitamin D in their diet, such as cats, dogs, and polar bears, appear unable to endogenously produce vitamin D from UVB exposure. By contrast, insectivorous and herbivorous lizards with naturally low levels of vitamin D in their diet appear to use mainly the UVB-mediated endogenous source. Preliminary information on herbivorous green iguanas from research by Mary Allen and her colleagues suggests that the dietary route is not only less efficient, but insufficient to maintain proper vitamin D-condition without massive dietary doses likely to cause vitamin D toxicity.

Furthermore, some lizards, such as the Panther chameleon, have been shown by us to voluntarily adjust their exposure to UVB in a gradient depending on their internal vitamin D condition. They appear able to photoregulate their vitamin D condition. Given the lack of knowledge of vitamin D requirements from species to species, it has been suggested for species with this ability that UVB may be a better vitamin D source in captive husbandry than dietary sources, allowing the animal to self-regulate its vitamin D levels. However, knowledge of which species are able to self-regulate is lacking.

Vitamin D_3 incorporated from the diet or produced endogenously rapidly enters the blood circulation.

From a previous study by Mary Allen and colleagues, a single large oral dose of vitamin D_3 (10 IU/g) in vitamin D-deficient iguanas resulted in a peak concentration in blood in about 24 hours. It was then rapidly converted to 25-hydroxovitamin D_3 (calcidiol) in the liver, peaking within 7 days in the blood circulation. Vitamin D_3 dropped to near-baseline levels by day 14. Calcidiol returned to deficient levels by day 35. Calcidiol is the most abundant form of vitamin D_3 in the body and its blood-levels are considered the best measure of vitamin D-condition. Vitamin D_3 and calcidiol are relatively inert biologically. However, the latter is converted as needed to 1,25-hydroxyvitamin D (calcitriol), its hormonally active form, by the kidney.

Our current study is investigating the importance of both sources of vitamin D (dietary and UVB-generated) for restoring and maintaining vitamin D-condition in the Black-throated monitor *Varanus albigularis*. Data will reveal the relative efficiency of the two sources over an extended period. Information from this study will provide background for studying the attractiveness of a UVB source to the lizards and their ability to regulate their vitamin D-condition through basking. Results will provide valuable insight into the captive-management of this and related species regarding calcium/phosphorus balance.

Summary of Methods and Experimental Design

Sixteen captive-hatched monitors were raised at the Dallas and Fort Worth Zoos for approximately 2 years, rendering them safe for serial bleeding. Raised and housed individually, their diet and lighting regimens were modified. All sources of dietary vitamin D_3 and UVB were removed from their environment. Serum levels of calcidiol were monitored until a significant drop was recorded. Then each individual was given a single dose of either vitamin D_3 or UVB. Dose levels were arbitrarily chosen and "bracketed" (varied around the estimated mean) based on levels previously suggested to be adequate for maintaining good vitamin D-condition in herbivorous green iguanas and panther chameleons. Circulating calcidiol levels were monitored at specific time intervals after the single dose to assess changes in level. Based on an observed "post-dose spike" of calcidiol level, weekly doses were begun and maintained for 90 days.

Preliminary Results

1) Deprivation of all sources of vitamin D_3 resulted in an average of 30% depletion of circulating calcidiol in approximately two months.

2) A single dose of dietary vitamin D_3 or UVB resulted in a significant peak of increase in calcidiol at an average of seven days with return to baseline in an average of 14 days.

Planned study

1) Statistical analyses will be completed to verify relative efficiency of two sources of vitamin D for restoring and maintaining circulating calcidiol levels.

2) Circulating vitamin D_3 levels will be analyzed to see how their patterns coordinate with those of calcidiol.

3) Circulating levels of calcium and phosphorus, as well as bone density, will be compared over the 90 day maintenance period to determine the relative efficiency of the two sources of vitamin D_3 for maintaining appropriate calcium/phosphorus balance and bone health.

4) Behavioral studies are planned with the current group of monitors to verify behavioral attraction to UVB. Future studies are being planned with additional juvenile monitors to test their ability to regulate vitamin D-condition via voluntary modification of UVB exposure.

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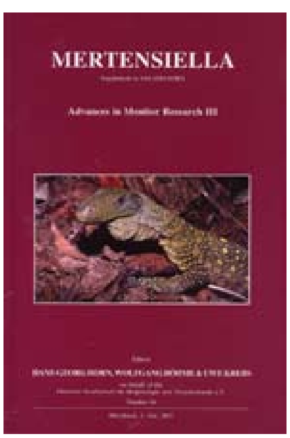
Advances in Monitor Research III



Edited by Hans-Georg Horn, Wolfgang Böhme and Uwe Krebs, the most recent volume of Mertensiella, annual publication of the Deutsche Gesellschaft für Herpetologie und Terrarienkunde (DGHT), includes papers presented at the Third International Symposium on Monitor Lizards, held at Museum Alexander Koenig in Bonn, Germany, 3-5 October 2005. In attendance were varanid researchers from all over the world, presenting on an assortment of subjects including varanid systematics, ecology, physiology, and captive breeding. Below is a listing of all papers published within this volume.

Böhme, W. and T. Ziegler. 2007. Notes on the distribution, diet, hemipenis, morphology and systematics of *Varanus spinulosus* Mertens, 1941. Mertensiella 16: 100-108.

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