BIAWAK

Journal of Varanid Biology and Husbandry

Volume 13 Number 1

ISSN: 1936-296X

On the Cover:
Varanus komodoensis

The hatchling Komodo dragon (*Varanus komodoensis*) depicted on the cover and inset of this issue was photographed by **Gunther Schmida** (E-mail: ggg32@bigpond.com.au) near the ranger station on Komodo Island in late April, 2015. The *V. komodoensis* was seen emerging from a tree hollow at a height of about 2.5 meters. There were quite a few people around and the dragon did not descend from the tree during the observation. Gunther Schmida wishes to thank David Hau and his team, and Marcus Schmidbauer.

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INTERNATIONAL VARANID INTEREST GROUP
www.varanidae.org

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 varanid lizards and the advancement of varanid research. Membership includes subscription to *Biawak*, an international research journal of varanid biology and husbandry, and is available online through the IVIG website.

ISSN 1936-296X

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Journal of Varanid Biology and Husbandry

Volume 13 Number 1
July 2019

NEWS NOTES

Two in Queensland Bitten by Lace Monitors

An eight year-old girl was injured when a monitor lizard bit her foot. The incident occurred at a beachside campground on South Stradbroke Island, Queensland. Few specifics of the incident were given, but it occurred while the girl was walking through the campground, and she suffered a severe laceration. Several people were needed to remove the animal's jaws from her foot. She was taken to the Gold Coast University Hospital and was listed as being in stable condition. The animal, identified from photographs as a large lace monitor (*Varanus varius*), was later captured and relocated to property near Jimboomba. Three weeks later, a man in Toogoolawah suffered deeps cuts to his legs when he attempted to get between a lace monitor and his flock of peacocks. His injuries were sustained while attempting to carry the lizard away from his flock. A paramedic who arrived to treat his wounds was also injured.

Sources: Blue Mountain Gazette, 24 January 2019; Brisbane Times 14 February 2019

Captive Komodo Dragon Deaths

Sunny, Albuquerque BioPark Zoo's Komodo dragon (*Varanus komodoensis*), has died. The 18 year-old male's cause of death was listed as kidney failure. Sunny originally came to Albuquerque from the San Diego Zoo in 2015 as a match for their resident female, Nancy. However, Nancy was euthanized in 2018 and the two never produced offspring.

Selat, a male Komodo dragon, was euthanized at the Woodland Park Zoo in Seattle. The twenty year-old animal, one of the oldest in North America, had been suffering from osteoarthritis and joint deterioration. Following unsuccessful treatments from a variety of therapies, zoo officials determined that the animal's quality of life had decreased to the point where euthanasia was considered the only humane option.

The Denver Zoo announced the death of Raja, a sixteen year-old male Komodo dragon. Unlike many captive dragons that are often transferred to other facilities, Raja had spent his entire life at the zoo, having hatched there in 2003. Zoo officials noted that the animal had a number of health problems including spinal disease and arthritis and that he had recently exhibited declining health.

A female Komodo dragon (*Varanus komodoensis*) at Zoo Knoxville has died. According to zoo officials, initial necropsy results suggested the cause of death was related to an infection of the reproductive tract. The dragon had been transported to a local university for a CT scan when it was believed that she was gravid with eggs. The female experienced difficulties recovering from anesthesia associated with the procedure, but was reported to have been recovering; it was found deceased two days later. Hatched at the Los Angeles Zoo in 2010, the dragon arrived at Zoo Knoxville in 2011.

Sources: Albuquerque Journal, 23 January 2019; The Seattle Times, 28 March 2019; FOX31 Denver, 27 March 2019; www.wvlt.tv, 17 June 2019

Crocodile Monitors Hatched at Honolulu Zoo

The Honolulu Zoo has announced the successful hatching of five crocodile monitors (*Varanus salvadorii*). Crocodile monitor reproduction in captivity remains a rare event with so far only four zoological facilities worldwide (and an unknown number of private keepers) having experienced success. This recent clutch is not the first time Honolulu has bred this species; a total of twenty-four have been hatched there since 1999. It was noted that the hatchlings are being hand-fed and have developed a familiarity with keepers there. No ultimate plans for the young animals were announced.

Source: Honolulu Star Advertiser, 2 April 2019

Man Pleads Guilty to Smuggling Philippine Monitors

A man pleaded guilty in federal court in Massachusetts (USA) to the smuggling of monitor lizards from the Philippines into the United States. Twenty six-year-

old Derrick Semedo pleaded guilty to a single count of wildlife trafficking in violation of the Lacey Act, the federal law that prohibits trade in fauna and flora that has been collected, acquired, or otherwise traded in violation of law (both domestic and foreign). The defendant had attempted to smuggle more than twenty live animals into the U.S. concealed within audio speakers. The animals were only described as being "water monitors"; therefore, the exact species in question is unclear. The defendant also admitted to selling several of the animals shortly after receiving them; the fate of the others was not given. He faces up to five years in prison and as much as a $250,000 fine when sentenced in August.

Sources: New Hampshire Union Leader, 23 April 2019; The Boston Globe 23 April 2019

Black Dragon at Maritime Aquarium Dies

The Maritime Aquarium in Norwalk, Connecticut (USA) announced the death of its black dragon. Black dragons are a melanistic form of the water monitor (*Varanus salvator*) previously treated as a distinct subspecies (*Varanus salvator komaini*), and remain rare in captive collections. The six year-old, seven foot (2.1 m) long lizard had shown a loss of appetite in the days before its death and was undergoing medical care. Aquarium officials announced that a necropsy will be performed.

Source: Norwalk Daily Voice, 24 April 2019

Police Stop Attempted Smuggling of Komodo Dragons

A network of organized criminals that was attempting to smuggle out dozens of Komodo dragons (*Varanus komodoensis*) was stopped by East Java police. Officials stated that the suspects (nine were arrested) were planning to sell 41 of the animals to collectors in three unidentified Asian countries via Singapore, with the transactions being completed through Facebook. Reportedly, the animals were to sell for as much as 500 million rupiah ($35,000) each. Officials further stated that five (or six, depending on the source) juvenile dragons had been confiscated, all of which were collected on the island of Flores. They are currently in the care of the East Java Conservation Agency and it is planned to return them to the wild at some point. The suspects face up to five years in prison and a $7,000 fine. Although the smuggling of Komodo dragons is not a new issue, this is the first time that suspects have been caught within Indonesia itself.

Sources: The Jakarta Post, 28 March 2019; Mongabay, 5 April 2019

Controversial Measures for Komodo Island

Officials have announced that Komodo Island will be temporarily closed to tourism beginning January 2020. The closure is in response to the recently uncovered smuggling of Komodo dragons. While officials insist the closure is temporary, no specific dates were given and it was said the closure may last for up to a year. Travel to the other islands that make up Komodo National Park will not be affected. This was one of several conservation measures proposed to aid the lizards, which would include the temporary relocation of all of the island's 2,000 residents. When the island reopens, the number if visitors would be capped at 50,000 a year and they would have to pay a fee (from$500 to $1,000) to do so. Dragons from Rinca could be relocated to Komodo, despite the two populations being separated for 70,000 years. East Nusa Tenggara Governor Viktor Bungtilu Laiskodat (who proposed the closure of the island) plans to replenish Komodo Island with Timor deer (*Rusa timorensis*), a major prey species of the dragons whose population has declined. On another note, the governor also proposed genetically enhancing the dragons to increase their size (why, or exactly how this would be accomplished was left unsaid). The various measures have generated enormous controversy from ecotourism operators, locals, and conservationists, and it remains to be seen which (if any) are actually put into place.

Sources: Bloomberg, 29 March 2019; The Star Online, 31 March 2019; The Sydney Morning Herald, 1 June 2019

74 Komodo Dragons Hatched at Surabaya Zoo

Between January and February 2019, a total of 74

Komodo dragons (*Varanus komodoensis*) were hatched by the Surabaya Zoo (Indonesia) from a total of 114 eggs laid by seven females the previous year. This brings the zoo's dragon population to a total of 142 individuals.

Source: www.sharjah24.ae, 6 March 2019

Hunters Caught with *Varanus flavescens*

Wildlife officials in Kurukshetra, Haryana State, northern India arrested two local hunters that were in possession of twelve protected animals. Among these were Schedule I and II protected species (Wildlife Protection Act, 1972) including a jackal (*Canis aureus*), a jungle cat (*Felis chaus*), and two dead and eight live yellow monitors (*Varanus flavescens*). Officials report that the monitors are smuggled into the black market where their body parts and skin are in high demand for medicinal purposes.

Source: Times of India; 6 July 2019

Monitor Sex Organs Seized in Western India

Forest department officials in Rajkot, Gujarat, western India seized 18 dried monitor lizard hemipenes from a book stall owner. Sale of monitor lizard organs is prohibited under the Wildlife Protection Act, and officials believe that the hemipenes are sold for use in religious rituals and black magic.

Source: Times of India; 1 May 2019

Varanus panoptes horni. Captive-bred hatchling. Photographed by **Martin Weil**.

A Tribute to Hans-Georg Horn (1935-2019)

This issue of *Biawak* is dedicated to Hans-Georg Horn, who passed away earlier this year. The personal reflections and accounts that follow are testaments to how much he was loved and appreciated by friends and colleagues, and how important he was to the study and keeping of monitor lizards.

Remembering Prof. Dr. Hans-Georg Horn

UWE KREBS

On 17 February 2019, at the age of 84, Hans-Georg ("George") Horn passed away within his family circle. His moving family history is a good representation of the influence of politics on the life of individuals. His ancestors had been German merchants in St. Petersburg, Russia but were forced to leave Russia after World War I and the Communist Russian Revolution, resettling in Silesia, a South–Eastern part of Germany. Hans-Georg was born in this new homeland in 1935. But, at the age of ten, at the end of World War II in 1945, the next displacement took place because their homeland of Silesia became Polish territory and Germans were displaced roughly. The family escaped to Thuringia, a part of Eastern Germany, but by 1948 there remained no other option but to escape from the upcoming German communist regime in the East, to Lower Saxony, a North-Western part of the later Federal Republic of Germany.

A reverberation of his German-Russian roots was the fact that Hans-Georg's mother, who spoke a well-pronounced Russian and owned assertiveness, had impeded sexual assaults and other encroachments in the early stages of the Russian occupation period in East Germany. The young Russian soldiers respected her like a type of 'strict mother' and she translated orally for the Russian officers. Her ten year-old boy stayed by her side often, as Hans-Georg once vividly told me.

Hans-Georg Horn received his high school diploma in Lower Saxony and around this time met his wife Ingrid ("Inge"). At the time of his passing, Inge and Hans-Georg had been married 57 years and had five children, which by the way, all have pretty Russian forenames. The whole family supported many varanids, many terraria and many guests from both Germany and abroad over the decades. This is not a matter of course, considering the quantity.

I remember my first visit at the end of the 1970s well, because it was so unusual. I had asked to see a few varanid species because I had to choose one species for a scientific project.
When I arrived, Hans-Georg wasn't present but his little daughter in the middle of her crawling stage dashed forward on all fours and gave me my first 'introduction'. Unlike me, she had known several species of varanid lizard. Her "close friend" was a very tame *Varanus salvator* female, which distinctly exceeded her in size. The little girl explained its habits to me.

After receiving his high-school diploma, Hans-Georg moved to the University of Göttingen in Lower Saxony to study chemistry. Here he completed his diploma and dissertation in chemistry and went on to accept a position with the University of Heidelberg in Baden-Wuerttemberg as a research assistant. From Heidelberg, he moved to the University of Bochum in North Rine-Westphalia, where he became tenured as a professor in chemistry. He mainly worked in the field of

inorganic chemistry, primarily with inorganic polymers. Although his occupation as a professor in research and teaching was challenging, he developed his interest in varanids in the early 1970s as they began to fascinate him.

To many members of the international monitor lizard community, which may include field researchers, keepers and experienced breeders of varanids, and scientists, George Horn will not be forgotten. George never looked down on private keepers of reptiles - the so-called "lay people", in a condescending or supercilious manner. He clearly recognized their importance to herpetology, even if they didn't publish because oral knowledge is knowledge, too.

When he noticed that political opportunism based on the absence of facts (93% of the global trade in varanid lizards are for skins for the leather industry) threatened the right of German private keepers to keep and breed exotic plants and animals, he, together with like-minded people founded the BNA (Bund für fachgerechten Natur- und Artenschutz [= Federal Association for Professional Nature- and Species Protection]), an association strong in membership, which united orchids growers, keepers and breeders of tropical fishes, exotic birds, reptiles and amphibians, etc. Only associations strong in members are heard politically, and in this way, grave concerns could be addressed and prevented. George was the first president of the BNA. Clearly, a few NGO's in question had become upset because their business models were challenged, and they tried unsuccessfully to vilify the BNA. Ideologically-loaded opponents of the legal private keeping of exotic plants and animals are still active with slanderous statements and half-truths, and these activities had overshadowed the last years of George's life.

Hans-Georg Horn was an effective promoter of varanid research. This is shown not only by his ca. 80 publications on varanid matters such as keeping and breeding, field observations, behavior and aspects of nutritional deficiencies, but also as an active organizer of congresses. Together with Wolfgang Böhme and myself, George organized three international interdisciplinary congresses on varanid lizards in Bonn (the former German capital). Because they were fully financed by the "German Science Foundation" (Deutsche Forschungsgemeinschaft, DFG), colleagues from Australia and the United States were able to get invited to participate. The DGHT (Deutsche Gesellschaft für Herpetologie und Terrarienkunde [= German Society for Herpetology and Herpetoculture]) published the results of these conferences in the book series *Mertensiella*, entitled *Advances in Monitor Research* (1991: No. 2;1999: No. 11; 2007: No.16). Even today, looking through the topics of these three volumes is interesting, as it shows the development of varanid research over the last several decades.

With his death, an active and fulfilled life came to its end. Our heartfelt sympathy is with his wife and his children. Many members of the monitor lizard community both in Germany and abroad are grieving for him. "*This is a big loss to the monitor lizard community*", our American colleague Robert Mendyk wrote to me. I lost a friend.

Maybe, a word from the philosopher Immanuel Kant can be a consolation. Kant stated (in my translation): "*As long as a person is remembered, he is not dead. He is only far away; death is only for those who are forgotten*." The monitor lizard community will not forget Hans-Georg Horn.

Georg Horn

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As a youngster trying to learn about monitor lizards in the mid 1980s I received a sound piece of advice from Gerard Visser, then curator of reptiles at the Blijdorp Zoo in Rotterdam. "If you don't know Georg Horn, you don't know monitor lizards" were his exact words. I was aware of a couple of Georg's paper, but they were in German and published in journals that were almost impossible to find in the UK. It soon became apparent

that, despite the considerable inconveniences involved, his publications were going to be essential reading.

Because he never bothered with the internet, it might be difficult for the younger generation to appreciate the full extent of Georg Horn's contribution to the study of *Varanus*. He was the first to report on the captive breeding of a number of species, produced papers on species that were unknown, or virtually unknown at the time (and in some cases remain virtually unknown) and on facets of behavior that were scarcely understood. The international symposia he helped to organize were the first such meetings devoted to monitor lizards. Perhaps most crucially, Georg's work included many collaborations between professionals (academics and zoo staff) and amateur enthusiasts, which were perhaps regular occurrences in Germany, but much rarer in the English-speaking world. He also attended the only monitor lizard meeting ever organized in the USA, and his absence from the Interdisciplinary World Conference on Monitor Lizards in Bangkok, 2015, was keenly felt by everybody that knew him.

Georg was hugely enthusiastic, he loved monitor lizards and he was a staunch defender of people's right to keep them in Germany. Among many other achievements in his life, he was a pioneer of varanid study and husbandry.

Contemplations about Hans-Georg Horn: Monitor Lizards, Varanophilia and World Politics

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I became acquainted with Prof. Hans-Georg Horn when I was a young graduate student in the Department of Zoology of Tel Aviv University working on my MSc thesis on *Varanus griseus*. As it usually happens in routine communication within the scientific community, I encountered his name in the scientific literature and sent him requests for reprints, which were responded to promptly. Later on, we exchanged letters (airmail letters - long before the era of e-mails), mainly on *Varanus* matters, and then his letters became increasingly unorthodox (scientific-communication-wise), more personal, and emotional and ideologically oriented. We began to exchange views and ideas not only on *Varanus*, but on many other issues such as ecology, wildlife conservation, politics and other global matters. He was troubled and agitated by global crises such as human population explosion and the destruction of nature, and he expressed his opinions and ideas clearly, straightforwardly and assertively. Then we met each other for the first time at a European conference – unfortunately I cannot recall exactly which conference it was and in what year it took place (probably during mid-late eighties), but I remember very well the first words that he said to me: "*Michael, I want to hug you*". I admit that I was captivated by his personality and affection and we established a close friendship that lasted almost four decades, and that in spite of the fact that we lived in two different countries (Germany and Israel) and actually – on two different continents. Once in a while, I used to contact Georg at his home in Sprockhövel (Germany) and speak to him on the phone. I intended to ask him briefly how he is doing and what he is doing, but we always ended up conversing for 1-2 hours on *Varanus*, wildlife conservation, nature conservation, world politics and related issues.

When I started my graduate studies on *V. griseus,* I became fascinated by my research objects - varanids in general and *V. griseus* in particular. This fascination extended beyond the intellectual fascination that scientists ought to have with their research subjects, and in many cases - also with their research objects; and it evolved into varanophilia sensu lato (in the broad sense, see below). I tried to read whatever literature I could find on monitor lizards. Hence, I developed an extensive world-wide correspondence with fellow varanophiles. Regarding the varanophilic drive, at first I felt that I was somewhat unique in that respect. Later on, I learned that the reality was very far from that, and I was glad to find myself in a good company. Georg Horn was the first varanophile that I met in person.

Georg Horn will also be remembered by varanophiles for his many publications that added much-needed basic knowledge on the biology, behavior, zoogeography and husbandry of many *Varanus* species. Georg was the main promoter and organizer (together with Wolfgang Böhme) of the first three Multidisciplinary World Conferences on Monitor Lizards that took place at the Alexander Koenig Zoological Research Institute and Museum in Bonn, Germany. Georg also edited (together with Wolfgang Böhme) the proceedings of these conferences. In the proceedings of the third conference, Uwe Krebs joined the editorial board.

Georg Horn will also be remembered as the forefather of ideological varanophilia. Georg once confessed to me that he would never kill a monitor for scientific purposes, with which statement I could easily relate and sympathize. In that respect, he opposed the usage of the verb "to harvest" in contexts related to the act of collecting live monitors in the field and killing them for various scientific purposes, reiterating that the proper verb should be "to kill" (and not "harvest"). It seems to me that in that respect, he differed from many varanophiles. The majority of varanophiles probably endorse monitor lizard conservation, but many of them do not necessarily refrain from sacrificing individual monitors for the sake of science. I think that many *Varanus* researchers may agree that sacrificing individual monitor lizards for the sake of science, *e.g.*, collecting live monitors for preserving them as specimens in zoological collections, dissecting monitors for stomach-contents analyses, examination of gonad activity-cycles and other biological parameters is scientifically sensu stricto (in the strict sense) justified and valuable, and as such might be directly or indirectly beneficial to the conservation of monitor lizards in the wild. In that respect, scientific varanophilia sensu stricto may have conflicting standpoints with varanophilia sensu lato.

Fig.1. In the cozy kitchen of the Horns in Sprockhövel. Left to right: Georg, Inge, Georg's Labrador, me.

In either case, Georg Horn's oriented ideological varanophilia is ethically justified and probably equally important for the conservation of monitor lizards – especially in the spheres of consciousness of the populace at large as well as public relations.

Like most other varanophiles, Georg was a firebrand opponent of the commercial killing of monitor lizards, *i.e.*, for the international skin and the traditional-medicine trades. Nonetheless, he was also a firebrand opponent of laws that indiscriminately banned the keeping of *Varanus* in captivity, including professional and well-trained breeders of monitor lizards. His main argument against these laws was that the numbers of monitors depleted from natural populations for the pet trade are negligible when compared to the numbers of monitors killed for the commercial skin trade. Hence, they (the laws) were unreasonable, unjust and even absurd.

Georg and his wife Inge hosted me several times at their home in Sprockhövel. For Georg, hosting me – a Jew from Israel was a very emotional experience. Moreover, the drama was enhanced when I told him that my father was born in the city Breslau, Germany (today - Wroclaw, Poland) and barely succeeded in leaving Germany in 1936 for Israel. Later on, during World War II, my father volunteered in the British army and joined the Jewish Brigade that was composed mainly of Hebrew-speaking Jews from then Mandatory Palestine. I found out that for Georg, World War II and the Holocaust were much more traumatic than for me. I was born in 1952 and I don't think that I became fully aware of the horrors of the war and the Holocaust until I was around 12-years-old. For a young boy, events that had happened more than 14 years ago were considered ancient history. I tried to calm him down reiterating that for me the Holocaust was not really an issue, and that I am worried about the future and not about the past. Georg agreed, but still he used to return to issues related to the Holocaust – up to the point that I became worried that it might affect his health. In that respect Georg has always been a steadfast supporter of Israel and he always stood shoulder to shoulder with us Israelis – in good times, as well as hard times.

During the First Gulf War (August 1990 to February 1991) when then Iraq's President Saddam Hussein launched Scud missiles targeting Tel Aviv and other cities in Israel, Georg contacted me as well as Prof. Yehudah L. Werner (Israel's senior herpetologist) and

the late Prof. Heinrich Mendelssohn (the founding father of wildlife conservation in Israel and the supervisor of my thesis on *V. griseus*) and offered his help by inviting us to stay with him and Inge at his house in Sprockhövel. Eventually, it did not work out and the war ended. As an aside, Prof. Mendelssohn's house in the city of Ramat Gan (Tel Aviv metropolitan area) was hit by a missile, but the damage was minor.

Georg's love story with lizards began in his childhood and was probably influenced by his father who was an ardent herpetologist. During World War II, Georg's father was a soldier in the Corpus of Erwin Rommel (der Wüstenfuchs - the desert fox) in the Sahara Desert in North Africa. After the corpus surrendered to the Allies, Georg's father was taken to a POW camp. The POWs were allowed to write one postcard with a restricted number of words and to send it to their families in Germany. Georg's father filled the entire postcard with the scientific names of the lizards that he encountered in the Sahara Desert – another episode of Georg's stories.

Georg had a great sense of humor. Georg loved the Yiddish language and especially Yiddish songs. Yiddish is actually a mixture of Hebrew and German, and until the Second World War it used to be the main language of Jews in Eastern Europe. Georg's favorite singer was Theodore Bikel (RIP), who was an Austrian-Israeli-American troubadour of folk songs that sang in many languages including Hebrew and Yiddish. Georg unveiled to me that when he was courting Inge they used to sit all night long listening to the songs of Theodore Bikel, and invited me to a likewise late-night session of Theodore Bikel songs. After the third song I fell asleep on the couch and finally I was released and allowed to climb upstairs to my bedroom. Georg knew by heart many songs of Theodore Bikel, including Hebrew songs that he could recite - whole verses in perfect Hebrew without really knowing the meaning of the words.

In a way, Georg's sense of humor interacted with mine. Both of us "were not enthusiastic" about the Anglicization of non-English names, neither of animals nor of famous people, *e.g.*, the famous German poet Goethe. Horn said, with an apparent sense of contempt: "*The Americans call him Go-Ee-Thee!*" Contrarily, in a subtle humoristic antithetical way, sometimes he "switched sides" pronouncing words in a strict Anglicized way. For instance, once while we were discussing *Varanus* matters, I mentioned the perentie (*V. giganteus*). Then suddenly he said "*Jai-Gan-Tee-Us*". Jokingly, I said: "*I have never heard of this species*" and the conversation rolled along as follows:

Georg: "*I don't believe you – this is one of the biggest and most impressive Varanus species!*"

Me: "*If it is such an impressive species, why is it not included in Pianka and King's book (Varanoid Lizards of the World)?*"

Georg: "*It is included, and actually, I wrote this species account.*"

Me: "*You did not!*"

Georg: "*Yes I did!*"

Me: "*You did not! You wrote the species accounts only on V. salvadorii, V. gilleni, V. salvator (with Maren Gaulke) and V. giganteus (with Dennis King).*"

Georg: "*OK Michael. Va-Ra-Noos Gee-Gun-Te-Oos* [hard G (like Goose)]."

Me: "*O.K. I am relaxed, but we shall have to raise a toast for that!*"

Georg: "*Yes, we have!*"

And so we did.

Georg has been a dominant figure in the varanophilic community and his absence created a vacuum in the community, but from the personal perspective, I lost a close friend and I shall miss him very much. I shall miss our long conversations, I shall miss his sincerity, his friendliness and his sense of humor, and I want to end these lines with a saying that we Jewish people usually say in such circumstances יהי זכרו ברוך - may his memory be blessed.

Remembering George Horn

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After a few years of sporadic correspondence George invited me to present results from my year-long field study of *Varanus glauerti* and *V. glebopalma* at the Second World Conference on Monitor Lizards at Museum Koenig in Bonn, in August 1997. Later that year he invited me to present the same work as an address to a DGHT meeting and a different talk at his university in Bochum, and to stay with his family in Sprockhövel. I don't speak German, but George assured me it was taken care of at DGHT, and it was. The late Hans-Dieter Philippen stood on the stage and boomed out a simultaneous translation that would have done the UN proud. For the next week George showed me around German zoos and the collections of a number of private keepers. This involved a lot of driving on the autobahn, and George was not a patient driver, with colorful comments for anyone in his way. Alternatively, once when I asked "Shouldn't we be leaving for Frankfurt soon?" the reply was "No, Hans-Dieter is driving!" I found that while George was very liberal in his outlook, he also held his views about idiots with tenacity and enjoyed lengthy arguments, which did not always include paying attention to the road.

I was impressed by the deference everyone showed to George, which I think stemmed mostly from his work as the founder and first president of the German national pet-keepers union, which lobbied successfully against many restrictive proposals. Beyond that context, George was an honored professor of organometallic chemistry, the author of the seminal textbook, and head of a large research institute at Ruhr University in Bochum. I went there with him once, and he was surrounded by assistants from the moment he left his car on the lawn in front of the building up to and including the entire 8th floor, which was his office. Here George was a top-down taskmaster, barking orders on the speakerphone and in person to lesser employees who hovered nearby, while at home has was genuinely bottom-up with his family and friends. As long as you had a reason you could challenge anything he said and get a fair reply.

In my experience it would be hard to find a kinder man than George. The upper floors of George and Inge's big house always seemed to have visitors. Things started late in the morning there, and I got into the habit of taking 2-3 hour walks from daybreak, still to be the first person stirring when I returned. Talking went very far into the night in the Horns' kitchen, and breakfast was a lengthy affair, eventually followed by an afternoon inspection of his living monitor collection. The Horns had bought a former automobile garage, and the whole first floor was open to the walls on a concrete pad. Here he had built large and solidly-framed cages from floor to ceiling. In the late 90s he had 6 or 7 2nd and 3rd generation CB lace monitors, 5 adult WC crocodile monitors, 3 large *V. cummingi*, a ferocious 5' *V. doreanus*, and 20 or so smaller animals of several species. All of the lacies and four of the crocs were housed together, leading to some fearsome interactions with little or no actual damage inflicted. George was also an indefatigable collector of everything monitor-related, with a particular focus on tracking down copies of obscure video segments.

I had three papers in the proceedings of the Third World Conference (2007): a long account of the spatial ecology of *V. scalaris* and *V. tristis*, a biogeographic paper with Eric Pianka, and a paper on the distribution of *V. salvadorii* with Horn and Kai Philipp. The last effort was the only time I did science with George, although he was keen to do a paper on brain size in monitors. Despite the export of hundreds of animals per year from Papua, there were very few solidly-established localities for croc monitors, and via correspondence I came to realize that no biologist had every actually seen one in the wild. Working with George was interesting, because he held his views so strongly. He came to accept that croc monitors were limited to low-elevation forests, but never accepted that the total lack of records from the north coast of PNG east of the Sepik River meant anything, despite a long history of thorough zoological and ethnographic exploration of that formerly German-held part of the island. George became quite exasperated

with me towards the end, wondering why I did not accept his changes to the manuscript and had no comments as to why. This confused me, until one day he emailed to say "*My son has shown me what means Paperclip*" [attachment]. After that we were good. George never came to terms with the internet age.

George was a strong supporter of human rights, and he had no tolerance for creeping tendrils of either fascism or communism in Europe. He talked about history and politics a lot, and shared some of his early memories as a child in Silesia during WW II. His family had fled the communists in St. Petersburg a decade earlier, and as postwar Silesia became absorbed into Poland under Russian influence it was determined that George and his sister would escape to the west. They were hidden under a load of hay and crossed the border into the American sector successfully, only to be discovered. George said he expected they would be killed on the spot, but instead a soldier gave him his coat and a half pound of chocolate. He also described how his father-in-law, who had been a forester and later a Prussian officer, was visited by the British sector commandant days after war's end and given a rifle and ammunition and asked to help feed the village by shooting pigs in the forest. He mentioned these incidents more than once as forming the core of his outlook on political philosophies, and on life.

As far as I know George traveled, but not extensively. I never asked him why. Even so, the world came to his house, and in my short stays there I can recall at least 14 nationalities around the kitchen table. More than anyone else of that era, George pulled together the diverse threads of varanid biology and husbandry by creating and guiding (with Wolfgang Böhme and Uwe Krebs) the first three world conferences, and by getting each published in the DGHT monograph series Mertensiella. George was too ill to attend the 4th world conference in Bangkok in 2015, but his influence on many of the participants was clearly expressed. It is unlikely that we will see his kind again, a professional in an unrelated field whose all-consuming hobby and energy created an intellectual structure linking science and husbandry where little had come before.

Reflections on George Horn

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I first became aware of Hans-Georg ("George") Horn through several of his important earlier publications while conducting literature searches on varanid lizards as a budding varanid enthusiast. In particular, I regularly referenced his two-part series written with Gerard Visser, "*Review of Reproduction in Monitor Lizards*" (1989, 1997) in which they reviewed all known cases of captive reproduction in varanid lizards at the time. From these literature searches, I began reaching out to the authors of these works, striking up conversations and seeking their wisdom and insight on varanid lizard biology and husbandry. I began corresponding with George via email in 2008, and we immediately struck up a friendship that would last for many years. I was surprised to learn several years into this friendship and correspondence that George was not one for computers, and that all of my correspondence had actually been mediated through his wife Inge, who transcribed

Fig. 1. Forelimb-assisted extractive foraging behavior in *Varanus beccarii*, first described by Mendyk & Horn (2011). Photographed by Robert W. Mendyk.

Fig. 2. Four varanophiles at the Alexander Koenig Museum, Bonn. 2013. From left to right: Uwe Krebs, Robert W. Mendyk, Hans-Georg Horn and Michael Cota.

George's dictated messages to email. So, this friendship and appreciation extends to Inge as well.

I consider George to be one of several important mentors that have helped shape my ideas and perspectives towards varanid lizards, the behavior and intelligence of reptiles, and the importance of publishing one's results and experiences – even unsuccessful ones. Aside from conversations on varanid lizards, we discussed many other topics of interest ranging from the destruction of nature, to human overpopulation, and German and American politics.

As *Biawak* continued to grow and diversify in the scope and breadth of its coverage, I extended an invitation to George to join its editorial board in 2009. I've always enjoyed George's emails as his responses often gave me a good laugh, regardless of whether it was intentional or not. His response to my invitation made me laugh, in which he replied:

"... and if I say "yes" it means yes. It is no "yes + no". Often academics and politicians in Germany use this undetermined and unclear term for answers or comments. The unclear version in German is "yein" (ja + nein). I now have talked enough and I'll make it short now: Yes, I agree to do the job.

And a fine job he did. George's input and editorial feedback on each issue was thorough, timely, and much appreciated. His addition to the editorial board undoubtedly helped improve the journal from behind the scenes.

Knowing George's interest and expertise in the study of varanid behavior and intelligence through our conversations and his various publications on these subjects (see page 22 of this issue for an overview of his scientific contributions), I invited him in 2010 to collaborate on a paper describing a remarkable prey extraction behavior that I had discovered in the black tree monitor *Varanus beccarii* (Fig. 1). George was enthusiastic about collaborating, and we got to work right away. We did disagree on where to submit the manuscript, and in the end George was not happy with my decision to submit it to *Herpetological Review* rather than include it in *Biawak* where he wanted to see it published. However, I do think he eventually realized that publication in *Herpetological Review* would lead to greater exposure of this information outside the varanid lizard community, which could lead to follow-up studies. Our paper was eventually published the next year (Mendyk and Horn, 2011).

In 2013, I found myself traveling to Scotland for a wedding and used this as an opportunity to visit some of my European friends and colleagues, including George and Inge, who graciously invited me to stay with them at their house in Sprockhövel, Germany. In hindsight, our initial meetup was quite amusing, as there was apparent confusion or miscommunication about when and where I was to be picked up at the airport in Düsseldorf.

Unable to reach George by phone, I wandered the airport aimlessly for what was probably close to half an hour, looking for a person I had only seen in photographs that were probably 20 years-old; similarly, George had no idea of what I looked like either. Frustrated and unsure of what to do, I suddenly came across a man standing in the middle of a busy mob of airport travelers wearing a t-shirt with a *V. panoptes horni* on it. The message couldn't have been any clearer than if someone had been holding up a sign with my name on it. As a collector of herpetology-themed apparel myself, that's probably what I would have worn as well. Now that we had found each other, we shared a good laugh and then departed for a busy day of varanid-related activities.

We briefly visied the Aquazoo Löbbecke Museum in Düsseldorf to meet its curator and check out its reptile and amphibian collection before linking up with Michael Cota, who was also traveling in Germany at the time, and Uwe Krebs at the Alexander Koenig Museum in Bonn (Fig. 2). There, we would meet with Wolfgang Böhme and André Koch and check out some of the varanid type specimens in the museum's collection as well as some living varanid lizards in the museum's Vivarium. Michael and I then left to visit Thomas Ziegler at the Cologne Zoo and check out their impressive collection of varanid lizards before meeting back at the Horn residence in Sprockhövel, where we met Inge and a few of their adult children. Inge surprised their American guests with a delicious dessert of fresh apple pie.

George toured us through his private varanid menagerie. The space, which appeared to be an old converted automotive garage, was filled with many large enclosures. Most were now vacant given his age, ailing health and inability to care for such a large collection anymore; however, in his prime, George maintained over 100 monitor lizards of some 18 species, including species uncommon in captive collections at the time. Of the few specimens he did have during my visit, I recall a very handsome *V. varius* that he had hatched years ago and what had to be the largest *V. cumingi* I have ever seen (ca. 2 meters in total length). Although George had successfully bred several smaller varanid species including *V. gilleni*, *V. tristis orientalis* and *V. storri*, I learned that he eventually decided to move on to focus on larger species such as *V. varius* because of allergies he had with feeder insects. With larger species, he could feed rodents, which were not a problem for him.

During my visit, I learned that George was very proud of the many varanid biologists, enthusiasts and herpetologists he had come to know over the years, especially those who had visited him in Sprockhövel. He showed me a large photo album of pictures that he had amassed of all the varanophiles he had the pleasure of knowing throughout the years. I was humbled by his request for a photo of myself to be added to this album. My stay with George and Inge was brief – just a single night, but George, Michael and I made the best of our time together discussing all things *Varanus* late into the night. I'll never forget George and Inge's warm hospitality.

My correspondence with George waned in recent years, which I suspect was due in part to his declining health as well as decreased free time in my own life for casual correspondence. Many of us were saddened by his absence from the 2015 Interdisciplinary World Conference on Monitor Lizards in Bangkok, Thailand, but understood that his health precluded his travel. My last email correspondence with George was back in June 2017.

Much like the late Mark Bayless (see Mendyk & Aller, 2007), George was an extremely passionate varanophile who generously offered his time, assistance and resources to anyone else that shared an interest in varanid lizards. This included, but is not limited to long-distance phone calls and the exchange of offprints, photographs and other information with fellow varanophiles – often at considerable personal expense. He was truly a pioneer, and to the international varanid lizard community, George's absence will leave an unfillable void and loss of expertise. On a more personal level, with his passing I lost an important collaborator, mentor and friend.

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How I Remember George Horn

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It must have been around 1980 that George Horn visited the Rotterdam Zoo for the first time. If I remember correctly, he and Dr. Ulrich Schürer, director of the Wuppertal Zoo in Germany were visiting Dutch zoos, and as always, George was on the look-out for monitor lizards. Rotterdam was on his itinerary because the zoo just had succcesfully hatched white-throated monitors (*Varanus albigularis*) (Visser, 1981).

At the time, the zoo also had a special section in the building where we kept Australasian reptile species, and in one of the exhibits lived two Gould's monitors (*V. gouldii*). One of them looked a bit peculiar and we were in doubt about its identity.

But George recognized it immediately as a Rosenberg's monitor (*V. rosenbergi*), which was a surprise to us. I don't think that at the time that species had ever been in captivity in European zoos, so George was thrilled to see one. It was nice to meet a German scientist (George was a professor in chemistry) who was really down to earth and who was able to communicate on the same level with a humble zookeeper like myself. At that time this was not especially a common streak in German academics. His enthusiasm, which I found refreshing, and the fact that he recognized another monitor-lover in me, led to a friendship that lasted for several decades.

After his stay in Rotterdam, I visited George and his very hospitable wife Inge several times in Sprockhövel, Germany. In their house he kept numerous species of monitors in a spacious cellar. In those weekends other often distinguished biologists and herpetelogists from all over the world visited as well, and so we often had great and lengthy discussions on monitor biology and husbandry, but also on politics, World War II, the EU, religion, zoos, racism and the future of planet Earth in general, among other things. German beer helped. George never was shy to voice his opinions on a wide range of topics, but he was also able to understand the views of others and even – sometimes - to admit he could be mistaken…

In 1985 the Rotterdam Zoo's Reptile Department - meanwhile I had become Curator of Fishes and Reptiles - succeeded in hatching the first yellow monitor (*V. flavescens*) in captivity ever. George encouraged me to publish the data of this occurrence in Salamandra, the journal of the German Herpetological Societ (DGHT). His input was considerable and he also translated my manuscript into German.

Our friendship lasted and led in 1986 to a six week journey through Australia, of course aiming to find as many monitor species as possible. Our road trip took us from Cairns (Qld) to Darwin (NT) and Alice Springs in

Fig. 1. George and Rotterdam Zoo reptile keeper Jan Timmer during a visit to Wuppertal Zoo.

Fig. 2. George feeds one of his favorite monitors, a "Bell's phase" *Varanus varius* at his home in Sprockhövel.

the outback, and from there on a flight to Perth (WA). In Perth we stayed at the house of herpetologist Dennis King and his wife Ruth - again a few days of enthusiastic monitor-and-other-animal-talk, but also about English humor, the number of stars of Metaxa Brandy and Spike Mulligan.

George was very keen on meeting Dr. Storr at the Western Australian Museum in Perth, to discuss monitor biology with him and so we succeeded in meeting the man *Varanus storrii* was named after, in his office at the Museum. Glen Storr was head of the Department of Ornithology and Herpetology until 1986. With co-authors Lawrence Smith and Ronald Johnstone, he published a series of books on the West-Australian herpetofauna, the monitors being described in the second part of *Lizards of Western Australia*.

With Dennis King we travelled around through SW Australia for a few days, aiming to find *V. rosenbergi,* but we failed there. During the entire Australian trip we eventually found 11 species of monitor: *V. acanthurus, V. eremius, V. flavirufus, V. gilleni, V. giganteus, V. glebopalma, V. gouldii, V. mertensi, V. mitchelli, V. similis and V. tristis orientalis.* Which, we thought, was not a bad result. To illustrate George's wide scope of interest: we also found time to identify 161 bird species, 13 mammals and 29 non-varanid reptiles.

Even after those intense six weeks close together in the Australian bush our friendship had not suffered. I kept spending weekends in Sprockhövel whenever I could. George asked me to paint a large Austrtalian mural in the new exhibit he had built for his *V. varius*, which I managed to do in one weekend.

In 1989 Wolfgang Böhme and George organized the 'First Multidisciplinary Word Conference on Monitor Lizards', and they succeeded in bringing together a great number of leading herpetologists in Bonn. The Proceedings of this conference were published in a special volume of Mertensiella, a supplement to Salamandra (Böhme & Horn, 1991). On the cover was a great picture of *V. giganteus*, taken during our Australian expedition.

One of the contributions was our paper on basic data on the biology of monitors (Horn & Visser, 1991). I must admit that my main contribution was feeding the data that George had collected into a computer program to turn out nice bar graphs, which were included in that paper.

George and I also put together a large number of reproductive data. He made use of his great network and I had access to many colleagues in the zoo world. All this data were published in the International Zoo Yearbook (Horn & Visser, 1989, 1997). Initially, we did this without the aid of email so there was a stream of letters going back and forth between Sprockhövel and Rotterdam, and later on we were much aided by being able to use fax machines, which made life a lot easier. I found new faxes on my desk almost every morning.

After 1997 I became more and more involved in the zoo's masterplanning and exhibit design, notably the design and construction of the large Oceanium-building, which opened in 2000. Not only was it now mandatory for me to visit aquarium congresses instead of herpetology meetings, but I also had to visit aquariums in Europe, Japan and the USA for inspiration and information. Moreover, I was responsabe for putting together a presentable invertebrate and fish population for the aquarium and that took lot of my time and energy as well. All this made it very difficult for me to keep up with the developments in herpetology and especially in monitor husbandry and research. So the contacts with George dwindled, even after I had become the Coordinator of the European Breeding Program for the Komodo Dragon (2000–2010). Somehow, eventually, there was not enough common ground for us in that top end species. I had less and less time available. So with regrets I must admit that I didn't see enough of George over the last decade or so. In hindsight I must say that bothers me, but I also realize that it simply was how things were.

But, I remember him with gratitude. We spent many great hours together and I thank him for the laughs we had, the interesting people he brought me into contact with, and all the things he taught me.

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Prof. Dr. H.-G. Horn, My Close Friend and Collaborator over Many Years

PETER KRAUSS

I first had contact with George ("Jürgen") Horn almost 40 years ago. A Swiss friend suggested I could give him information about Australian monitor lizards. This was how we first made contact. Later when I visited Jürgen in Germany, I was surprised to learn he was also a collector and expert in Persian rugs and carpets.

What followed was Jürgen visiting me in Australia many times. During these times we travelled to almost all parts of this continent looking for monitor lizards. Jürgen photographed everything and recorded in his diary what we saw. During probably hundreds of camp fire chats we had discussions about life, our work and of course varanids. Jürgen was a very passionate man with great enthusiasm for everything he did. Among the memorable moments I recall one example when we were camped near Mt. Isa in Queensland. We were hoping to see some *Varanus glebopalma*. I knew the area well and selected a particular spot to make a hide for Jürgen to sit in. Jürgen sat in this retreat from 0830 h in the morning. When I picked him up at 1030 h, he was beside himself with pleasure. He had observed three "*Glebos*" only a few meters away doing natural things in their natural habitat. He had the biggest smile on his face! He was very excited! There were many other times during other trips when we had other similar experiences because of something we saw or did.

Fig. 1. Neville Burns (left), Hans-Georg (center) and Peter Krauss (right) at the Horn residence in 2015.

Jürgen was an academic, and always said: "*You must publish unusual material which is of special interest*". Then something very unusual happened at my place. Three lace monitors (*V. varius*) hatched from one egg! Jürgen co-authored the article which appeared in *Sauria* in September 2004 and *Reptiles Australia* around the same time.

Jürgen always entertained me with his stories and recollections when we travelled hundreds of km on the open road. I admired him for his intellect and intelligence.

I last saw Jürgen in 2015 during a short visit to Germany. He did have a fall about this time and his movement was restricted. Jürgens wife Inge told me of his passing at the beginning of March. Now when I think of Jürgen I don't only feel sad, but register a big loss in my own life. I still have memories of Jürgen stretched out on the ground focusing his camera to get a shot of a large perentie (*V. giganteus*) only a short distance away. This was in Kulgera, SA during our last trip 1986.This was Jürgen! Prof. Dr. H.-G. Horn, my friend.

My Professor Dr. Hans-Georg Horn

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The devastatingly sad news that Professor Dr. Hans-Georg Horn has passed away has revived a lot of touching recollections of our relations, which I would like to share with you, readers of *Biawak*, and through you perhaps with others who care. I am augmenting my model 1931 memory with my fairly detailed photographic records and my almost orderly file of German and English correspondence with Horn, H.-G., who soon switched to signing English messages "George", explaining that, "*Anglo-Saxon people call me that way*." My spelling of local place names follows the governmental 1:250,000 map, 1970.

Horn's earliest message on file, of 30 January 1990, written on the back of his impressive photo of a *Varanus giganteus* taken in the field in the Northern Territory, Australia, narrates how we had met at the First World Congress of Herpetology, Canterbury, in September 1989. Horn had introduced himself to me as a *Varanu*s amateur, without mentioning his being a professor of chemistry, and I remember this, we had been on stairs. This encounter turned out to be one of my great wins from this mega-enterprise that had taken Kraig Adler some five years to prepare and then to assemble nearly a thousand participants from all over, some of whom had sacrificed much to come, such as selling the car or taking a 30-year loan.

Soon thereafter Horn revealed himself as a many-fold extraordinary friend. In the Gulf War of early 1991, Iraq attacked Kuwait, the West counter-attacked Iraq, and Iraq retaliated by bombarding Israel with rockets, which were feared to eventually bear gas. The Professor of Chemistry Horn, Chair of the German Chemical Society, demanded of the German Government to act against those who were equipping Iraq. In March 1991 he received respectful, partly-positive, responses from both the Ministers of Justice and of Economy. At the university he admonished his students about the responsibility of chemists. Personally, doubting the effectiveness of our gas masks against the small-molecular nerve gas (sarin), he invited our "*children and grand-children*" to shelter in his home in Germany. This was neither necessary nor practical – our (adult) children could hardly abandon their activities – but extremely kind.

During 1992-1994 we corresponded, often by fax. Horn, busy and preoccupied on several fronts – university professor of chemistry, herpetologist, home menagerie keeper of varanids, and also caring family man – nevertheless found time for this human telecommunication. He expressed concerns about the clash of moral rights and legal limitations in the Middle East, German politics, and nature conservation. He candidly shared misfortunes – health problems of child, wife and (maybe worst) himself; two of their children had suffered attacks by "*foreign workers*"; a road accident had crashed the car when it was needed… But mainly we discussed the reproductive biology of *Varanus*. Questioning the relations among maternal body size, clutch size and egg size among Varanidae, I encountered observations that indicated that the giant *V. komodoensis* may be ovipositing like a bird, single eggs rather than compact clutch. We explored the possibility to research this. Further, and in part related to this, we explored possibilities of mutual visits.

Horn finally visited Israel in 1995; arriving on 7 April (Fig. 1). On Saturday 8 April, Nurit (my wife) and I drove him to Mt. Scopus, sighting on the way some orthodox in their Middle Ages black garb, and from there viewing the Old City including the Dome of the Rock with the morning sun behind us. Descending,

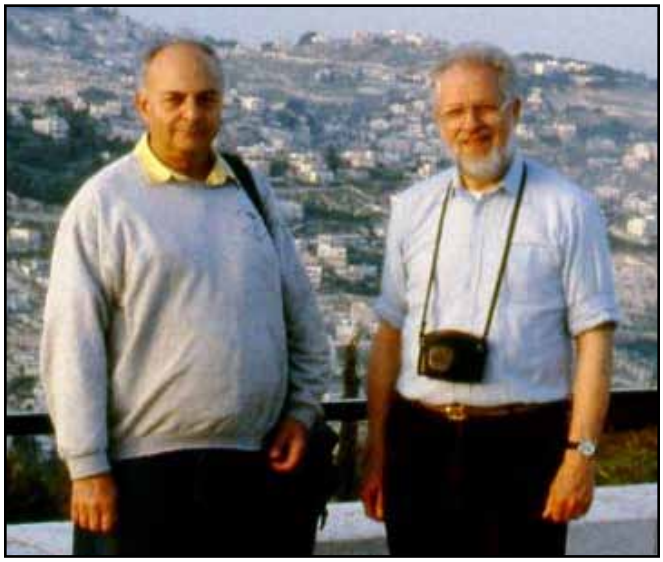


Fig. 1. Hans-Georg Horn (on the right) with Yehudah L. Werner in Jerusalem, 8 April 1995. Photographed by Nurit Werner.

we viewed the Old City from the opposite Mishkenot Sha'ananim, the historically first Jewish neighborhood outside of the Old City.

Horn enjoyed tasting the component of field trips that were part of my elective course "Introduction to the knowledge of the reptiles and amphibians of Israel" for Biology undergraduates (3rd year students) at the Hebrew University of Jerusalem. The two field trips were probably the course's main attraction and usually it was full -- the capacity was limited to 17 students because with the staff (teacher, two teaching assistants, and a technician) this filled the small bus that the budget enabled. In view of the climatic gradient of Israel, the first trip was to the warm (arid) south, before it would become uncomfortably hot, and starting in the barren habitats had the advantage that it was easier for the students to detect lizards. The second trip was to the cool (mesic and vegetated) north, when it became suitably warm. For assorted reasons the dates had to be determined and announced long before the weather was forecast, which then became "fact of life" and had to be lived with. Each field trip was preceded by two preparatory trips of the staff. The first, rather early, for geography and logistics (such as, where can the bus park, turn around; where can we spend the night, can we also hold a lesson there, etc. etc.). The second, as close to the trip as possible, was to acquaint the TAs with the local nature in that season (dominant plants, insects etc.) and assorted relevant methodology. Horn was interested in both the logistic and educational aspects of this operation.

On 12-13 April we took Horn on the preparatory trip for the first, southern, course field trip. We started with the southern Coastal Plain, Ziqim and spent the night at Nizzana and its dunes. H.-G. admired our ability to walk up-dune. The next day we visited HaMakhtesh HaGadol ("The Big Erosive Crater") and Ma'ale Aqrabim, the steep uphill serpentine road. Finally Hazeva (south of the Dead Sea) where we experienced a running *Uromastyx aegyptia* - second best after *Varanus*…

On 15 April, Passover Saturday, Nurit and I took him, and also Tony Oldfield, a PhD student from Australia, and his charming wife Kathrine, on the round walk on top of the wall of the Old City, whence one could see inside and outside.

On 16 April, Nurit and I took Horn to Tel Aviv-Yafo. In the Land of Israel Museum we saw amazing antiquities including mosaics. In the experimental zoo of Tel Aviv University, hosted by Prof. H. Mendessohn, we saw the rare and pretty *U. ornata* and of course some local adult *V. griseus*. We continued northwards, and viewed the fishponds teeming with water fowl of Ma'ayan Zvi near Zikhron Ya'aqov. On 17 April we reached Galilee where we have close Druze friends, the Farres clan. First we visited the village Kisra, namely Dr. Abdalla and his wife Nuha neé Farres who at age 17 had visited us for a week in Jerusalem; extremely liberal, advanced, daring on part of her parents. Then to the village Hurfeish to visit Nuha's older brother Nouhad and his wife Siham. With them we visited the neighboring Qibbuz Bar'am, whose little museum boasted a collection of Jewish traditional marriage agreements ("ketubot"), the oldest from Afghanistan, 1894. In the evening Nouhad and Siham fed us lavishly;

Hans-Georg Horn (red sweater) and Nurit Werner gratefully parting with their Druze hosts, Hurfeish, 18 April 1995. Photogaphed by Yehudah L. Werner.

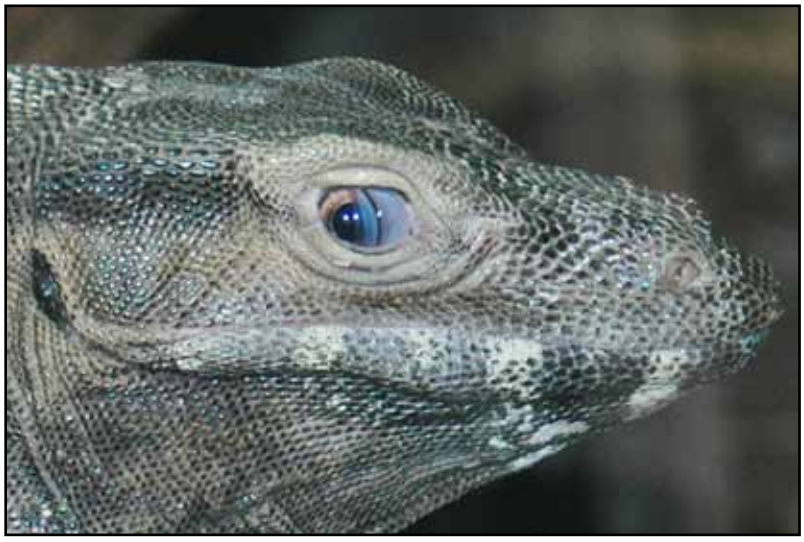
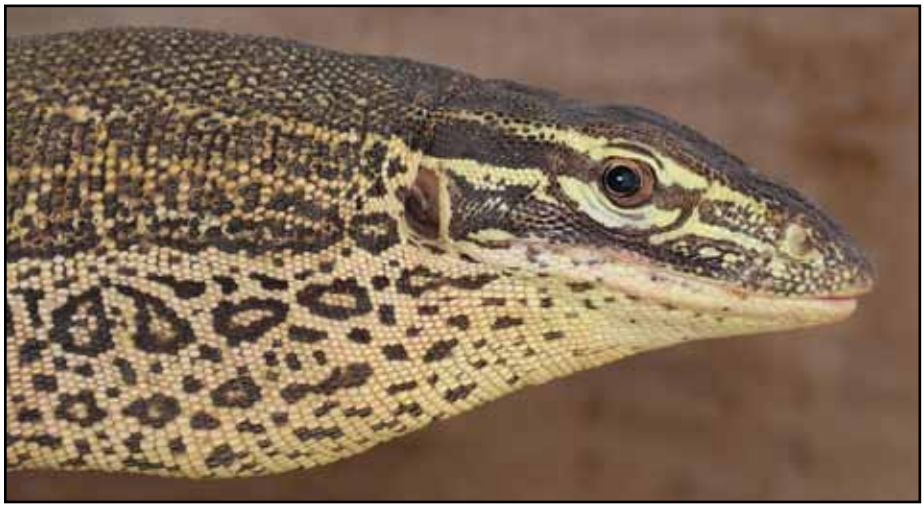


Fig. 3. Horn's *Varanus varius*, caught at a rare moment with half-closed nictitating membrane. Photographed by Alexandra Horn.

this was joined by his relation Hussein Farres (who later was to command the Border Police) and wife Amal. We spent the night at the Farreses (Fig. 2). On 18 April, we drove to the Golan Plateau, starting with the main town Qazrin and its museum rich with local antiquities. From the Ma'alé Gamla observatory, which had been erected by the local boys who had become "bar mizwa" (13) in 1993, we viewed the ruins of ancient Gamla and Lake Kinneret (Sea of Galilee), hitting it on the way back to Jerusalem. Horn flew home the following day.

In March 1997, Nurit and I at long last visited the Horn home in the village of Sprockhövel (an hour's drive from Münster). I was working for half a year at the reputed Technical University Munich and Nurit was visiting me. Horn sent me a hand-sketched detailed accurate map plus explanations how to, self-driving, find the remote village and their home, and it worked. The Horns hosted us most generously. Awe struck, I admired his private menagerie of several *Varanus* species, accompanied by a breeding colony of mice for food that was responsible for most of the smell. We seized an opportunity to visit the Horns again in August 2000, while we were staying with the (late) Uwe Hiller and family in Muenster as the last step in my ultimate sabbatical, 1999-2000. This visit was clouded by Horn being quite ailing.

We stayed in touch, somewhat concerned about each other's health. When I asked for a photograph of a *Varanus* head, I received a marvelous one. His daughter Alexandra had by sheer luck caught the eye in that fraction of a second when the nictitating membrane was half-way across the eye, demonstrating its mobility (Fig. 3). In my book *Reptile Life in the Land of Israel, with Comments on Adjacent Regions* (2016, Edition Chimaira, Frankfurt), this photograph is a bright jewel.



Varanus panoptes horni. Photographed by **Fernando Iglesias Puerta**.

Biawak, 13(1), pp. 22–31

A Lifetime's Pursuit of All Things *Varanus*: The Contributions of Hans-Georg Horn (1935–2019) to the Study of Monitor Lizards

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Introduction

With the passing of Hans-Georg Horn in February 2019, the herpetological community lost an important pioneer and contributor to the study of monitor lizards. Horn was a truly unique figure, as he bridged an oftentimes divisive gap between academia and amateur reptile hobbyists, and regularly stressed the value and importance of contributions by amateur hobbyists (Horn and Sprackland, 1992; Horn, 1985a, 1988a,b, 1991a). Horn himself published research on a broad range of topics from monitor lizard behavior to anatomy and physiology, taxonomy, biogeography, captive husbandry and reproduction. Beyond his primary focus on monitor lizards, Horn had additional interests and authored several publications on general herpetological matters (Horn, 2005; Horn & Visser, 1990a,b,c; Kuchling & Horn, 1995; Visser & Horn, 1990) and exotic animal keeping and breeding (Horn, 1985a, 1988a,b, 1991a). Although he held a PhD. and was a career academician, his field of study was chemistry. His lack of formal academic training in the biological sciences, however, did not impede his ability to carry out and collaborate on important biological research or prohibit him from stepping up to fight for the rights of private keepers in Germany to maintain monitor lizards and other exotic animals in captivity (Horn, 1985a, 1988a,b, 1991a, Kuchling & Horn, 1995; Schürer & Horn, 1988). Through his various authored and edited publications on monitor lizards, Horn collaborated with no fewer than 31 individuals from the academic, zoo, and herpetoculturist communities.

To fully illustrate the impact that Hans-Georg Horn has had on advancing the fields of monitor lizard biology and husbandry would be an impossible task, as his influences extend far beyond the tangible items outlined in this account. For example, it is unclear just how many amateur enthusiasts and professional scientists he offered guidance, mentorship and encouragement to that eventually went on to leave their own mark on the study or keeping of monitor lizards, or how many of his thoughts and ideas helped spark new questions or led to new avenues of research. Nevertheless, the following account highlights the various contributions made by Hans-Georg Horn to the study and captive management of monitor lizards, focusing primarily on his scientific and popular publications. For additional information, an earlier interview with Horn by Schmidt (1996) discussed some aspects of his background and how he became interested in reptiles, particularly monitor lizards, and his thoughts on monitor research and captive management.

Horn's Contributions

Behavior

Deeply fascinated by the behavioral complexity and intelligence of monitor lizards, Horn published extensively on various ethological topics. In particular, no other author has contributed as much to what is known about the ritualized combat behavior of monitors as Horn, having described combat in multiple species including *V. komodoensis*, *V. semiremex*, *V. timorensis*, *V. similis* (Horn, 1985), *V. cumingi* (Horn, 1994), and others (Horn *et al*., 1994). His pioneering work in this area has facilitated subsequent studies, including those on combat and game theory in reptiles (*e.g*., Eason *et al*., 2002).

Horn described and reviewed various examples illustrating the behavioral complexity of monitor lizards, making a direct comparison to mammals (Horn, 1999). These exceptional reproductive and foraging behaviors were then discussed in terms of their importance to the evolutionary success of monitors.

Mendyk and Horn (2011a,b) described a remarkable foraging behavior in the black tree monitor, *V. beccarii*, documenting for the first time in a reptile, the skilled and coordinated usage of the forelimbs to extract hidden prey items from narrow holes and crevices in trees (Fig. 1). This report called further attention to the problem solving abilities and behavioral complexity of monitors, as well as offered new opportunities for arboreal monitor lizard enrichment in captivity (Mendyk, 2012; Kuppert, 2013).

Horn had been working for several years on a book on monitor lizard behavior. It is unclear, however, if this work had been completed prior to his death or if it will ever be completed and published posthumously.

Taxonomy, Systematics and Biogeography

Horn's astute observational skills as a private keeper proved to be crucial to advancing the fields of monitor lizard taxonomy and systematics. According to Koch *et al*. (2010), as early as 1974 Horn alerted Wolfgang Böhme to morphological differences he noticed between New Guinea populations of *V. panoptes* and those from mainland Australia. This information eventually led to Böhme's (1988) assignment of a new subspecies for the New Guinea population which was named after Horn, the Argus monitor, *Varanus panoptes horni* (Fig. 2).

Several years later, having previously noted differences in tongue coloration between captive specimens of the *V. indicus* group back in the 1970s (Horn, 1977), Horn once again presented his findings to his taxonomist colleagues which raised further questions surrounding the taxonomy of this group (Koch *et al*., 2010). Horn was included as a coauthor of the resulting taxonomic revision which resurrected the taxon *V. doreanus* as well as created a new subspecies, *V. doreanus finschi* (Böhme *et al*., 1994), which would eventually be elevated to species status (Ziegler *et*

Fig. 1. Forelimb-assisted extractive foraging in *Varanus beccarii* (see Mendyk & Horn 2011a,b)

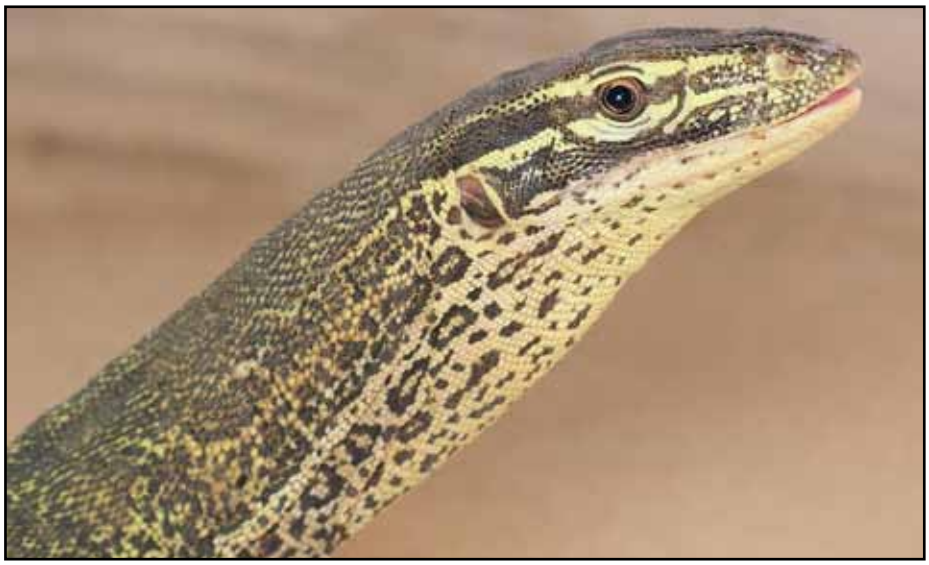

Fig. 2. *Varanus panoptes horni*; named after Hans-Georg Horn in 1988. Photographed by **Fernando Iglesias Puerta**.

al., 1999). Had it not been for Horn's keen attention to detail and notation of unique character differences between his captive specimens, there may never have been an impetus to study the taxonomy and systematic relationships of this group, which has since undergone extensive taxonomic revisions over the last two decades. Thus, to some extent, Horn deserves recognition for indirectly stimulating modern efforts aimed at resolving the taxonomic and systematic relationships of *Varanus*.

Varanus salvadorii remains one of the most enigmatic and poorly studied monitor lizards, and virtually nothing is known about its habits and occurrence in the wild. Although it is occasionally collected for the international pet trade, published field observations of this species are scant. As an important first step towards better understanding the biology of this species, Horn coauthored a report with Samuel Sweet and Kai Philipp that described the known distribution of *V. salvadorii* in New Guinea (Horn *et al*., 2007). Such information will be necessary for any future field studies on the species.

Anatomy and Functional Morphology

Horn collaborated with several other researchers on studies related to the anatomy and functional morphology of monitor lizards. Horn and colleagues discussed the biomechanics of bipedalism in monitors and other reptiles, and the implications for its evolution in the Reptilia (Christian *et al*., 1994a; Preuschoft *et al*., 1994). He co-authored a study describing the morphological structure and histology of scale glands and pre-anal glands in several species of monitor lizard, and discussed their potential functions (Andres *et al*., 1999). Röll & Horn (1999) studied the structure of the eye in *V. griseus caspius*. Horn (2007) studied the transmission and reflectance spectra of the skin of 14 species of monitor lizard, noting key interspecific differences attributed to ecological adaptations.

General Biology and Natural History

Several of Horn's monitor publications focused on more general biological topics and natural history overviews. For example, Horn authored and co-authored a total of five species accounts for Pianka & King's (2004) book, *Varanoid Lizards of the World*, including accounts for *V. salvadorii* (Horn, 2004b), *V. gilleni* (Horn, 2004c), *V. salvator* (subspecies; Horn & Gaulke, 2004), *V. giganteus* (Horn & King, 2004), and *V. salvator* (nominate form; Gaulke & Horn, 2004). Horn and colleagues discussed various biological attributes of *V. cumingi* (Wicker *et al*., 1999), and prepared accounts describing the natural history of *V. mertensi* (Schurer & Horn, 1976), *V. varius* (Horn, 1980), and *V. giganteus* (Horn & Visser, 1988). Horn also authored several popular articles on monitor lizards appearing in various hobbyist magazines in German (Horn, 1994b, 1995, 2006), Dutch (Visser & Horn, 1989, 1990) and Czech (Horn, 1996) languages.

Captive Husbandry and Reproduction

By far, Hans-Georg Horn's most significant contributions to the study of monitor lizards pertain to

captive management and reproduction. For well over a century, keeping monitor lizards alive in captivity was challenging and frequently met with failure, and instances of successful, purposeful captive reproduction were virtually non-existent. Many improvements in the way that monitors were kept were made possible through the efforts of Horn beginning in the 1970s. By the late 1970s, monitor husbandry had advanced to a point where some private keepers and zoos began experiencing better keeping results and even successful captive reproduction (see Horn & Visser, 1989, 1997). Horn's innovations and pioneering efforts were later aided by the important works and perspectives of Bernd Eidenmüller, Klaus Wesiak, Frank Retes and many others, who helped further advance monitor husbandry to its current state. Today, captive breeding is now commonplace for dozens of monitor species, with some taxa having reached the 20th captive-bred generation or more. Between 1976 and 2004, Horn authored and coauthored at least 23 publications on the captive management and reproduction of monitor lizards.

Over a span of more than four decades, Horn maintained at least 17 species of monitor lizard at his home in Sprockhövel, Germany, including several noteworthy species that are no longer kept in European collections today such as *V. eremius*, *V. glebopalma, V. mitchelli, V. flavescens* and *V. nuchalis* (Horn, pers. comm.). He began preparing articles describing his experiences with keeping monitor lizards in the mid to late 1970s (Horn, 1976), and contributed early accounts on the care of *V. jobiensis* (Horn, 1977), *V. dumerilii* (Horn & Shultz, 1977), *V. glebopalma* (Horn & Schurer, 1978), *V. mertensi* (Schürer & Horn, 1976) and *V. rudicollis* (Horn & Petters, 1982). In 1984, Horn and colleagues described the veterinary diagnosis and treatment of an injured captive *V. bengalensis* (Wisdorf *et al*., 1984). Two decades later, he prepared an article which discussed the construction and design of monitor lizard terraria (Horn, 2004a).

Of the many monitor species kept in his private collection, Horn was successful in breeding four species and is credited with being the first person to reproduce *V. gilleni* and *V. tristis orientalis* in captivity in 1978 (Horn, 1978; Horn & Visser, 1989) and 1982 (Bröer & Horn, 1985), respectively. Horn was also the first person to successfully reproduce *V. varius* outside of Australia in 1988 (Horn 1991; Horn & Visser, 1989), and successfully bred *V. storri* in 1983 (Bröer & Horn, 1985).

Collaborating with other private keepers and zoo professionals, Horn prepared many additional captive breeding reports, including accounts on *V. storri* (Stirnberg & Horn, 1981; Eidenmüller & Horn, 1985), *V. timorensis* (Schmutz & Horn, 1986), *V. giganteus* (Bredl & Horn, 1987), *V. exanthematicus* (Röder & Horn, 1994), *V. varius* (Horn *et al*., 1997; Krauss & Horn, 2004a,b), *V. salvadorii* (Schmicking & Horn, 1997), *V. cumingi* (Wicker *et al*., 1999), and *V. jobiensis* (Engelmann & Horn, 2003). Hagen *et al*. (1995) presented important information on the reproductive biology of *V. niloticus*.

Two of Horn's most important and widely cited publications were coauthored with former Rotterdam Zoo curator Gerard Visser, and provided a global review all known cases of captive reproduction in monitor lizards as of 1988 (Horn & Visser, 1989) and 1995 (Horn & Visser, 1997). At the time, when captive breeding was still rare and reproductive data were scattered in the literature or not reported at all, these works compiled reproductive data from published and unpublished sources from zoos and private keepers, and discussed various critical elements of captive care and breeding. Beyond their significance to captive breeding efforts, these works also provided valuable reproductive data that aided many subsequent biological studies on monitor lizards. An additional paper by Horn & Visser (1991) presented further reproductive data as well as information on other biological parameters of monitor lizards including hatchling growth rates. Lastly, Horn (2004d) prepared a chapter for the book, *Varanoid Lizards of the World* (Pianka & King, 2004) which discussed various logistical, technical and legislative problems associated with the captive management of monitor lizards.

Symposia and Proceedings

A further testament to his ability to network with, befriend, and bring together monitor enthusiasts and researchers from all backgrounds, Horn helped co-organize three international symposia dedicated to the study of monitor lizards. Convened at the Alexander Koenig Zoological Institute and Museum in Bonn, Germany in 1989, 1997 and 2005, each of these "*Advances in Monitor Research*" symposia brought together researchers from all over the world and covered a broad range of topics including taxonomy and systematics, morphology, ecology, evolution, behavior, physiology, parasitology and captive management. Horn also served as an editor for all three proceedings resulting from these symposia (Böhme & Horn, 1991; Horn & Böhme, 1999; Horn *et al*., 2007). With a combined total of 78 papers and 1071 pages, these three

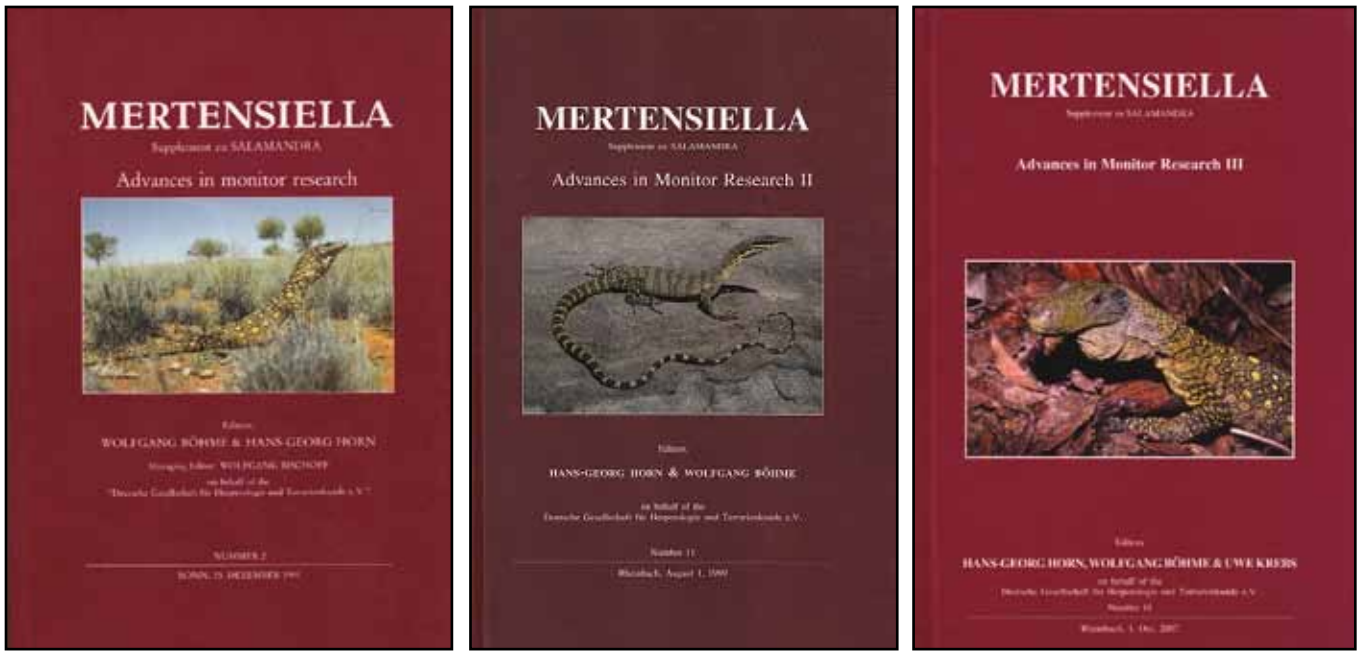

Fig. 3. "*Advances in Monitor Research*" volumes I (1991), II (1999) and III (2007).

works remain to this day some of the most important volumes ever published on the biology and captive management of monitor lizards (Fig. 3). Although the earlier two volumes are now long out of print and can be difficult to come by, all three volumes deserve a spot on every varanophile's bookshelf.

Organizational Positions

Hans-Georg Horn served as the Chairman of the Deutsche Gesellschaft für Herpetologie und Terrarienkunde's (DGHT) Arbeitsgemeinschaft Warane und Krustenechsen (German Monitor Lizard and *Heloderma* Working Group) from 1995–2003, which held periodic meetings in Germany and produced the newsletter *Monitor* which published notes and articles (in German) on the biology and husbandry of monitor lizards. In 2009, Horn joined the editorial board of *Biawak – Journal of Varanid Biology and Husbandry* as an editorial reviewer and maintained this appointment up until his death.

Awards, Recognitions and Other Miscellany

Having dedicated more than four decades of his life to the study of monitor lizards, Horn received various laudable distinctions for his work, with undoubtedly the greatest distinction being the naming of *V. panoptes horni* after him. In recognition of his contributions to monitor biology and husbandry, Horn was presented with the Joseph Laszlo Award at the International Herpetological Symposium held in Miami, Florida, USA in 1993 (see Bayless, 1993).

Concluding Remarks

The various contributions highlighted in this review exemplify the significant mark that Hans-Georg Horn has left on our understanding of the biology and captive management of monitor lizards, as well as the importance of collaboration between individuals across fields and communities. The number, breadth and scope of Horn's publications also illustrate what could be accomplished by those lacking a formal academic background in biology or herpetology. Moreover, they serve as encouragement and a model for other dedicated amateur monitor enthusiasts to follow and strive for.

Acknowledgments – I wish to express my gratitude to Inge Horn who provided useful information that allowed me to complete this account, as well as Uwe Krebs and André Koch for providing additional resources and

assistance. Lastly, I thank the Smithsonian Institution libraries for assistance with sourcing obscure literature.

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ARTICLES

Biawak, 13(1), pp. 32–42

Is the New Guinea Emerald Tree Monitor Lizard (*Varanus prasinus*) Native to Mainland Australia?

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Abstract - We summarize and evaluate anecdotal information and observations about the potential occurrence of the New Guinea emerald tree monitor lizard, *Varanus prasinus* (Schlegel, 1839), on mainland Australia. Several independent but unconfirmed reports about sightings of large green lizards in the rainforests on Cape York Peninsula have been published in the last 40 years, but still no photographs or voucher specimens exist. The closest confirmed occurrence of *V. prasinus* to mainland Australia is on Moa (also known as Mua or Banks) Island, one of the islands in the Torres Strait that separates New Guinea from Australia. The shallow tropical waters of the Sahul Shelf surrounding these small islands were dry land during Pleistocene glacial periods and facilitated faunal exchanges between both huge landmasses in the past. Consequently, a natural occurrence of *V. prasinus* on Cape York, together with the endemic *Varanus keithhornei* (Wells and Wellington, 1985), the canopy goanna, seems plausible. Likewise, a possible polymorphism in the color pattern of the latter species as a putative result of repeated introgression and/or hybridisation events as source for the sightings of green tree monitors deserves further investigations. Therefore, we encourage future field work in this remote area to finally answer the question if the New Guinea emerald tree monitor is native to mainland Australia.

Introduction

Tree monitor lizards are among the most colorful reptiles in the world. This applies particularly to the New Guinea emerald tree monitor lizard, *Varanus prasinus* (Schlegel, 1839), which is characterized by a brilliant light green background coloration in combination with black chevrons on the dorsum (see Fig. 1). This color pattern is thought to provide camouflage in the rainforest canopy. There are, however, some partly or entirely melanistic species in this closely-related group such as *V. beccarii* or *V. bogerti* (Ziegler *et al*., 2007). In general, the distribution range of the *V. prasinus* group is concentrated around New Guinea and its various offshore islands (Koch *et al*., 2013). While most species are endemic to single islands, such as Waigeo (*V. boehmei*), Misool (*V. reisingeri*), Batanta (*V. macraei*) or Biak (*V. kordensis*), *V. prasinus* has by far the widest distribution.

The known range of *V. prasinus* includes the lowland rainforests of New Guinea and several islands of the Torres Strait in the south (Koch *et al*., 2014). Colonization of these islands by the highly arboreal tree

Fig. 1. The New Guinea emerald tree monitor (*Varanus prasinus*) showing its characteristic brilliant green coloration with black dorsal chevrons. Photographed by **Gunther Schmida**.

monitor lizards was fostered during the Pleistocene, when global sea levels were considerably lower than today (Jongsma, 1970; McCulloch *et al*., 1999) and the Sahul shelf formed a continuous landmass over long periods of the past 2,500,000 years (Voris, 2000).

Lavery *et al*. (2012) recently summarized the distribution of *V. prasinus* on the various Torres Strait Islands and provided both the traditional and modern English island names (Table 1). Accordingly, *V. prasinus* occurs on Boigu (Talbot) Island (Clarke, 2004; Schaffer, 2010), Dauan ([Mt.] Cornwallis) Island (Günther, 1879; Loveridge, 1934; see also NMW 12390, two juvenile specimens, and BMNH 1878.10.14.4-6, a young and an adult according to Boulenger, 1885), and Saibai (Borsboom, 2007), all of which lie only a few kilometers off the coast of Papua New Guinea. Further south, the species inhabits Mabuiag (Mabuyag/Jervis) Island (Borsboom, 2007), Badu (Mulgrave) Island (TSRA undated a), and Moa (Mua/Banks) Island (Whittier and Moeller, 1993; Wilson 1996; Ingram, 2008). The latter island is considered the southernmost occurrence of *V. prasinus* (Whittier & Moeller, 1993), which is known to the local people as Wyniss (Wilson, 1996). On Boigu Island it is called Tamai (Schaffer, 2010). Interestingly, photographs by Rohan Clarke (http://www.pbase.com/wildlifeimages/varanus_prasinus) show a specimen from Boigu Island with the same yellowish background coloration as is typical for *V. reisingeri* from Misool Island off the coast of West Papua, Indonesia (Eidenmüller & Wicker, 2005), and demonstrate the intraspecific variation of this species (see also Koch *et al*., 2014).

Notably, a publication from the Torres Strait Regional Authority (TSRA, undated b) stated, that *V. prasinus* represents a "significant species" on Ki(r)riri (Hammond) Island. Kiriri in turn is close to Muralug (Prince of Wales) Island, the largest of the Torres Strait Islands situated only a short distance off the coast of Cape York Peninsula (Fig. 2). In this regard, Schaffer (2010) claimed that *V. prasinus* is also found on Prince of Wales Island and referred to Whittier & Moeller (1993) for this record, but in their article nothing regarding this island is mentioned. In addition, Boulenger (1885) listed four adult voucher specimens (BMNH 1878.10.16.35-38 according to an BMNH online catalogue) of *V. prasinus* from Mer (Murray), one of the easternmost of the Torres Strait Islands, and the TSRA Land and Sea Management Unit (2013) stated, that *V. prasinus* might also occur on Ugar (Stephens) Island, although verified reports were not yet available. Borsboom (2007: 3) also reports *V. prasinus* from Mer (Murray) Island far to the east, stating "Islanders on Mer Island currently report 'the monitor is frequently seen on the island in a variety of habitats, most recently in the village and the scrub adjacent to the airstrip', "crediting this information to M. Helling (in litt. Nov. 2006), Landcare Officer, Torres Strait Regional Authority.

Table 1. Occurrence of *V. prasinus* on the Torres Strait islands.

Traditional Island Name	English Island Name	Source	Evidence/Remarks
Boigu	Talbot	Clarke, 2004; Schaffer, 2010	Photographs by Rohan Clarke (http://www.pbase.com/wildlifeimages/varanus_prasinus) show a specimen with yellowish background coloration as is typical for *V. reisingeri*
Dauan	[Mt.] Cornwallis	Günther, 1879; Loveridge, 1934; Boulenger, 1885	NMW 12390 (two juvenile specimens), BMNH 1878.10.14.4-6 (a young and an adult according to Boulenger 1885)
Saibai	-	Borsboom, 2007	-
Mabuiag/Mabuyag	Jervis	Borsboom, 2007	-
Badu	Mulgrave	TSRA undated a	-
Moa/Mua	Banks	Whittier and Moeller, 1993; Wilson, 1996; Ingram, 2008	-
Kiriri/Keriri	Hammond	TSRA, undated b	-
Muralug	Prince of Wales	Schaffer, 2010	He claimed that *V. prasinus* is found on Prince of Wales Island and referred to Whittier and Moeller (1993), but therein no such island record is mentioned
Mer	Murray Island	Boulenger, 1885; Borsboom, 2007	Islanders on Mer Island currently report 'the monitor is frequently seen on the island in a variety of habitats, most recently in the village and the scrub adjacent to the airstrip'
Ugar	Stephens Island	TSRA Unit, 2013	-

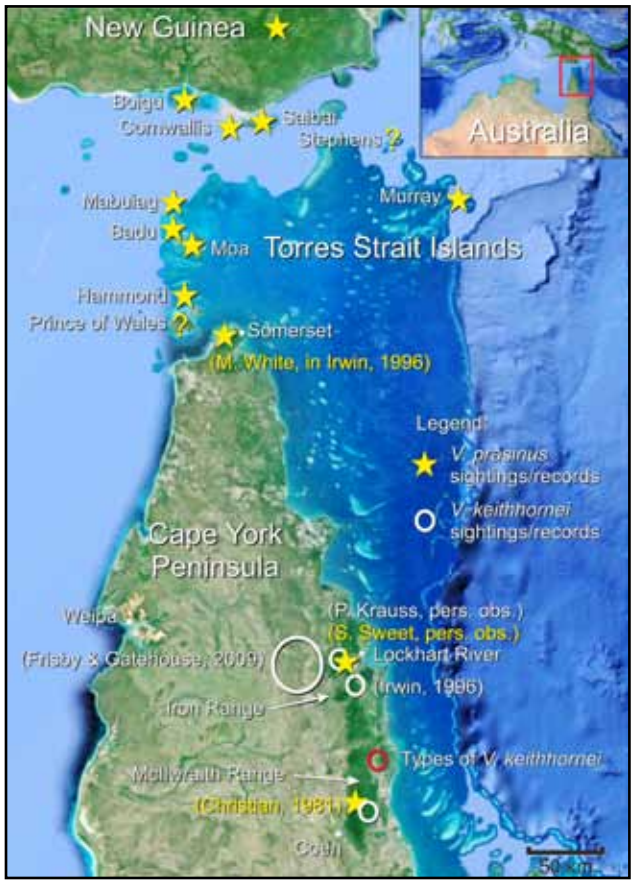

Fig. 2. Map of the Cape York Peninsula showing the confirmed and unconfirmed occurrences of tree monitors on the Torres Strait Islands and mainland Australia. See the text for the respective sources to single (island) records. The rainforests of the Iron and McIlwraith Ranges and around Somerset are indicated by the green land cover.

Fig. 3. The canopy goanna (*V. keithhornei*) is a rather melanistic tree monitor endemic to the Iron and McIlwraith Ranges of Australia's Cape York Peninsula. Photographed by **Jannico Kelk**.

Tree Monitors on Mainland Australia: A Historical Perspective

Cogger (1975) first mentioned unconfirmed records of tree monitors from the Northern Cape York Peninsula. A few years later, Czechura (1980) published the first record of *V. prasinus* sensu lato for mainland Australia. Despite differences in coloration and pattern (the lizards had a predominantly black background color with indistinct yellow chevrons across the body), he allocated the three specimens (QM J31566, QM J35450, QM J35451) collected east of Coen in the Iron and McIlwraith Ranges to *V. prasinus* (see also Covacevich *et al*., 1982), which at that time was considered polytypic with four subspecies (Mertens, 1963). Subsequently, Wells & Wellington (1985) noticed the taxonomic distinctness of the Cape York tree monitors and described them as a new species, *Odatria* (= *Varanus*) *keithhornei*, the canopy goanna (Fig. 3). At the same time, *V. prasinus* was restricted to New Guinea and the Torres Strait Islands. The following year, Cogger (1986) described the distribution area of bright emerald-green *V. prasinus* as including the Northern Cape York Peninsula. Likewise, Wilson and Knowles (1988) listed *V. prasinus* from Australia, but noted that the Cape York population is dark in color, while the animals from the Torres Strait Islands are green. At the same time, these authors mentioned that there had been a few sightings of green animals on Cape York, but they provided no further information. Also either ignoring or not being aware of Wells & Wellington (1985), Sprackland (1991) revised the *V. prasinus* complex and redescribed the population of Cape York, based on the same specimens mentioned above, as a novel species, *V. teriae*. However, the older name *keithhornei* had to be given nomenclatorial priority (ICZN 2001) and Sprackland (1991) had omitted the Torres Strait Island populations of tree monitors.

In subsequent editions, Cogger (1992, 2000) mentioned, that the coloration of the Australian tree monitors is black or dark brown to bright emerald green, but made no distinction between the island taxon (*V. prasinus*) and the lizards described from the Iron Range (*V. keithhornei*), respectively. Similarly, Ehmann (1992) and Waldren (1996) only listed *V. prasinus* from mainland Australia. While the former author noted strikingly green-colored tree monitors next to deep blue-black specimens in the same area of Cape York, the latter mentioned that all specimens observed were melanistic. For the first time, Wilson & Swan (2003, also in the 2008 and 2010 editions, respectively) recognized both *V. keithhornei* and *V. prasinus*, probably biding the official ICZN (2001) decision about the taxonomic validity of Wells & Wellington's (1985) name for the mainland tree monitor population (see also Kaiser *et al*., 2013).

In the most recent edition of his book on the amphibians and reptiles of Australia, Cogger (2014) also mentioned both tree monitor species, even though he again limited the distribution range of the green-colored *V. prasinus* to New Guinea and the Torres Strait Islands (thereby providing the first photographic record for little Daru Island), while *V. keithhornei* was restricted

to McIlwraith and Iron Ranges, although the area is incorrectly indicated on the map at Lakefield National Park about 100 km south of the actual distribution range.

Methods

In order to evaluate the lasting rumors about the potential occurrence of *V. prasinus* on mainland Australia, we attempted to summarize and review all available anecdotal information about sightings of green tree monitors in the (non-) herpetological literature together with personal observations from the field communicated by several colleagues and friends. An online query of the Queensland Museum (QM) database revealed three *V. prasinus* specimens from Australia, two of which (QM J82370 and QM J82371), however, were confiscated by customs and the third originated from the Torres Strait Islands (QM J81737). In addition, the herpetological collections in London (BMNH) and Vienna (NMW) were consulted and relevant specimens examined. To better visualize the confirmed and unconfirmed occurrences of tree monitors on the Torres Strait Islands and mainland Australia, a map was created (Fig. 2).

Results

Repeated independent sightings of Varanus prasinus on mainland Australia

In the literature sightings of green tree monitor lizards on Cape York Peninsula have long been known and published, but so far there are still no documented proofs available such as photographs or voucher specimens. To our best knowledge, the first reliable published sighting is by Christian (1981; reissued 1997), who saw one "emerald tree monitor 'snaking' its way through the tree tops" at the McIlwraith Range near Coen. On another occasion, he encountered two specimens that were "deep blue/black in colour." Since *V. keithhornei* was not yet scientifically described at that time, both green and dark specimens he observed were assigned to *V. prasinus* (see, for instance, Cogger, 1992). Tucker (1988), a botanist, reported having seen "a small greenish goanna that climbed amongst the vines" in the area of the Claudie River near Lockhart River in the Iron Range (Fig. 2).

The first sighting of a tree monitor outside of the Iron and McIlwraith Ranges in mainland Australia was reported by Irwin (1996). He cited a personal observation and detailed description by M. White, who had spotted "a bright green specimen with wide black crossbands" dorsally about 6 km west of Somerset at Lockerbie Scrub, which is close to the tip of the Cape York Peninsula. This observation supports Günther's (1877) historical report about *V. prasinus* among a collection of reptiles from Somerset and the Torres Strait Islands. Unfortunately, the collector, Rev. S. MacFarlane, provided no exact locality data for the specimen(s) (but see Günther, 1879). In his catalogue, Boulenger (1885: 322) merely noted "Islands of Torres Straits" for an adult specimen called "a" (BMNH 1877.3.3.16). Why this author restricted the locality to the Torres Strait Islands is unknown, but for the two new species described by Günther (1877), viz. *Carlia* (= *Lygisaurus*) *macfarlani* and *Thecadactylus* (= *Pseudothecadactylus*) *australis*, these islands are also given as a rather vague type locality (Boulenger, 1885).

Fig. 4. Rainforest near the Cook's Hut camping site at the Kutini-Payamu (Iron Range) National Park, where S. Sweet spotted *V. prasinus* in 2009. Photographed by **Bernd Eidenmüller**.

Fig. 5. The Iron Range, habitat of *V. keithhornei* and possibly also of *V. prasinus.* Photographed by **Bernd Eidenmüller**.

This is also evident in the name of *Peripia torresiana*, the third new species, which is considered a synonym of *Gehyra baliola* (Uetz *et al*., 2016).

Recently, Lemm (2014) summarized the available evidence for the occurrence of *V. prasinus* on mainland Australia. Next to varanid biologists, he mentioned that many "birders […] claim to have observed tree monitors that are green in color from the Cape York Peninsula." In addition by referring to a personal communication with S. Sweet, he stated that emerald monitors were well-documented in an unpublished Queensland Parks and Wildlife report (Environmental Protection Agency, Borsboom 2007), but it remains unclear if this includes both the Torres Strait Islands and the Australian mainland. Also according to F. Parker (pers. comm., 2014 in Shea *et al*., 2016) "anecdotal records unsupported by [voucher] specimens suggest that true *V. prasinus* may occur in the Iron Range." In this regard, S. Sweet (pers. comm.) told us that he spotted a green tree monitor about 200 m west of Cook's Hut camping area in the Kutini-Payamu (Iron Range) National Park in 1999 (Figs. 2 and 4). Being aware of the ongoing discussion about the occurrence of *V. prasinus* in Australia he confirmed that the specimen was typically green and not a pale grey one as is the case in *V. keithhornei*. Peter Krauss (pers. comm.) also observed tree monitors at this place but reported black specimens. Lastly, Patrick Couper (pers. comm.) recently informed us, that he is aware of sightings of *V. prasinus* on Cape York Peninsula, but unfortunately, no further details such as exact locality data were available to him.

Discussion

Why have tree monitors in Australia been overlooked for so long?

The independent observations of green tree monitors on mainland Australia as outlined above certainly warrant further investigations in the herpetofauna of Cape York. Although long-time residents and researchers doing intensive field work on the peninsula could not confirm the presence of *V. prasinus* in that area (Natusch and Natusch, 2011; D. Natusch; N. Weigner and D. Wilson, pers. comm.; Wilson and Heinsohn, 2007), such statements do not automatically prove its absence, and may simply be an indication of the elusiveness of the species (Covacevich *et al*., 1982; Meiri, 2016). The scarcity of anecdotal reports surrounding the presence of *V. prasinus* on Cape York Peninsula may also be influenced by the arboreal nature of the species (but see, *e.g.* Irwin [1996] and Sanders [2009] for *V. keithhornei* that appears to regularly visit the forest floor) and the inaccessibility of many areas of the rainforests of the Iron and McIlwraith Ranges (Fig. 5). In addition, their green and dark coloration provides excellent camouflage in the canopy of the rainforests making these enigmatic lizards nearly elusive in their habitat. Moreover, and despite their medium to large body size, the diversity of Australian monitor lizards seems to have been neglected in the past. Storr (1980), for instance, characterized two new species and three subspecies in his monograph about Western Australian goannas, and even today new species are regularly described (Aplin *et al*., 2006; Maryan *et al*., 2014), although most of these discoveries are based on intra-specific analyses merely representing differentiated parapatric populations of already well-known monitor species (Camina Vega & Koch, 2017).

In this context, it is noteworthy that about a hundred years prior to Czechura's (1980) late discovery of tree monitors from Cape York, De Vis (1887) provided a description of an unidentified monitor lizard from Herbert River, North Queensland, which he considered "a local variety of *V. prasinus*". The color pattern and the undifferentiated supraocular scales, however, do neither match *V. keithhornei* nor *V. prasinus*. Moreover, the locality is far out of the preferred habitats of tree monitors. Most probably, De Vis (1887) had an *Odatria* specimen at hand, presumably *V. semiremex* that is found along the East coast of Queensland (Pianka 2004; Tremul, 2017), but no clear determination is possible since the voucher specimen is no longer traceable in the collections of the Queensland Museum in Brisbane (P. Couper and A. Amey, pers. comm.). There, Charles W. De Vis (1829–1915, until 1882 Devis) was curator since 1882 and director from 1901 until his retirement in 1905. Notably, both the Australian dwarf monitors and the tree monitors were long jointly assigned to the subgenus *Odatria* due to their tail being round in cross section (see *e.g*. Günther, 1877; Mertens, 1942, 1963). This morphological character, however, is the result of convergent evolution. Instead, based on hemipenis morphology Böhme (1988) revealed the phylogenetic sister group relationship between tree monitors and Pacific or mangrove monitors, the *V. indicus* group, and classified them together in the subgenus *Euprepiosaurus* (Ast, 2001; Ziegler *et al*., 2007). Recently, however, the tree monitors were transferred to their own subgenus, *Hapturosaurus*, due to their unique scale morphology in concert with their prehensile tail and other systematic evidence (Bucklitsch *et al*., 2016).

Facilitated colonization via Pleistocene sea level changes

Of course, it cannot be excluded that the sightings of green tree monitors resulted from intentionally released individuals or single specimens of *V. keithhornei* with an aberrant (plesiomorphic) color pattern as is sometimes observed in *V. prasinus* specimens with a bluish-turquoise background coloration instead of the eponymous emerald green (Eidenmüller, 2016). Phylogenetically, the tree monitor lizards' common ancestor probably evolved a greenish coloration as an adaption to an arboreal lifestyle (see Ziegler *et al*., 2007; Eidenmüller *et al*., 2017). Notwithstanding, from a zoogeographic point of view a natural occurrence of *V. prasinus* on the Australian mainland seems plausible due to the existence of repeated land bridges connecting New Guinea and Australia during the Pleistocene. Hence, during the past 2,500,000 years, for the last time about 14,000 years ago, global sea levels were repeatedly up to 120 m lower than today (Jongsma, 1970; McCulloch *et al*., 1999). At these occasions, when the shallow tropical waters surrounding the small Torres Strait Islands were dry land, faunal elements used the temporary land bridges of the Sahul shelf to colonize previously unoccupied areas. New Guinea and Australia remained largely connected via the emerged Torres Strait with sea levels as little as 10 m below present levels (Voris, 2000). Therefore, species naturally migrated from New Guinea to the various satellite islands finally reaching Northern Australia, and vice versa. Examples of squamates inhabiting both New Guinea and Northern Australia include, for instance, the snake genera *Acanthophis*, *Oxyuranus*, *Pseudechis*, and *Pseudonaja* as well as monitor lizards of the *V. indicus* species group (Kuch *et al*., 2005; Wüster *et al*., 2005; Ziegler *et al*., 2007; Williams *et al*., 2008). While these cases show only little or no (intra)specific differentiation between the allopatric populations on New Guinea and Northern Australia, tree monitors seem to represent an exception, since they developed into independent evolutionary lineages on both sides of the Torres Strait resulting in *V. keithhornei* on Cape York and *V. prasinus* on New Guinea (Ziegler *et al*., 2007).

The fact that *V. prasinus* not only occurs in evergreen rainforests, but also inhabits tidal mangrove forests (*e.g.,* Clarke, 2004), the predominant vegetation type on the Torres Strait Islands, makes it even more likely that this species repeatedly spread south during the Pleistocene and successfully colonized mainland Australia. There, they may have hybridized with the darker mainland population of tree monitors. These repeated introgression events could represent an explanation if *V. keithhornei* should be revealed in the future to exhibit a higher degree of intraspecific variation in color pattern as currently known. The same scenario of a southward expansion applies to the ancestor of *V. keithhornei* which is the sister species to *V. beccarii* (Ast, 2001; Ziegler *et al*., 2007) from the Aru Islands located west of New Guinea and likewise situated on the Sahul shelf.

Are Varanus prasinus and V. keithhornei sympatric on Cape York?

The area on Cape York, where a natural occurrence of *V. prasinus* would be most likely is at the northern tip of the peninsula at the Lockerbie Scrub. There, according to Irwin (1996) M. White had seen an emerald tree monitor. However, reports about *V. keithhornei* from this area are lacking. So far, the known distribution of the canopy goanna is limited to the Iron and McIlwraith Ranges on the east coast of North Queensland's Cape York Peninsula. Of all Australian varanids, it has one of the most restricted distribution ranges and is considered rare or insufficiently known (Covacevich *et al*., 1982; Cogger *et al*., 1999; Irwin, 2004). Currently, merely a dozen voucher specimens are deposited in the Queensland Museum collection (P. Cooper, pers. comm.). The three specimens of the type series were collected near Buthen Buthen mine (Fig. 2). In the meantime, further specimens have been observed north of the type locality. Hence, Irwin (1994) was able to catch four specimens near the Claudie River in the Iron Range, where Tucker (1988) had earlier observed a greenish tree monitor. On the way from the Claudie River to Weipa, just before reaching the main road, another specimen of *V. keithhornei* was discovered (Frisby & Gatehouse, 2009). Also the independent sightings by Christian (1981), S. Sweet, and Peter Krauss (see above) of green and dark tree monitors within the Iron Range suggest the sympatry between both tree monitor species in that area.

Conclusions

The fact that green tree monitors were independently and repeatedly sighted on Cape York Peninsula by experienced herpetologists and laypersons who provided an exact description of *V. prasinus*, makes it very likely that mainland Australia could actually harbor two, probably sympatric tree monitor species. Since there are no other large green, arboreal lizard species in northern Queensland (Cogger, 2014; Wilson & Swan,

2003, 2008, 2010), confusion with another species can be excluded and we assume the sightings by non-herpetologists to likewise represent the New Guinea emerald tree monitor. This would form an exception since all other members of the subgenus *Hapturosaurus* are allopatrically distributed (Koch *et al*., 2014; Ziegler *et al*., 2007). The potential sympatry of *V. prasinus* with *V. keithhornei* would indicate an advanced speciation process and support the specific status of both taxa within this otherwise very closely-related group of tree monitors (Ziegler *et al*., 2007).

Although we could not provide new evidence for the potential occurrence of *V. prasinus* on mainland Australia, the information we gathered allowed us to reach the conclusion that this scenario is very likely and we hope to stimulate further field work on Cape York Peninsula and the Torres Strait Islands to study the still partly unknown herpetofauna of this remote tropical region. Likewise, the polymorphism hypothesis of single greenish specimens of *V. keithhornei* exhibiting a plesiomorphic coloration deserves further investigations of this little known Australian monitor lizard.

Acknowledgments - We thank Patrick Couper, Andrew Amey, Daniel Natusch, Peter Krauss, Gunther Schmida, Glen Shea, Sam Sweet, Nicholas Weigner and David Wilson for sharing their knowledge and field observations from Cape York. The former also kindly provided information about voucher specimens in the herpetological collection of the Queensland Museum (QM), Brisbane. Thankfully, the same did Patrick Campbell for the BMNH collection in London. Gunther Schmida and Jannico Kelk kindly provided photos of the emerald and canopy goanna, respectively. An earlier draft benefitted from helpful comments by Robert Neal. Nicholas Weigner pointed our attention to the possibility of greenish specimens of *V. keithhornei*. An earlier draft benefitted from helpful comments by Robert Neal, Sam Sweet and an anonymous reviewer.

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Received: 13 April 2019; Accepted 29 May 2019

Biawak, 13(1), pp. 43–45

Fire-associated Injury in the Southern Rock Monitor (*Varanus albigularis albigularis*)

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Abstract - Three cases of fire-associated injury observed in the Southern Rock Monitor *Varanus albigularis albigularis* (Daudin 1802) are reported on in Northern KwaZulu-Natal, South Africa, describing the extent and nature of observed injuries.

Habitat combustion has been implemented as a method of ecological and wildlife management in various fire-adapted ecosystems across the world. Globally, few reports have been published on the direct effect of fire on fauna (injury and mortality) when compared to longer lasting indirect effects (post fire succession) which are considered of greater ecological importance, (Dickenson *et al.,* 2010; Engstrom, 2010). Here we describe three separate observations of the direct impact of fire on the Southern Rock Monitor *Varanus albigularis albigularis* (Daudin, 1802) in savanna and grassland habitat, in Northern KwaZulu-Natal, South Africa.

Sileza Nature Reserve (SNR) experienced a daytime arson fire linked to wildlife poaching activities on 25 October 2018, where less than 100 ha of woodland and grassland vegetation underlain by unconsolidated sandy substrate was burnt. On 3 November 2018, a live adult *V. a. albigularis* (SVL 41 cm; TL 90 cm; 1.464 kg) was encountered along the north-eastern perimeter road on the edge of the burnt area (-27°04'56.8" S; 32°36'27.5" E) with extensive external thermal injuries impacting its locomotion, subsequently making it slow and easy to catch. No scales were present on the tail, which appeared necrotic, desiccated, and stiff (Fig. 1). These injuries extended to the posterior dorsal body and both hind feet were lignified and scaleless like the tail (Fig. 2). The carpi and digits of the front feet were scorched, characterized by varying degrees of dermal tissue loss and secondary inflammation typical of first to second degree cutaneous thermal injury (Fig. 3). High numbers of *Amblyomma exoranum* (Koch, 1844) ticks were present in the nasal openings, accompanied by interspersed dipteran larvae. Clumps of maggots in early development were present in the right eye which was non-functional and degraded through myiasis whilst fly eggs were observed around the left eye. During the initial examination of the individual in the field *Chrysomya albiceps* (Wiedemann, 1819) flies continually landed on the specimen and the observed dipteran eggs and maggots are presumed to belong to this species. High tick loads were likely the result of a combination of suppressed immunity following the stressful thermal injury event, the inability to effectively remove parasites by mechanical means, and a prolonged recumbency period creating an opportunity for ectoparasitic attack. The open dermal wounds with necrotic tissue and tick-associated dermal lesions may also have provided opportunity for myiasis to develop, as was observed in this case.

Two prior instances of fire-associated injury in *V. a.*

Fig. 1. Fire-induced caudal injury in a *Varanus albigularis albigularis*. Photographed by **A.N. Green**.

Fig. 2. Thermal damage and necrosis of the rear-foot of a *V. a. albigularis*. Photographed by **P.R. Jordaan**.

Fig. 3. Thermal damage to the front feet of a *V. a. albigularis*. Photographed by **A.N. Green**.

albigularis have been observed from Tembe Elephant Park (TEP), which is in the same general area as SNR. Following a management fire during the 2015 austral winter, an adult *V. a. albigularis* was discovered as a fire fatality under the burnt remnants of the palm *Hyphaene coriacea* (-27°01'18.30" S; 32°27'29.70" E). This specimen was degraded, as it was only encountered two weeks after the fire, but exhibited the same external pathology on its palms and feet present in the 2018 specimen (Fig. 4). Another adult specimen was observed during October 2015 in TEP with what appeared to be healed fire wounds (-27°02'43.69" S; 32°25'16.72" E). The rear-right limb and all the digits of the hind left foot were amputated (Fig. 5) with some minor scarring along the tail, the tip of which was absent. The individual had a sub-optimal, but not poor, body condition and could propel itself slowly forward using its right hip in the absence of the missing limb.

From these three observations it appears that the feet and tail of adults of this species are most susceptible to fire-related injury and likely originates from individuals moving over embers or heated substrate. Fire-induced mortality in *V. a. albigulris* may result, but extensive thermal damage can be survived, and even heal allowing individuals to survive long after being injured despite negative impacts on locomotion efficiency. The mortality and injury of large, highly-mobile animals such as *V. a. albigularis* arising during burning events is

Fig. 4. Fire-induced *V. a. albigularis* mortality. Photographed by **P.R. Jordaan**.

Fig. 5. Healed fire-induced amputation in a *V. a. albigularis*. Photographed by **C.C. Hanekom**.

unexpected as such species are considered able to avoid the negative effects of fire effectively by moving away from the fire front (Engstrom, 2010). Incidence of fire-associated injury in the species, however, remains rare.

Acknowledgments - We thank C.C. Hanekom for commenting on the article as well as an anonymous reviewer.

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Received: 4 April 2019; Accepted: 27 May 2019

Biawak, 13(1), pp. 46–49

Mobbing Behavior by White-vented Mynas (*Acridotheres javanicus*) Towards a Southeast Asian Water Monitor (*Varanus salvator macromaculatus*)

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Abstract - The Asian water monitor *Varanus salvator* is considered to be a generalist and opportunistic carnivore of both vertebrates and invertebrates. In this account we describe an observation of mobbing, a predator- deterrent behavior by the white-vented myna, *Acridotheres javanicus* directed towards an adult *V. salvator macromaculatus* in an urban royal palace in central Thailand, and discuss subsequent implications.

Introduction

Both predators and their prey have previously been suggested to benefit from predator- deterrent signals, including mobbing behavior (Barbour & Clark, 2012). Mobbing, the behavior exhibited when individuals approach a potential predator and perform a series of conspicuous displays, is important primarily in driving the predator away from an area (Curio, 1978), and is common among birds (Curio, 1978; Flasskamp, 1994; Caro, 2005). During mobbing events, predators and prey assess each other, which can influence predation rates (Owings & Morton, 1998). Agonistic responses of birds towards snakes, mobbing, has been documented frequently as to constitute a method for locating snakes (*i.e.*, identifying natural history characteristics of flocks or individual birds mobbing and then following them to the individual organism they are mobbing; Fitch, 1987; Das, 2016). Avian mobbing directed towards monitor lizards specifically has been well documented in Australia (Poiani, 1991; Boland, 2004; Kaplan *et al.*, 2009; Koboroff *et al.*, 2013), but not outside of this region.

Greatly expanding their natural range from Java and Bali, the white-vented myna (*Acridotheres javanicus*) has been introduced to, and is now naturalized in Taiwan, Puerto Rico, Japan, throughout the Thai-Malay peninsula, Singapore, and other parts of Indonesia (Craig & Feare, 2016). The pet trade and conversion of land from natural forest to open habitat have largely contributed to this successful expansion (Yap & Sodhi, 2004; Peh, 2010). Primary conservation concerns associated with this expansion include the occupation of nest sites of native birds and aggression directed

towards native bird species at shared communal nest sites (Peh, 2010). Additionally, white-vented mynas also irritate and disturb humans through their fecal droppings and noise at nighttime roosts (Hails, 1985). They are small birds (average mass: 96.7 g) with a white vent and white tips to the tail feathers, and a whitish- yellow iris (in contrast to the dark eye of the very similar *A. grandis*, Counsilman *et al.*, 1994). White-vented mynas are not a clearly (visually) sexually dimorphic species, although males may develop a slightly larger crest than females during the breeding season (late March- early April, Tunhikorn, 1989) which are often molted after the breeding season concludes (Counsilman *et al.*, 1994). Interestingly, the white-vented myna is listed as Vulnerable by the International Union for Conservation of Nature (IUCN, 2016) in its native range, but is also a protected species in Thailand (ONEP, 2007). The common name, white-vented myna, has confusingly been applied to several other myna species present in Thailand including *A. grandis* and *A. cristatellius* (Duengkae, 2010; Gill & Donsker, 2018).

The geographic distribution of the Asian water monitor *Varanus salvator macromaculatus* includes parts of Myanmar, Vietnam, Cambodia, Malaysia, Singapore, Indonesia, and Thailand (Cota *et al.*, 2009). Throughout its range, *V. salvator* has been recorded as a scavenger and predator of a wide variety of both vertebrate and invertebrate prey (Gaulke, 1991; Losos & Greene, 1988; Shine *et al.*, 1998; Traeholt, 1994a,b). In urban central Thailand, *V. salvator macromaculatus* has been recorded to exhibit a catholic diet, foraging upon fish, crabs, turtles, frogs, birds (including *A. javanicus*), rats, dogs, cats, discarded food scraps, and carrion (Bundhitwongrut *et al.*, 2008; Stanner, 2010; Cota & Sommerlad, 2013; Kulabtong & Mahaprom, 2015).

Here, we describe an observation of mobbing behavior by a cosmopolitan bird species, *A. javanicus*, towards a *V. s. macromaculatus* in an urban environment in central Thailand.

Observations

On 20 July 2018 at approximately 1320 h, we observed an adult (> 1.5 m total length) *V. salvator macromaculatus* wandering the grounds of the Bang Pa-in Royal Palace (also known as the Summer Palace) in Bang Pa-in District, Phra Nakhon Si Ayutthaya Province, located in central Thailand (114°13’57.7776” N; 100°34’44.9760” E; WGS 84; 12 m elev.). Directly adjacent to the Chao Phraya River, the palace consists of about 20 main buildings of varying sizes and purposes constructed originally in 1632 by King Prasat Thong but restored and reconstructed multiple times since. Our observation took place closest to the residence of the late H.H. Princess Saisavali Bhiromya (< 15 m); immediately adjacent to an open lawn (< 20 m from observation), a paved path (< 5 m wide) which runs through the palace complex, and around 20 large scattered trees (> 50 cm diameter).

The *V. salvator macromaculatus* was initially observed crawling slowly towards the base of a large tree (> 1 m in diameter). It then moved towards and rapidly climbed up and into a small (< 4 m in diameter) isolated patch of bamboo before visibility was lost at approximately 1330 h (mobbing observation 10 min in total duration). The individual exhibited rapid tongue flicking, and was intermittently mobbed by two white-vented mynas (*A. javanicus*) while moving from the base of the large tree towards the bamboo patch. Mobbing behavior included flying towards the *V. s.*

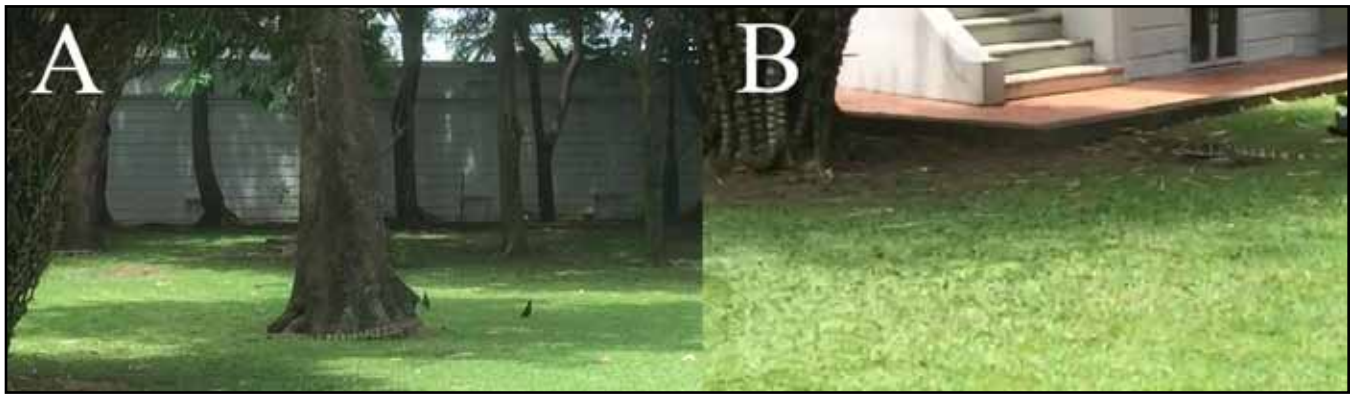

Fig. 1. *Acridotheres javanicus* exhibiting mobbing behavior characterized by perching on the ground < 5 m from (A) and flying towards and making direct contact with *V. s. macromaculatus* (B) while vocalizing loudly.

macromaculatus, making direct physical contact on at least two occasions during flight, perching on the ground less than 5 m from the monitor, and vocalizing loudly while flying and when perched (Fig. 1).

It was unclear as to whether the *V. salvator macromaculatus* was fleeing from the *A. javanicus* or foraging for a potential nest in the bamboo patch, but it appeared to be moving at a slightly faster than normal pace. The monitor did not initially appear to be affected by the predator- deterrent signals when approaching the tree (primarily limited to vocalizing and perching in close proximity), but later appeared agitated when moving towards the bamboo patch (as evidenced by faster pace of movement). The most intense mobbing effort (vocalizing and direct contact while flying) was observed while the monitor was moving towards the bamboo patch.

Discussion

Studies on the form, function, and effectiveness of predator deterrence and overall predator-prey relationships have been limited for monitor lizards in natural and human- dominated landscapes. Our account represents the first documented observation of mobbing behavior by *A. javanicus* directed towards *V. salvator*, and further study is required for understanding the role and mechanisms of predator-deterrent behavior of birds towards monitor lizards. The two *A. javanicus* in our observation may have represented a breeding pair (a nest was not observed but may have been hidden, although our observation was outside of the species' known reproductive season), or perhaps were simply mobbing as a general defense mechanism against a potential predator.

Furthermore, *A. javanicus* and the closely-related, and similarly well-adapted common myna (*Acridotheres tristis*) and crested myna (*Acridotheres cristatellius*) to urban environments are invasive within other parts of the range of *V. salvator macromaculatus* (Nee *et al.*, 1990; Yap & Sodhi, 2004; Peh, 2010). The predator-prey relationships between these species could carry significant conservation implications. The outcome of the mobbing event we observed was unclear; however, attempts by mynas at deterring *V. salvator* may suggest potential natural biological control of invasive myna populations or alternatively explain the persistence of mynas despite threats of predation by *V. salvator*.

Acknowledgments - We thank Suranaree University of Technology for supporting our ongoing research of reptiles in human- dominated landscapes and the Bureau of Royal Household for the opportunity to observe interesting urban natural history during the course of learning about and appreciating Thailand's unique cultural and historical heritage at the Summer Palace. We are grateful to the editors of Biawak for patient review of this manuscript.

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Received: 1 August 2018; Accepted: 26 May 2019

Biawak, 13(1), pp. 50–53

Cruelty to *Varanus* Species of the Barak Valley, Assam, India

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Abstract – The Barak Valley, located in India's northeastern state of Assam, is a part of the Indo-Burma biodiversity hotspot and harbors a rich wildlife assemblage. The valley is characterized by a diverse blending of forests, wetlands, rivers, hills and plains. Of the four species of *Varanus* reported from India, two are distributed within the Barak Valley, the Asian water monitor (*V. salvator*) and the Bengal monitor (*V. bengalensis*). Since the last century, an increasing human population and the destruction of wildlife habitats due to logging, the expansion agricultural land, encroachment on forests, the establishment of tea gardens, and infrastructure development have resulted in severe population declines for the wildlife of the region, including varanids. This has also led to human-wildlife conflicts and retaliatory killings and the hunting of the varanids for their meat and oil. However, studies on the conservation status, ecology and threats to varanids in the region are lacking. This article reports on incidences of varanids killed by local residents and discusses the prevailing threats in the area. Based on these accounts, we provide recommendations for the conservation of the varanids of the valley and encourage more studies on these species.

Introduction

The Barak Valley, one of the two valleys of Assam, forms the southern part of the state of Assam, India. It is constituted by three districts - Cachar, Hailakandi and Karimganj, which are surrounded by diverse physiographic regions including the Barail Range (in the northeast), Manipur Hills (in the east), Mizo Hills (in the southeast), Tripura Hill tracts (in the south-west), and the plains of the Surma Valley extending to Bangladesh (in the northwest) (Choudhury, 2013). Primary vegetation consists of tropical wet evergreen and semi-evergreen forests, and tropical deciduous forest (Champion & Seth, 2005; Choudhury, 2013). The Barail Hill Range has an elevation of up to 1850 m (Choudhury, 2013). In addition, tea plantations, secondary forest, wetland, monoculture orchards and agricultural fields are some of the other characteristic features of the region (Choudhury & Choudhury, 2017; Mazumder, 2014). Another important feature of this region is its large network of rivers and wetlands. Some of the important rivers are the Dhaleswari, Katakhal, Sonai, Dolu, Jatinga, Boleswar, Longai, Kushiyara and Singla, forming the tributary and distributary systems of the River Barak. The wetlands include Son beel (Karimganj), Bauuwa beel (Hailakandi), Banskandi Anwa (or, ox-bow lake) (Cachar), and several others (Mazumder, 2014; Mazumder *et al*., 2014; Singha *et al*., 2013). Such a unique blending of wetlands, rivers, hills and plains provides suitable habitat for monitor lizards.

In India, the family Varanidae is represented by four species: the common Indian monitor or Bengal monitor (*Varanus bengalensis*), Asian water monitor (*V. salvator*), yellow monitor (*V. flavescens*) and desert monitor (*V. griseus*) (Denial, 2002). Of these four species, three have been reported to inhabit Assam: *V. bengalensis*, *V. salvator* and *V. flavescens* (Smith 1935; Ahmed *et al.*, 2009; Das, 2008; Whitaker & Whitaker, 1980; Koch *et al.*, 2013; Mazumder *et al.*, in press), and *V. bengalensis* (Das, 2008) and *V. salvator* (Ahmed *et al*., 2009; Whitaker & Whitaker, 1980; Mazumder *et al*.,

in press) have both been reported to inhabit the Barak Valley of Assam.

While *V. salvator* prefers areas associated with water bodies, the species is replaced in plains areas by *V. bengalensis*, and *V. flavescens* is found in hilly terrains at elevations greater than 160 m (Khatiwada & Ghimire, 2009). Important publications on the reptiles of northeast India include those by Ahmed *et al.* (2009), Das (2008), Choudhury (1989, 1992, 1993a, 1993b, 1995, 1996a, 1996b, 1997, 1998, 2011) and Mazumder *et al*. (in press). However, none of these publications provide special treatment to the monitor lizards of the region, especially for the Barak Valley.

In light of this absence of literature, this article seeks to provide some reports of the occurrence and various threats facing monitor lizards in this part of India. Hence, this article has implications for the conservation of these species in India.

Reports

In July 2015, a man captured and killed a *V. bengalensis* with a spade. The species is easily identified by the shape of its head which is flat and triangular, and its body coloration is grayish on the dorsum with scattered black spots and a yellowish ventrum. The man claimed that this species had regularly attacked and predated upon his poultry (ducks and hens). The incident took place near Kabuganj, in Cachar District of the Barak Valley in an area near the bank of the Sonai River in mixed vegetation of shrubs, bamboo and agricultural land. Similar locations in this region have been identified as suitable habitat for *V. bengalensis* (Fig. 1; Mazumder *et al*., in press).

Fig. 1. A local man kills a captured *Varanus bengalensis* at Kabuganj, Cachar district. Photographed by **Parthankar Choudhury**.

In September 2016, an incident involving a *V. salvator* occurred in Hailakandi District of the Barak Valley, where an individual was severely beaten and killed with sticks. The specimen had yellowish ocelli on a brownish dorsum and yellow belly, typical of the species. This area was located near the Dhaleswari River and had mixed vegetation of shrubs and bamboo. This location may be preferred by this species, as many sightings have

Fig. 2. A *V. salvator* that was killed in retaliation near the Dhaleswari River, Hailakandi District. Photographed by **Rofik Ahmed Barbhiuya**.

Fig. 3. Another *V. salvator* that was a victim of retaliation near Gorgori Rapids, Cachar District. Photographed by **Pijush Kanti Das**.

been recorded from similar habitat (Mazumder *et al*., in press) (Fig. 2). Similarly, in October 2017, another *V. salvator* was beaten to death in Cachar District. The location was near a small series of rapids called Gorgori, which is a bifurcation of the Amjur River, a tributary of the Sonai River (Fig. 3). Vegetation is similar to that of the previous account. In both cases, the *V. salvator* were killed for predating on poultry such as hens or ducks. It has been reported by the locals that such killings of *V. bengalensis* and *V. salvator* are common in the Barak Valley.

Discussion

Based on the present cases, it appears that monitor lizards in the Barak Valley are mostly killed in retaliation for lifting poultry. Thus, they are regarded as pests and killed whenever in sight. *Varanus salvator* is also known to affect fisheries, and subsequently persecuted. Such incidents are likely to increase in the near future, because most of their preferred habitat sites are preoccupied by human settlements. Additionally, both *V. bengalensis* and *V. salvator* are known to scavenge for food, which can also attract them to the vicinity of human settlements (Bennett, 1995; Traeholt, 1994). Apart from this, these species are also killed for traditional medicinal purposes as well as their meat (Mazumder *et al*., in press; Ahmed *et al*., 2009; Daniel, 2002). Most importantly, monitors lizards are among the most ignored species of the region, and very few studies have been conducted on their habitat preferences, ecology and distribution. Although both species are categorized as 'Least Concern' by the IUCN (Bennett *et al*., 2010; Papenfuss *et al*., 2010) and included in Schedule I of the Indian Wildlife (Protection) Act of 1972, which prohibits their killing, killings of these species are still common due to a lack of awareness and ineffective implementation of legislature. Therefore, through this article, we urge NGOs, universities, colleges and the Department of Environment and Forest (Govt. of Assam) to initiate studies on these species, and spread awareness to local residents about the importance of scavenging animals like monitor lizards in the ecosystem. It's high time to protect these species as the region has already lost other large herpetofauna including the Gharial *Gavialis gangeticus* (Choudhury, 1997) and the Marsh crocodile *Crocodylus palustris* (Choudhury *et al*., 2019).

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Received: 6 December 2018; Accepted: 30 May 2019

Biawak, 13(1), pp. 54–61

Observations and Experiments on "Spinning Behavior" in *Varanus albigularis*

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Abstract – This article deals with behavioral observations and behavioral experiments on captive *Varanus albigularis*. As the habitats of all three subspecies of *V. albigularis* have unparalleled quantities of large mammals, the question arises - what would a monitor lizard do if it is confronted with oversized prey such as a dead gazelle? In the 1980s, four captive juvenile *V. albigularis* were presented with a large dead rabbit. The four juveniles bit into the rabbit and displayed a spinning motion along their longitudinal axis. This behavior was unknown to monitor lizards, but documented in crocodiles as the "death roll". Because of the wariness of these juveniles, this behavior could not be documented. Therefore, in 2017 the experiment was repeated with three tame adult *V. albigularis* at the Reptile Zoo in Landau, Germany. While the two oldest specimens did not display spinning behavior, possibly because they both suffered from arthrosis, the youngest individual (7 kg, 141 cm total length) which was not handicapped successfully displayed the spinning behavior to both sides, with full rotation. In addition to this behavior, the intelligence of *V. albigularis* is discussed.

Introduction

The term 'savannah' has the Spanish root 'sabana', which means 'grass plain' and is now used exclusively for tropical grasslands with wet-dry seasons (Müller, 1977). The African savannah is the biotope of several monitor lizard species belonging to the *V. exanthematicus* species group which together with the water-bounded species group *V. niloticus* presents the subgenus *Polydaedalus.* The *V. exanthematicus* species group is systematically divided into the three species *V. exanthematicus*, *V. albigularis* and *V. yemenensis* (Böhme, 2003; Pianka *et al*., 2004).

Additionally, *V. albigularis* is ordered (Böhme, 2003) into the three subspecies: *V. albigularis albigularis*, distributed in southern Africa (Namibia, Rep. South Africa) (Phillips, 2004); *V. albigularis angolensis* which occurs north-west of southern Africa (Rep. of Angola) and *V. albigularis microstictus* which is found in eastern Africa from Ethiopia in the north down to Mozambique in the south (Branch, 1988; Phillips, 2004; Eidenmüller, 2009). *Varanus albigularis* has by far the largest distribution when compared to that of *V. exanthematicus* and *V. yemenensis. Varanus exanthematicus* inhabits the small strip of grass steppe and light woods across central Africa from east to west (Eidenmüller, 2009). To a certain degree, *V. exanthematicus* is ecologically 'walled in' between the Saharan desert in the North and the rain forests in the South. *Varanus yemenensis* inhabits the dry and rocky foothills of the south-west corner of the Arabian Peninsula. Considering that the African savannah is the biotope of two monitor species (*V. exanthematicus and V. albigularis*), one of which even has three subspecies, it seems misdirecting that in English the name 'savannah monitor' is restricted to *V. exanthematicus.*

The compact body shape of members of the *V. exanthematicus* group points to a primarily terrestrial way of life. With their sturdy forelegs and sharp claws they build self-dug burrows but they are also capable of climbing trees, *e.g.*, for raiding bird nests, resting, and fleeing from danger (Philipps, 2004).

Fig. 1. Portrait of *Varanus albigularis*. Photographed by **Uwe Krebs**.

Their adult body size typically reaches 120 cm in *V. yemenensis*, and about 150 cm in *V. exanthematicus* and *V. albigularis.* Some specimens of *V. albigularis* may exceed 200 cm (Eidenmüller, 2009).

Members of this species group produce very large clutch sizes in comparison to other African varanid species. For example, record clutch sizes have been 53 eggs in *V. exanthematicus* and 65 eggs in *V. albigularis* (Eidenmüller, 2003). For *V. yemenensis*, no clutch size has been reported (Böhme, 2004), and only 10–20 eggs have been reported for the desert monitor *V. griseus* (Stanner, 2004).

All three sub-species of *V. albigularis* inhabit areas like savannah, sometimes with clear woodlands. Data on the ecology and behavior of *V. albigularis* in nature such as home range size, movement patterns, mating and hunting were reported by Phillips (1995, 1998, 2004). Data on captive husbandry and breeding of *V. albigularis* have also been published (Visser, 1981; Bayless & Reynolds, 1992; Balsai, 1992; Bayless, 1994; Bayless; 2006).

On a scale between dietary generalist and specialist, *V. albigularis* is a distinct generalists and this may also have consequences for its behavior, too. The diet of *V. albiguaris* comprises a broad spectrum of prey and contains, for example, slugs, snails, locusts, centipedes, beetles, and venomous and non-venomous snakes (Branch, 1988; Phillips 1995). Only pythons (*Python sp.*) were not considered to be part of the diet (Phillips, 2004; Eidenmüller, 2009).

Hypothetically, the exceptional clutch sizes documented for *V. albigularis* should be seen in connection with an exceptional competition with mammals and birds for nourishment in the savannah biotope, and may be an answer to the evolutionary pressures facing this monitor species. Compared with the biotopes of the African desert-dwelling *V. griseus* and the water-bound Nile monitor (*V. niloticus*), competition with the higher and endothermic zoological classes of birds and mammals seems to be higher in the savannah biotope. Additionally, *V. albigularis* will not only have to cope with competition for food but also with predatory pressures on their eggs and juveniles by mammalian predators and birds of prey, which presumably occur in higher densities in the savannah biotope than in the desert.

In contrast, the African desert has limited food resources for endothermic vertebrates with their greater physiologically-driven energy needs. Such conditions are more favorable for ectothermic animals with low energy expenditure like monitor lizards. To survive under these conditions, the desert-dwelling *V. griseus* typically needs a large home range to find enough food (Stanner & Mendelsson, 1983; Vernet, 1988). Additionally, *V. griseus* is a hibernator that remains inactive during periods with limited food availability (Stanner, 2004). One can conclude that the main evolutionary pressures on this species would be to survive with the advantages of hibernation and large home ranges, but not with an exceptional clutch size.

Aspects of Habitat and Behavior

It is not by chance that the large continent of Africa supports only six monitor species, whereas the smaller continent of Australia supports substantially more

monitor species (Pianka *et al*., 2004). In their evolution and dispersal, the modern competitors of monitors, some placental mammalian predators (*e.g.,* foxes, cats) never reached Australia. One exception are the dingoes, but they reached Australia 4,600–18,300 years ago (Oskarsson *et al*., 2011), much later than monitors, which as a genus appeared millions of years earlier.

So, in contrast to Africa, in Australia these competitors of monitors are missing. This large diversity of monitor species primarily reflects lower evolutionary pressures from mammalian predators on competing ectothermic reptiles like monitors. An example of different evolutionary pressures on monitor species of different size is the consequences of Wallace's Line (Southeast Asia). As Sweet and Pianka (2007) pointed out, varanid lizards "… are properly regarded as convergent on the lifestyle of small predatory mammals", and demonstrated that Wallace's Line is the "distributional boundary for nearly all small, carnivorous placental mammals…" with the consequence of a substantial increase of small monitor species east of Wallace's Line (Sweet & Pianka, 2007).

Behavioral Observations with Captives in the 1980s

Four juvenile *V. albigularis* measuring about 60 cm in total length were purchased from a commercial dealer in 1980. A room measuring about 12 square meters was used as a terrarium for the *V. albigularis*. The floor and ceiling were insulated, the ceiling degraded with Styrofoam. The room was equipped with a normal room heater (about 20 to 30 °C.), which was covered to avoid burn injuries. Fluorescent tubes provided ambient lighting, and stone plates were provided for basking areas under spot lights (about 40 °C). Sand was offered as a substrate, several flat cement boxes were offered as caverns, and snags and a few tree trunks were leaned diagonally into two of the corners for climbing.

The *V. albigularis* remained shy and were difficult to observe, which may have been an effect of the large enclosure. On the other hand, this relatively large enclosure allowed for an unexpected degree of activity patterns by the monitors. Observations were made through a window from a somewhat dark adjoining room. However, any small noise alerted the monitors causing them to stand motionless with their heads slightly raised. As a nearly daily routine they used some time in the morning for basking under the spot lights, followed by moving around, probably for inspecting and foraging activities.

To replicate natural conditions, the food, mainly locusts, snails and mice, were offered at different locations while water was given at the same place. For example, if a freshly killed mouse was placed on the top of a tree trunk, this trunk was then integrated into the animals' forays for several days, which included regularly climbing up the trunk even though no mouse was present. Small remaining olfactory traces of the mouse on the top of the trunk may have been of importance, but it could not establish the way up to the trunk even though there was no mouse.

The impression was that *V. albigularis* when hungry, accurately inspect previously sourced locations of prey for some days. Such behavior is reminiscent of hunting dogs which remember over extended periods, the locations where they had found prey (*e.g.*, a hare) and then go to these places.

This somewhat conspicuous accuracy was also observed in experiments with different numbers of snails (Pianka *et al*., 2004). *Varanus albigularis* were offered the same number of snails for a couple of days (*e.g.*, four snails) "… in separate compartments with moveable partitions which were opened one at a time to allow monitors to eat each batch of four snails". Upon finishing the fourth snail, lizards were allowed into another chamber containing four more snails. After such conditioning, one snail was removed from some snail groups. Lizards searched extensively for the missing fourth snail, even when they had access to the next group. Similar experiments with varying numbers of snails showed that these varanids can count up to six, but with groups of snails larger than six, the monitors seemed to stop counting and merely classified them as 'lots', eating them all before moving on to the next chamber" (Pianka *et al*., 2004).

With no doubt, this ability to differentiate between quantities up to six displays unexpected cognitive abilities and should be compared with birds, mammals and even humans (Krebs, 2007). Because humans own languages, they will label the snails of the snail group with words like 'one', 'two' or 'three'– spoken or not spoken – if they were asked to quantify the snail group. This, we call 'counting'. The function of this simple cultural technique, a 'verbal labelling', is to order the phenomena in single file. Although it is a simple process, it has wide-ranging consequences as it allows more or less endless counting.

Disparate from this technique is the ability to differentiate simultaneously between phenomena. This is probably a more intricate task in terms of perception and cognition. In experiments with magpies (Sauter, 1952), pigeons (Arndt, 1939), ravens and humans (Koehler,

1943, 1956), test subjects could not differentiate more than six or seven phenomena simultaneously. The design of the experiment with humans excluded the ability to count – verbal or non-verbal – because of the shortness of the visual stimulus presentation.

To differ between the human cultural technique of "counting" and the simultaneous differentiation of phenomena will hell help to avoid any possibility of confusion. *Varanus albigularis*, as a matter of fact, has an unexpected higher level ability in the simultaneous differentiation of phenomena. But, the fact that pigeons also reach this level points to the problem that this ability of simultaneous differentiation is a mixture of abilities in perception and cognition. It is still unclear how these two different abilities vary in the cited results. For example, it may be possible that in these experiments humans have sufficient cognition but limited perception speed, while magpies demonstrate the opposite, with limited cognition and good perception. Both combinations may result in an identical outcome.

More generally, we can conclude that *V. albigularis* has a good memory (*e.g.*, reported forays), a conspicuous accuracy when searching for food (*e.g.*, Phillips' experiments and reported observations), and the ability to differentiate simultaneous between quantities, which reaches the level of ravens. Altogether, this recommends *V. albigularis* for further semi-natural experiments, particularly those which focus on the solutions derived from problems which occur in the wild. If we take the ability to learn, the ability to remember, the ability for abstraction to an unknown degree and also the ability for generalization and differentiation to an unknown degree as criteria for intelligence in varanids (Krebs, 2007), *V. albigularis* may prove to be an advantageous subject in further experiments.

Experiments on "Spinning Behavior"

Because the biotope of *V. albigularis* includes many large mammals as mentioned, from time to time there will be freshly dead mammal carcasses to be found. So the question arises, what would a hungry generalist like *V. albigularis* do, if it is confronted with oversized prey such as a freshly dead gazelle? In nature, this type of prey will be both rare and rewarding. One can expect that a monitor will not ignore this amount of food, but such prey is oversized for the typical prey-handling behaviors of the species, such as biting and shaking. To address this question, a whole freshly dead adult rabbit was offered to the four juvenile *V. albigularis* in the enclosure. At this time their approximate total lengths (TL) varied individually a bit but were around 100 cm and their weights were about 3 kg. The four *V. albigularis* had been deprived of food for some days. All four bit into the skin and showed a spinning movement on their longitudinal axis. During these spinning movements, the lizards maintained their grip with the jaws and the legs were pressed to their body. This behavior was repeated several times, but the juvenile *V. albigularis* were not successful in tearing off smaller pieces of flesh. It may have been be successful with specimens of greater body size and mass because then the spinning behavior would have more force to tear the skin and access the meat.

This spinning behavior is known from crocodiles (Ross, 2002; Drumheller *et al*., 2019). The skin and fur of larger prey such as buffalos and zebras are a massive hindrance to accessing the meat because the sheer bite force is not strong enough to tear open the skin. Crocodiles resolve this problem by a bite into the skin of the prey in combination with spinning movements along their longitudinal axis. After a few attempts, the skin of the prey is usually lacerated. Ross (2002) even described cooperation of crocodiles with this attempt.

Because of the shyness of the four *V. albigularis* and the necessity of artificial light for filming in that non-digital era, it was not possible to document this behavior by film or photographically. However, 'forbearance is not acquittance', and in 2017 the experiment was repeated in collaboration with the second author, who provided the experimental design and the three *V. albigularis* from his reptile zoo, the Reptilium Landau (Southern Germany). Here, we would retry the experiment with a freshly dead rabbit to document the spinning behavior with video.

Material and Methods

Three very tame adult *V. albigularis* were deprived of food but not of water for a fortnight. Specimen number 1, a male, which measured 162 cm TL and 12.5 kg, was around ten years old and in good physical shape, but handicapped with arthrosis. Specimen number 2 was a male of unknown age, which measured 156 cm TL and 11 kg; it was also handicapped with arthrosis. Lastly, specimen number 3, a male of unknown age (but estimated to be younger than the other individuals) measured 141 cm TL and 7 kg and was in good physical shape with no underlying conditions.

A freshly dead rabbit was attached with wire on each leg and securely fixed crosswise to a sheet metal plate of sufficient size and placed inside the monitors' home terrarium, which measured about 3 x 3 m and was

equipped with sand substrate, rocks and tree stumps. Behaviors were filmed with a video camera.

Results

All three specimens approached the rabbit and repeatedly bit into its head and neck region, shaking their head to both sides while biting. All three were also seen clawing at the head and neck of the rabbit with both forelimbs. No aggression was observed between the three monitors. After some minutes without success to get through the fur and skin to the meat, the two handicapped specimens left the prey and were removed from the terrarium for some time to observe number three without possible disturbances.

The lack of spinning behavior in number 1 and number 2 may have been caused a lack of hunger or their arthrosis, or a combination of both. Specimen 3, however persistently displayed the "spinning behavior". He bit into the head and neck region of the rabbit and spun along its longitudinal axis, while all four legs were pressed to its body. This behavior was repeated several times and to both the left and right sides, always completing one full rotation. The monitor was successful after several trials as it opened the skin a few centimetres and gained access to the meat of the prey. After this, the experiment was concluded.

Discussion

Although the literature on *V. albigularis* is comparatively rich, neither in older literature, such as Branch (1991; with data of Brown from 1869 to 1909) or more recent publications (Philipps, 2004; Bayless, 2006) has this spinning behavior been observed and mentioned. Additionally, researchers familiar with monitor lizards like Daniel Bennett (pers. comm., 2018) Hans-Georg Horn (pers. comm., 2018), Robert Mendyk (pers. comm., 2019) and Sam Sweet (pers. comm., 2019) have never observed this behavior either, neither in the field nor under human care. Eidenmüller (2019) observed spinning behavior with two *Heloderma*

Fig. 2. Two adult *V. albigularis* approach the freshly dead rabbit in their enclosure at the Reptile Zoo, Landau, Germany. Photographed by **Uwe Krebs**.

Fig. 3. The youngest adult (right) tries to get through fur and skin with a spinning behavior that uses its body mass to tear the skin of the rabbit. The handicapped specimen (left) relies on biting, shaking and clawing only. Photographed by **Uwe Krebs**.

Fig. 4. Turn of the spinning behavior. Notice the strong bite and the position of the legs. Photographed by **Uwe Krebs**.

Fig. 5. The repeated turns to both sides were very powerful and include a full rotation of the body. Photographed by **Uwe Krebs**.

Fig. 6. After some rotations, the spinning behavior was successful in using the 'law of inertia' to tear the skin to access the meat. Photographed by **Uwe Krebs**.

suspectum under his care, feeding at the same time on a dead mouse.

On the one hand, it seems surprising that the water-bound crocodiles and a dweller of arid areas like *V. albigularis* share the same behavior towards oversized prey with skin and fur. On the other hand, it is the same problem to be solved. Body mass plays an important role in the successful performance of this behavior, as it relies on the 'law of inertia'. It seems to be an efficient way to overcome the limited bite-force of these reptiles.

That this "spinning behavior" in monitor lizards has been unknown up to now can be a consequence of a rare event. The identical behavior used by the four juvenile *V. albigularis* in the 1980s and the one adult individual at the Reptile Zoo Landau in 2017 suggests a genetically fixed behavior (Krebs, 2016). This would make sense for two reasons. Firstly, large prey is rare, where there may be few opportunities to learn how to feed on such prey. Secondly, large prey is a very rich food and to know how to handle it without experience would be rewarding. An alternative to the assumption of a genetically fixed behavior would be to concede the ability of monitors to analyze the given problem in order to find the best solution to it. Too little is still known about the mental abilities of monitor lizards to exclude this possibility beforehand.

Based on these observations, further experiments with *V. albigularis* and other large monitor species as well, hatched under human care and therefore naïve to oversized prey are recommended. If they display the same behavior without prior knowledge or experience, a genetically fixed behavior will became a more likely explanation for it.

Acknowledgments – This article is dedicated to the memory of Hans-Georg Horn (26 February 1935 – 17 February 2019) who for decades, as a long-time keeper of many monitor species, scientist and international organizer, strongly advanced our knowledge of monitor lizards. We thank most sincerely two anonymous reviewers who tirelessly improved our 'German English' and added helpful comments.

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Received: 19 March 2019 ; Accepted: 22 June 2019

Biawak, 13(1), pp. 62–70

Track Marks, Body Postures and Agonistic Behavior in *Varanus rosenbergi* with a Re-assessment of the Vertical Clinch Posture in Varanid Lizards

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Abstract - A number of field studies of *Varanus rosenbergi* have been undertaken on Kangaroo Island, South Australia, over several years. During these studies, incidental observations were made of the general behavior, postures and agonistic interactions of this species. It appears that *V. rosenbergi* conforms to the elements of ritual combat behavior shown by varanid lizards in general. However, the observation of a non-aggressive upright clinch posture in mating *V. rosenbergi* suggests an unrecognized behavioral trait that may be present in other varanid species.

Introduction

Rosenberg's goanna (*Varanus rosenbergi*) is a mid-sized monitor lizard that is found in the southern regions of mainland Australia and associated islands. The species is located in three main geographic areas that are isolated from each other (King & Green, 1993): Western Australia, South Australia/western Victoria and New South Wales/Australian Capital Territory. These three regions contain a total of five evolutionary significant units, but the degree of genetic differences clearly indicates a single species across its range (Smith *et al.*, 2007). While the general biology and ecophysiology of *V. rosenbergi* has been subjected to extensive research (reviewed by King and Green, 1993; Christian & Weavers, 1994; Rismiller *et al*., 2010; Sutherland, 2011; Kirshner, 2016), little has been reported on the general behavior of the species, particularly those interactions associated with breeding. This is mostly due to these interactions being comparatively brief, irregular and somewhat cryptic, providing limited observer opportunity.

The present paper provides data on the postures and agonistic behavior of *V. rosenbergi* on Kangaroo

Island, South Australia. The extended time frame of the observations reported here is due to the chance nature of such interactions, mainly in the comparatively brief pre-nuptial and mating periods of the species.

Materials and Methods

The study was conducted in the Dudley West area of Kangaroo Island, South Australia. The area consists of undulating Linois plains with rough, broken calcerinite lowlands (Northcote, 1979). The vegetation consists of Mallee woodlands dominated by *Eucalyptus cneorifolia, E. diversifolia, Callitris gracilis, Allocasuarina verticillata* and *A. paradoxa.* The Mallee woodlands are punctuated with open, sandy areas.

Most observations were made on individuals that were marked with PIT tags and acrylic paint marks as part of other on-going field projects, while some observations are reported for unknown individuals outside the main study areas. All observations were of adult animals, with the gender of most determined from nuptial activity over several years of study. Sexually active adult males on Kangaroo Island exhibit a mean snout-vent length (SVL) of 451 ± 18 mm (n = 41) and a mean tail length (TaL) of 598 ± 48 mm (n = 31); a total length (TL) of 1049 mm. Sexually mature females have a mean SVL of 385 ± 14 mm (n = 31) and a mean TaL of 536 ± 25 mm (n = 31); a TL of 921 mm (Rismiller, MacKelvey & Green, in prep.).

Both still and movie cameras were employed whenever possible.

Results

Tracks and Postures

After emergence from a burrow first thing in the morning, *V.rosenbergi* usually adopted a flattened prone position for basking, occasionally changing position to maximize heat transfer from the substratum as well as from insolation (Fig. 1). Sometimes the goanna would take advantage of a nearby log or low branch to achieve a more vertical basking posture.

Several minutes later, the goanna would adopt a more alert posture with the head and thorax raised by the erect forelimbs before moving off to commence its daily peregrinations.

Varanus rosenbergi leaves distinct trail marks as it moves about. The most common track observed consisted of a narrow sinuous line left by the by the terminal section of the tail, with associated footprints to either side (Fig. 2a). This type of drag mark is found throughout the active seasons and can be regarded as the normal errant track of a foraging animal, and is passively made. However, two other types of drag mark are generally seen during the pre-nuptial and breeding season in late December and January, and are actively created by the animal. One track type consists of a deeper, broader sinuous track (about 2 cm wide) produced by the animal adpressing a more central tail section to the ground while moving forward (Fig. 2b).

The nature of this track is unclear, but possibly provides a visual cue to other conspecifics. More

Fig. 1. Typical basking posture of *Varanus rosenbergi*.

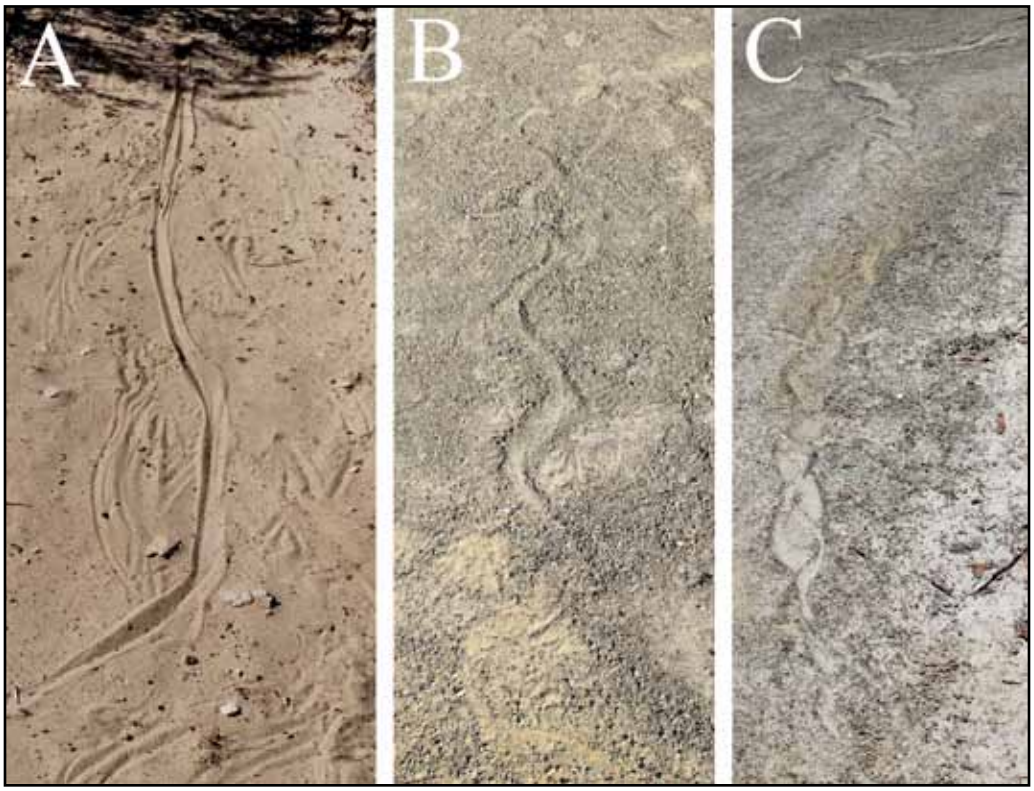

Fig. 2. A) Normal errant track; B) Broad sinuous track.; C) Cloacal squidge track.

commonly in the breeding season, a deep furrow is produced by the animal pressing the cloacal and basal tail regions into the ground, with more sinuous lateral movements that produce drag marks with substantially raised sides. This drag mark has been called a squidge mark (Rismiller *et al*., 2010) (Fig. 2c). In making this drag mark, the coprodial part of the cloaca can be seen as slightly prolapsed before it is adpressed to the ground (Figs. 3a and 3b). This latter drag mark was particularly common around the apron of termitaria nests during the breeding season and along game trails, and presumably represents scent marking (Rismiller *et al*., 2010).

Fig. 3. Cloacal prolapse prior to squidge marking.

During summer, it was common for male goannas to climb into low shrubs and rub their bodies back and forth in the foliage. The shrubs most commonly used in this way were highly aromatic (*Senecio odoratus* and *Prostanthera aspalathoides*), but it is not clear if this behavior was to acquire scent for the animal's body or to deposit cloacal odor on the plant as a marker, or both (Fig. 4). Since non-aromatic plant species are also used for this activity (*e.g.*, *Correa* and *Hibbertia*) it is more likely that the aim of the activity is scent marking via the cloaca. This behavior was only observed in males and while mainly seen between copulatory sessions, it was also observed around unoccupied burrows.

Agonistic behavior

Varanus rosenbergi exhibited a range of reactions when a conspecific was encountered. The most common reaction was where one animal fled at the approach of another, without a contest or fight. However, in late spring and during summer, interactions between animals, particularly males, sometimes led to more obvious agonistic behavior and combat.

The basic aggressive posture shown by *V. rosenbergi* involved inflating the thorax and abdomen and using the inflated gular pouch to produce loud hisses. In some

Fig. 4. A male *V. rosenbergi* rubbing itself in a *Prostanthera* bush.

Fig. 5. Aggressive posture with forelimbs raised.

cases, the forelimbs are raised from the ground with the tail making whip-like movements (Fig. 5).

Another aggressive posture observed involved the animal compressing the body laterally and walking with fully extended limbs, such that the animal moved in a stilting manner. This posture was generally shown by a male intruder into the vicinity of a nuptial burrow and often preceded confrontation with a resident male (Fig. 6).

The mating season in *V. rosenbergi* was marked by aggressive interactions between individuals, predominantly males. Usually these interactions were brief and involved one animal approaching the flank of another, sometimes moving in a circular fashion. Both antagonists normally adopted an arched, puffed-up posture with limbs extended (Fig. 7).

In most circumstances, one individual would immediately break away and run off, with the antagonist in brief pursuit. However, on occasion the interactions were more involved and aggressive, as outlined in the following incidences which are summarized in Table 1, using the five stages of varanid combat proposed by Horn *et al*. (1994).

January 1997 - Two paint-marked males approached each other head-on. At a distance of about a meter both animals inflated themselves while hissing and elevating themselves on all four limbs, arching their backs, while swaying from side to side. Their heads were about 30 cm apart and they smelled each other for a few moments before both rapidly adopted a vertical stance, supported solely by the hind limbs and tail.

They firmly embraced each other with the forelimbs, with their heads held in a vertical position. The animals held this pose for about 40 seconds during which there was much muscular trembling accompanied by side to side swaying movements. After this brief period, the animals toppled to a horizontal position while still maintaining their grasps, with one animal supine beneath

Fig. 6. Stilting posture in *V. rosenbergi*.

Fig. 7. Initial agonistic interaction in *V. rosenbergi*.

the other which was in a prone position. Immediately after hitting the ground, the supine animal broke free from the embrace and made off, closely pursued by the other. Both animals then moved out of sight.

January 2002 - Two animals were encountered that were already engaged in a wrestling embrace on the ground, one animal supine with the other prone above it. All four limbs were engaged in the embrace and the tails were turned out to opposite sides. The prone animal used its head to push the erect head of the supine animal from side to side in a continuous manner, while the tails were used to counteract these head movements. At one stage, the supine animal bit the mouth of the prone animal causing some bleeding.

Attempts by the supine animal to disengage were rebuffed. This activity continued for about 45 minutes, at which point the prone individual began to bite the flank of the supine animal, biting its own forearm in the process. Soon after this, the supine animal managed to roll onto its belly and began to move off, but not before the prone animal gave a strong bite across the width of the head of the supine animal. The supine animal was then pursued to a burrow (about 5 m away) which it quickly entered, at which point the interaction ceased. The prone animal remained outside the burrow licking its face. While the gender of the supine animal was unknown, the prone animal was a known female.

January 2002 - Two animals were encountered already engaged in a wrestling embrace, exactly as described for the previous encounter. Again the prone animal was using its head to push that of the supine animal from side to side. After about five minutes, the supine animal started to bite the neck of the prone animal and after vigorous shaking broke free. It was then chased out of sight by the prone animal. The genders of both animals were not known.

January 2007 - Shortly after an animal was observed emerging from a burrow, another animal appeared. The resident animal approached the new-comer and both animals engaged in tongue-flicking for about 20 seconds, whereupon both animals rose up on their hind legs while gripping each other chest to chest. This upright stance was maintained for only a few seconds before the combatants twisted and rolled to the ground, both using their hind legs and tails trying to roll the opponent onto its back. They then briefly paused and separated before repeating the aggressive interaction twice more. At one point, one animal was lying on top of the other, both belly-down, until one broke free. A brief chase ensued over a few meters, whereupon the resident animal stopped chasing and the interloper ambled off. The whole fight from approach to chase spanned about one minute.


Fig. 8. *Varanus rosenbergi* engaged in a ground wrestle.

October 2010 - Two paint-marked males (Green 10 and Purple 9) approached each other head-on before rushing towards each other and grappling on the ground. One animal was supine and the other prone, with their tails turned out to opposite sides to maintain purchase while they wrestled with all four limbs engaged in an embrace. This wrestling episode lasted for only about 10 seconds before the supine animal broke free and was chased from the area by the prone animal which then remained. This wrestling encounter is shown in Fig. 8.

October 2011 - The same two marked males from October 2010 (Green 10 and Purple 9) encountered each other in a clearing. Green 10 moved towards Purple 9, which was positioned side-on, with both animals inflating their bodies. After briefly circling each other they both engaged in a brief upright grapple, trying to flip each other over. Green 10 proceeded to use its tail for leverage and succeeded in flipping Purple 9 onto its back. Purple 9 managed to briefly regain an upright posture but Green 10 again arched both animals to a vertical stance (Fig. 9), before using its tail to force Purple 9 into a supine position. Moments later, Purple 9 managed to disengage and escape. This whole skirmish lasted about one minute.

January 2014 - Male Pink 13 appeared while forming a drag mark. It then raced towards male Yellow 11 and placed itself over the dorsum of Yellow 11, which assumed a subservient prone posture with head flat on the ground. Pink 13 then started to “peck” the dorsum of Yellow 11, in a manner similar to courting males,

Fig. 9. *Varanus rosenbergi* collapsing from an upright clinch to a ground wrestle.

Fig. 10. Pseudo-courtship behavior in *V. rosenbergi*.

and stroked Yellow 11's flanks with the forelegs. After 45 seconds of this behavior Yellow 11 managed to run off, but was immediately re-caught by Pink 13 and the pecking/stroking behavior re-established for a further 30 seconds. Yellow 11 again escaped briefly before Pink 13 re-established the dominant pecking/stroking activity (Fig. 10), until a final escape by male Yellow 11. This whole sequence lasted about two minutes.

January 2014 - Male Orange 13 approached the flank of male Yellow 11 and commenced swaying movements with the limbs extended. Within seconds, both animals came to grips in an upright clinch (Fig. 11) that lasted only 15 seconds before they collapsed to the ground wrestling. Orange 13 quickly adopted a dominant prone position above the supine Yellow 11, wiping its head across alternate sides of the throat of Yellow 11. After 90 seconds of this action, Yellow 11 managed to extricate itself and ran off pursued by Orange13. However, Yellow 11 was caught by Orange 13 within a few seconds, with Orange 13 covering Yellow 11, both in a prone position. Yellow 11 adopted a subservient posture with its head flat on the ground while Orange 13 proceeded to "peck" the dorsum of Yellow 11 in a similar fashion to the action shown by males engaged in the pre-nuptial courtship of females. After 35 seconds of this behavior, Yellow 11 again broke free and was chased and caught by Orange 13. Over the next 5 minutes, this pattern of Yellow 11 escaping but being re-caught by Orange 13 was repeated 5 times, with Orange 13 biting the flank of Yellow 11 on one occasion. Finally, after a total engagement of about seven minutes, Yellow 11 escaped while Orange 13 moved off without giving chase.

January 2014 - An unmarked goanna approached a burrow occupied by the male Purple 9. Purple 9 emerged and advanced towards the flank of the unmarked animal. Immediately, both animals entered into a very brief vertical clinch before both fell to the ground, with Purple 9 in a prone position above the supine interloper. The supine animal tried at all times to disengage while Purple 9 undertook lateral movements of the head against that of the other animal. They remained engaged in this manner for about five minutes before the supine animal managed to break free and run off, pursued by Purple 9.

December 2014 - Two males (Yellow 14 and Silver/Red) were observed engaged in a contorted vertical grapple; they were upright for about 15 seconds before keeling over and wrestling on the ground. Although Silver/Red was able to assume a superior prone position for much of the fight, eventually the pair broke apart and Yellow 14 chased off Silver/Red. The whole sequence lasted between two and three minutes.

December 2014 - Males Yellow 14 and Silver 11 were observed in an upright wrestle that lasted about 40

Fig. 11. An upright clinch in *V. rosenbergi*.

Table 1. Various fighting behaviors observed in *V. rosenbergi*.

Date	Display	Encompass	Clinch	Catch/Ground Wrestle	Subpression
January 1997	X	X	X	X	-
January 2002	-	-	-	X	-
January 2002	-	-	-	X	-
January 2007	X	-	X	X	-
October 2010	-	X	-	X	-
October 2011	X	X	X	X	-
January 2014	-	X	-	-	X
January 2014	X	X	X	X	X
January 2014	-	-	X	X	-
December 2014	-	-	X	X	-
December 2014	-	-	X	X	-

seconds before they collapsed to the ground with both tails arched. Neither animal was able to achieve a dominant prone position and both separated with Yellow 14 chasing off Silver 11. Again, the whole interaction lasted between two and three minutes.

These observations of agonistic interactions are summarized in Table 1.

Discussion

Various terms have been used to describe the track marks made by varanids; drags and traces (Tsellarius & Men'shikov, 1994), vent dragging (Phillips & Millar, 1998), trackway patterns (Farlow & Pianka, 2000) and squidges (Rismiller *et al*., 2010).

There is general agreement that the drag marks that involve the cloacal region being pressed to the ground represent scent marking. In *V. varius* (Carter, 1990) and *V. albigularis* (Phillips and Millar, 1998), males have been observed closely following the trails left by females. We consider that the drag marks produced by male *V. rosenbergi* and their bush-marking behavior represents scent marking.

Our observations of fighting in *V. rosenbergi* show many similarities to those displayed by other non-Odatrian varanids, (reviewed by Horn *et al*., 1994) and are referred to as ritual combat. Horn *et. al*. (1994) proposed five main elements to ritual fighting in varanid lizards based on reports of combat in 15 non-Odatrian species:

1) Display phase; aggressive posturing

2) Encompassing phase; combatants circle each other.

3) Clinch phase; bipedal stance in wrestling pose with mutual embrace.

4) Catch phase; tilting over and wrestling laterally on the ground, trying to achieve a superior position.

5) Subpressive phase; the inferior animal is subjected to pseudo-copulation, biting and chasing-off.

The agonistic postures and behaviors of *V. rosenbergi* appear to fit all of the combat elements proposed by Horn *et al*. (1994). Fighting is initiated when one animal approaches the flank of another and they then begin to circle and grip each other with all limbs, sometimes in an upright clinch. They then begin to wrestle using their tails to try and gain a superior position. Once this has been achieved, the top (prone) animal forces the head of the bottom (supine) animal from side to side, while the supine animal continues to attempt to overturn the situation. The fight may continue for more than thirty minutes or so before the animals break off the fight and one animal, usually the prone animal, chases off the other. In some cases the two protagonists meet front-on and rise up in a vertical embrace, balanced on their hind limbs and tail. The upright phase of combat varies from brief seconds to several minutes of quivering muscular action before the pair topple over and engage in ground wrestling and subsequent chase-off. On a couple of occasions the subpressive phase was observed; however, it took the form of pseudo-courtship (pecking and stroking by the dominant animal) rather than pseudo-copulation.

While females are usually submissive during the copulatory phase and appear to be accepting of any male for coitus, there are occasions when males are vigorously rejected and driven off. One female allowed copulation to occur with the same male on two separate

days, but immediately after a single copulation started a post-coital fight and drove off the male. On a separate occasion an interloping male entered a nuptial burrow and was immediately chased off by the occupying female. Female *V. rosenbergi* have also been reported displaying the stilting and upright aggressive postures against nest marauders, both conspecifics and *V. varius* (Kirshner, 2016).

The upright embrace stance (clinch phase) may not be restricted to fighting. A pair of *V. rosenbergi* was observed at a roadside in mid-January at 1430 h (D. Churchett, pers. comm.); they were clasped together in an upright motionless stance with heads erect and no sign of muscular wrestling. This pose was held for over a minute, at which time they were disturbed by the closer approach of the observer to photograph the encounter (Fig. 12). The pair separated and ran to an adjacent roadside burrow; one animal entering the burrow while the other stayed at the burrow entrance. The two animals did not separate in a chase as is usual in ritual combat. On a visit to the site the following day, a pair of animals was observed copulating, after which the female retreated to the roadside burrow. It is possible that the erect posturing observed initially at this site was pre-nuptial, courtship behavior.

A similar non-combative vertical embrace has been observed in *V. mertensi*, (R. Braithwaite, pers. comm.; Fig. 13). A pair of *V. mertensi* was observed in an upright clinch at a river's edge. The observers left the scene and returned with cameras about 30 minutes later. They observed that the animals were still engaged in an upright embrace, although it is not certain if the same embrace had been continuously engaged in during the observers' absence. However, soon after their return, the animals separated with no subsequent aggressive action or chasing off. The vertical embrace in *V. mertensi* appeared to be passive, with no obvious aggressive intent between the couple.

Braithwaite's photo of this upright embrace in *V. mertensi* has been previously reproduced as an example of ritual combat (Greer, 1991; King & Green, 1993). However, a revision of this interpretation as ritual combat is called for, along with the interpretation of a pair of *V. gouldii horni* embracing in a water body (Horn *et al*., 1994).

Fig. 13. *Varanus mertensi* in an upright clinch.

Thus it appears that the upright clinch posture may take two forms; a brief pre-cursor to aggressive wrestling on the ground (mainly in male/male interactions) and a co-operative pre-nuptial display by a male/female pair. It is not known if this pre-nuptial upright clinch posture is shown by other varanid species, but clearly further observations are needed to firmly establish the existence of this posture and behavior.

Acknowledgments - Apart from Fig. 5 (Branka Gregor), Fig. 12 (Darren Churchett) and Fig 13 (Richard Braithwaite), all figures are the copyright of Graham Churchett. We thank two anonymous reviewers for their comments on an earlier draft of this manuscript.

Varanus rosenbergi in the process of disengaging from an upright clinch.

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Received: 12 December 2018; Accepted: 23 June 2019

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