BIAWAK

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On the Cover:
Varanus salvadorii

The copulating *Varanus salvadorii* depicted on the cover and inset of this issue were photographed at Singapore Zoo by **Borja Reh** on 22 March 2019. The animals were kept together for three weeks during which courtship and copulation were observed on several occasions. The female laid eggs on 6 May, which resulted in a second captive-bred generation of *V. salvadorii* that hatched on 21 November 2019. This event marked the culmination of a breeding project that began in 2016 with the design of Reptopia, a new reptile facility at Singapore Zoo. The project intended to highlight the best practices and essential requirements for keeping *V. salvadorii* in a captive zoo environment.

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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.

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ORGANIZATIONAL NEWS

COVID-19 and its Impacts on the IVIG and *Biawak*

In early 2020, the world was caught off-guard by the emergence of SARS-CoV-2, a novel respiratory pathogen which quickly escalated into a major viral pandemic. Bound by no political borders, the virus quickly spread throughout the world and as of December 2020 still continues to threaten the health, wellbeing and livelihoods of much of the world's human population. Beyond the virus' devastating impacts on human health and mortality, the pandemic has disrupted and upended life as many of us knew it, forcing much of the world's population to adapt to new routines, workloads and the various other hardships and challenges presented by the pandemic. Not surprisingly, these impacts have also affected the lives of *Biawak*'s editorial board members, peer reviewers and authors, ultimately resulting in fewer manuscript submissions, a slower than usual review process, and subsequently the delayed release of this single, joint issue for the year.

Despite the setbacks of 2020 and continued uncertainty about the future of the pandemic, 2021 looks to be a promising year for *Biawak* and a return to business as usual. With several manuscripts in queue for publication and others currently under review, *Biawak* seeks to return to its normal biannual publication cycle with the first issue planned for release in June 2021. As always, article and photographic submissions are welcomed and encouraged from all varanid enthusiasts; submission inquiries should be directed to the editor.

IVIG Mourns the Loss of Daniel Bennett, Associate Editor and Regular Contributor to *Biawak*

Daniel Bennett, distinguished monitor lizard biologist and an original associate editor and regular contributor to *Biawak*, passed away on 25 February 2020 at the age of 53. A celebration of his life and contributions to the field of monitor lizard biology and conservation, with personal reflections from his family, friends and colleagues, begins on page 9 of this issue.

Two recent devastating losses to the international monitor lizard research community, IVIG and editorial board of *Biawak* - Daniel Bennett (1966-2020), associate editor, and Hans-Georg Horn (1935-2019), editorial reviewer.

NEWS NOTES

Emergency Surgery for Komodo Dragon at Zoo Miami

Emergency surgery was required for a nine-year-old female Komodo dragon (*Varanus komodoensis*) at Zoo Miami after it consumed a plastic water bottle that had been thrown into its enclosure. The surgery took three hours, but the obstruction was removed successfully. Zoo officials did not say whether the incident appeared to be accidental or intentional, but note that the consumption of foreign objects thrown or dropped into enclosures by zoo visitors is becoming increasingly common.

Source: FOX 13 Tampa Bay; 7 July 2020

Florida Man Pleads Guilty to Smuggling Philippine Monitor Lizards

A 44 year-old Pasco County, Florida man pleaded guilty to one count of wildlife trafficking in violation of the Lacey Act in connection with the smuggling of more than 20 live monitor lizards (*Varanus salvator* complex) from the Philippines to the United States over five shipments in 2016. The monitors were packed in socks, and concealed in the backs of stereo speakers and other electronic equipment. Akbar Akram, 44 who pleaded guilty to arranging the smuggling, used social media to communicate with conspirators in the Philippines and Massachusetts. Akram claimed the lizards were worth around $1,000 each, but federal prosecutors noted that their retail value in the exotic pet trade can be as much as $2,500 each, for a total value of upwards of $50,000. Some of the smuggled specimens ended up in private collections in Massachusetts, Connecticut and Colorado; however, according to court records, not all of the smuggled specimens survived. Earlier in 2019, a federal judge in Boston sentenced Derrick Semedo, the recipient of the illegally trafficked monitors, to 24 months of probation.

Sources: https://www.justice.gov/opa/pr/florida-man-pleads-guilty-trafficking-cites-protected-water-monitor-lizards; 8 January 2020; https://www.tampabay.com/news/business/2020/01/10/pasco-man-pleads-guilty-to-smuggling-monitor-lizards-from-the-philippines/; 10 January 2020

Indian Astrologer Arrested for Killing Monitor for Black Magic

An astrologer was arrested in Trichy (Tiruchirappalli) in southern India for killing a monitor lizard (presumably *Varanus bengalensis*) for the purpose of conducting black magic. The accused had posted a video on social media in which he claimed that he had prepared Kohl (Kajal), an eye cosmetic from the flesh of the animal, which would provide him with the ability to mesmerize people. He marketed the product by indicating that it could be used to control family members or for businessmen to neutralize their enemies. All native *Varanus* species are protected under Schedule 1 of India's Wildlife Protection Act.

Source: https://timesofindia.indiatimes.com/city/trichy/astrologer-held-for-killing-monitor-lizard-for-black-magic/articleshow/76185427.cms; 4 June 2020

Deaths of Zoo Komodo Dragons

An adult male Komodo dragon (*Varanus komodoensis*) passed away from heart failure at the St. Augustine Alligator Farm and Zoological Park. Hatched at the Toronto Zoo, Tujah came to St. Augustine in 2012. A fourteen year-old male *V. komodoensis* hatched at the San Antonio Zoo was euthanized at the Birmingham Zoo due to a continued decline in health and sudden onset of hind limb weakness following complications from heart disease.

Source: The Trussville Tribune 23 June 2020

Monitors Consume Abandoned Infant

The remains of an infant abandoned in Nakhon Si Thammarat in southern Thailand are believed to have been consumed by water monitors (*Varanus salvator*). The body was placed in a plastic bag and left near a pond inhabited by the animals. The remains were found

after a group of boys playing nearby noted a foul smell. Police noted that the newborn had been dead for at least one or two days and that the bite marks on the body matched those known to be produced by large monitor lizards. Authorities are now performing DNA tests and examining security camera footage from the area to try and determine who abandoned the infant.

Source: https://www.sciencetimes.com/articles/25688/20200514/double-tragedy-monitor-lizard-preys-newborn-baby-dumped-next-pond.htm; 14 May 2020

Parthenogenesis Confirmed in Chattanooga Zoo Komodo Hatching

Three Komodo dragons hatched at the Chattanooga Zoo in August 2019 have been confirmed via DNA analysis to have been produced through parthenogenesis. Parthenogenesis is now a well-documented phenomenon in monitor lizards, first described in *Varanus panoptes* in 2005 (Lenk *et al*. 2005. A parthenogenetic *Varanus*. Amphibia-Reptilia 26[4]: 507-514). It was subsequently recorded in *V. komodoensis* in 2006 (Watts *et al*. 2006. Parthenogenesis in Komodo dragons. Nature 444[7122]: 1021-1022), and since then has been recorded in several additional species of monitor lizard. Parthenogenesis has now occurred multiple times in *V. komodoensis* held in several zoological collections.

Source: https://www.cnn.com/2020/03/09/us/komodo-dragons-parthenogenesis-scn-trnd/index.html; 9 March 2020.

Parthenogenetic Komodo Dragons Hatch at the Denver Zoo

Two *Varanus komodoensis* hatched at the Denver Zoo in March 2020 were produced through parthenogenesis. The mother had laid the clutch seven months earlier, and has since been transferred to another zoo. One of the hatchlings will be retained by the zoo; the other will be transferred to another facility for display.

Source: https://www.9news.com/article/life/animals/two-komodo-dragons-hatch-at-the-denver-zoo/73-9caa03e1-2dc2-4634-9dcc-14c03cdc7802; 24 April 2020

Varanus gouldii. Nambung NP, Western Australia. Photographed by **Steve Sharp.**

Florida Man Sentenced for Trafficking in Water Monitors

A 44 year-old Florida man was setenced to four years of probation after pleading guilty to illegally importing 20 live monitor lizards from the Philippines in 2016. In violation of the USFWS Endangered Species Act and the Convention on Inteernational Trade in Endangered Species (CITES), the animals were placed in socks and then sealed inside audio speakers and electronic equipment, then shipped to an accomplice in Massachusetts. The animals were then sold to other individuals in the United States.

Source: Winknews.com ; 22 September 2020

Six Arrested for Poaching Monitor Lizards

Six individuals from Uddo Kelshi, Cavelossim, in southwestern India were arrested for poaching three monitor lizards (species not identified) at Agapur in Ponda taluka. The suspects were apprehended in a sting operation led by forest officials, and it is believed that the animals would have been killed for their meat and skin

Source: Indiatimes.com; 30 August 2020

Cincinnati Zoo Dragon Receives Double Cataract Surgery

A 17-year-old male Komodo dragon (Varanus komodoensis) recently underwent double cataract surgery at the Cincinnati Zoo after it was noticed that the animal had lost its eyesight.. A team of specialists performed the surgery, and the animal is said to be recovering off-exhibit.

Source: local12.com; 25 November 2020

Monitor Lizard Genitals Illegally Sold to Treat Female Infertility

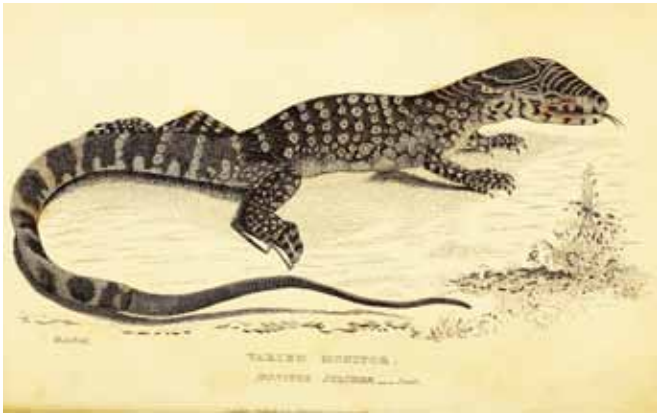
Four men connected to a religious cult were arrested in Karnataka State in southwestern India for allegedly selling the sex organs of monitor lizards (species not specified) to women of the group who were apparently having difficulty conceiving. Officials seized a total of 498 monitor sex organs and 503 sea fans through a joint operation led by local police and the Karnataka Forest Department. Both the monitor lizard genetalia and sea fans are protected under Schedule 1 of the Wildlife Protection Act.

Source: thenewsminute.com; 11 September 2020

Worker Seriously Injured by Komodo Dragon on Rinca

A 46-year-old worker was seriously bitten and injured by an adult Komodo dragon at a controversial wildlife resort centered around the dragons that is being constructed on Rinca, Lesser Sundas, Indonesia. The man, who sustained serious injuries, was evacuated by speedboat from the island for medical attention.

Source: Dailymail.uk; 16 December 2020



"*Monitor pulcher*" (= *Varanus niloticus*). From: Cuvier, B. 1835. A Classified Index and Synopsis of the Animal Kingdom Arranged in Conformity with its Organization. Reptilia. Volume IX. Whittaker & Co., London. 591 pp. + supplement

Native, Not Introduced: New Research Shows that Two Species of Monitor Lizards are Endemic to the Islands of Micronesia

Are Micronesian monitors native or introduced? A recently published study resolved this long-lasting question, which has practical consequences for the conservation of these Pacific monitor populations. The research revealed that the monitor lizards of Palau, the Western Caroline and Mariana Islands represent two separate and endemic species, which are most closely related to each other. Their nearest relatives are *Varanus rainerguentheri* and *V. lirungensis* from the northern Moluccas and the Talaud Islands of eastern Indonesia, suggesting that colonization of Micronesia took place from that region, presumably riding ocean currents out into the Pacific.

The monitor species occurring in the Mariana Islands was already described in 1929 by a Japanese zoologist, Kyukichi Kishida, who named it *Varanus tsukamotoi* to honor his colleague Iwasaburo Tsukamoto. *Varanus tsukamotoi* has since long been considered synonymous with *V. indicus* because the original description lacked a detailed diagnosis and comparison with closely related species. Based on a broader morphological sampling and supported by a molecular dataset across the entire group of Pacific monitor lizards, the name *V. tsukamotoi* was now revived for the monitor lizard of the Mariana Islands. The monitor lizard inhabiting Palau, the Western Carolines, and Sarigan Island was named *Varanus bennetti* in memory of the late Daniel Bennett (1966–2020).

Because of the historical presumption that Micronesian monitor lizards are non-native, and due to their predation on chickens and endemic animal species, these reptiles have often been viewed by local inhabitants as dispensable pests. Therefore, some attempts to eradicate or control monitor lizards' numbers on single islands have been made in the past. Some of the Micronesian islands east of Palau do in fact have populations introduced by colonial governments in the past century or so. However, the fact that most of these Pacific monitor lizard populations are actually endemic to large parts of Micronesia argues for caution when such plans are considered to ensure that populations targeted for removal are indeed introduced and not native. Conservation of healthy populations of these top predators must be a priority in the future.

Fig. 1. *Varanus tsukamotoi* on Guam. Photographed by **Peter Xiong**.

Fig. 2. *Varanus bennetti* on Losiep Island. Photographed by **James Reardon**.

Source: Weijola, V., V. Vahtera, A. Koch, A. Schmitz & F. Kraus. 2020. Taxonomy of Micronesian monitors (Reptilia: Squamata: *Varanus*): Endemic status of new species argues for caution in pursuing eradication plans. Royal Society Open Science 7(5): 200092.

A Tribute to the Life and Career of Daniel Bennett (1966 - 2020)

Daniel Bennett, a world-renowned biologist most celebrated for his contributions to the study of monitor lizards, passed away on 25 February 2020 from complications related to leukemia. The following tribute is a celebration of Daniel's remarkable life and distinguished career, as well as his profound impacts on advancing the study, conservation and captive management of monitor lizards over three decades and the many amateur and professional herpetologists he inspired and impacted along the way. A forthcoming biographical account in this journal will outline his many scientific contributions to the study of monitor lizards and their captive management.

Daniel with *Varanus exanthematicus* in Ghana, 2018.

Daniel collecting *Pandanus* fruits on Polillo Island as part of his dissertation research on the ecology of *Varanus olivaceus*.

Daniel presenting on his fieldwork on *Varanus olivaceus* at the Inderdisciplinary World Conference on Monitor Lizards in Bangkok in 2015.

Andaman Sea, western Thailand, 2015.

Daniel – A Eulogy of Sorts

Sekki Tabasuares

The Daniel I met and married was more than so many of the roles played in his life. He was already an accomplished expert in his field. He was the proud father of a very sensible, fully grown young woman. When he found out that the local paper in his hometown of Glossop was folding in 2012, he promptly launched another one. Together, we produced several issues that focused on local politics and controversial issues. These had never been covered in such a thorough and earnest way before, even after the more established local paper got new funding and started going again. As newspaper editor, he was passionate about highlighting real issues connected to policymaking and the local councils, demanding more transparency from politicians in the area. He also started the town's first local bat group, publishing a survey of the local habitat of Glossop's bats.

He was a member of the George Formby Society, and his taste in music was eclectic. He listened to the Inkspots and Lead Belly, Jimmie Rodgers, Johnny Cash and Blaze Foley, Jimmie Driftwood and John Prine, Lee Hazlewood and Nancy Sinatra, Jacques Brel and Nirvana, but he could also belt out Nicki Minaj and Lady Gaga music. He attended quite a few Rammstein concerts in the last few years. He played the banjo, the piano and the ukulele. The last concert we went to together was a Sparks concert. He was also an avid fan of the Sensational Alex Harvey Band in his youth, with one of the proudest moments in his early life playing the guitar that a band member had asked him to hold during a live performance. In the last two days before his death, we played a mix of Johann Sebastian Bach and Beyonce by his hospital bed.

He surrounded himself with the most interesting mix of friends from all around the world. He could engage in the most bracing, interesting conversations without being the slightest bit mean-spirited. He could offer a couch to a stranger who took the wrong late night train and was stranded in the wrong town, but he could also be impatient with narrow-mindedness and incompetence. He loved good coffee to a fault, and found the world unendingly fascinating. He introduced me to the meditations of Marcus Aurelius. He took more pride in showing me a local sheepdog competition than Stonehenge when taking me around the UK on my visits. He instinctively sought out the underdog in every story and fought in that corner. He would hold my hand as we crossed busy streets and ask me to proofread important papers and other compositions he had drafted. He was very good at making people aware that they had something valuable to offer the world.

At an early age, he co-owned an iguana with a good friend and neighbor. When he was a bit older, he got himself a monitor lizard and realized that he couldn't find much material to help him understand monitor lizards better. As a teenager he read the works of Karl Marx and the autobiography of Malcolm X, recognizing that the first job he had as a boy "was slave" and not work. In the 1980s he lodged with a family in Cranford whose patriarch had been a colonel in the Pakistani army and had tried to stage a military coup with other colonels to depose Zia ul Haq. The stories he told Daniel about Afghanistan, Russia and America didn't fully make sense to Daniel for 15 years. The experiences he gathered at this impressionable age, complementing the open-mindedness his mother instilled in him, shaped his world view and sharpened his sense of adventure and inclusion. He travelled the world extensively, chasing after his biggest passion, monitor lizards. Right until his last few days in the hospital, he was still trying to organize work and delegate what he felt needed doing. He believed in just getting things done, and getting them done the right way.

There are so many other things about him I could write down, because I never stopped learning from him until the day he was taken away. I have never met anyone else who did the kindest, most generous things with the simple air of someone just out taking a walk. The world fascinated him and he shared this life of exploration with me. I am extremely lucky to have been by his side for 13 years. It will always feel that this was not enough time, of course.

I quote three words from a book about grief that describe what he was to me: Unfinished. Beautiful. Everything.

In Memory of Daniel Bennett, Red List Authority of the IUCN Monitor Lizard Specialist Group

Mark Auliya & André Koch

Co-Chairs, IUCN SSC Monitor Lizard Specialist Group
Zoologisches Forschungsmuseum Alexander Koenig, DE

When we founded the Monitor Lizard Specialist Group (MLSG) in September 2014 as part of the Species Survival Commission (SSC) of the IUCN (International Union for Conservation of Nature, www.iucn.org), the world's largest organization for nature conservation, Daniel Bennett was, of course, among the first who expressed their interest to become a member.

Throughout his academic life, Daniel devoted all his energy to the study and conservation of monitor lizards. He has undoubtedly been an exceptionally passionate field herpetologist who, over many years, has conducted research on monitor lizards in West Africa, especially focusing on *Varanus exanthematicus* in Ghana, and on the endemic monitor lizards of the Philippines. Daniel was constantly working out field methods to reduce uncertainties on population sizes, activity patterns or home range sizes, in order to adjust the conservation status of certain monitor species.

Fig. 1. Daniel Bennett and Mark Auliya together with Aaron Savio Lobo, member of the Marine Conservation and Sea Snake Specialist Groups, at the IUCN SSC Leaders Meeting in Abu Dhabi in October 2019.

Due to his broad expert knowledge on these particular reptiles together with his interconnectedness with colleagues all around the word, we decided that Daniel would be the perfect candidate to become the Red List Authority (RLA) of the new specialist group devoted to the conservation of monitor lizards. As RLA it is essential and necessary to cross-check the content of individual species assessments with available published data in order to either confirm the Red List status or to amend it with proper arguments. Daniel was very familiar with this procedure because in the past he had already been involved in Red List assessments for several monitor lizard species, either as reviewer or assessor.

Although we intended to determine the RLA at the MLSG inaugural meeting (kindly hosted by Michael Cota at the Phra Nakhon Rajabhat University in Bangkok in July 2015), already by the end of 2014, Daniel had officially been appointed RLA by the IUCN and, consequently, co-signed the official announcement about the establishment of the MLSG in this journal (see Auliya et al. 2014, Biawak 8[2]: 59). At the inaugural meeting, which was jointly held and organized together with the Interdisciplinary World Conference on Monitor Lizards, Daniel was, of course, among the 16 attendees of the MLSG. He gave a presentation about priority monitor species to be assessed by the specialist group in the near future and played a key role during discussions about the tasks and goals of the new MLSG.

Since no second meeting of the MLSG has taken place since 2015, at least one of us (MA) was lucky to meet Daniel again in October 2019 at the IUCN SSC Leaders Meeting in Abu Dhabi. Meanwhile, Daniel had devoted a lot of time to create an official homepage for the MLSG, which unfortunately was hacked and can no longer be used. Earlier we had learned about his severe illness and so we were very relieved when Daniel wrote us that the therapy had seemingly been

successful. During the conference, Daniel and Mark had dinner together several times and exchanged anecdotes, which they had experienced on their various field trips. It was clearly noticeable, which would certainly be confirmed by those close to Daniel, how enthusiastically he reported his experiences with a constant glint in his eyes. Saying goodbye to him in Abu Dhabi was actually a good and confident one and Daniel seemed especially optimistic and motivated to complete the remaining Red List assessments of monitor species still to be reviewed by March 2020, a given deadline by the IUCN.

Soon, however, communication with Daniel became more and more sporadic and he eventually informed us that the cancer had returned. Despite – or perhaps just because of – his illness, he was determined to carry out a new monitor lizard project and asked us for a letter of recommendation, which we were of course happy to issue to him. His premature death thwarted his research plans about another little-known monitor species.

On 11 February 2020, we received Daniel's last email. He was in the hospital and the estimated chance of survival was merely 30%. Facing his tragic situation, Daniel was reluctant to resign from his position, but judged it unlikely that he would be able to contribute to the review process of assessments for at least another six months. Barely two weeks later, we learned of Daniel's passing. He left us far too soon.

Given the fact that we know so little about the biology, threats, and population sizes of many monitor lizard species, it takes a lot more people like Daniel Bennett, who go out into the field and gather first-hand observations and valuable data about varanids in order to protect them for the future. We have lost one of the most dedicated members of our MLSG and this loss from our small community will be very difficult to compensate. Therefore, we are very happy that Michael Cota kindly offered to take over the position as RLA and we hope to continue the conservation work, which we started together with Daniel, efficiently in his memory.

Encounters with Daniel Bennett

Michael Stanner
Faculty of Education, Naresuan University, Phitsanulok 65000, Thailand

In the early 80's I received a letter (airmail letter – before the era of e-mails) from a guy I didn't know named Daniel Bennett. At that time I was a graduate student at the department of zoology of the Tel Aviv University (TAU) working on my M.Sc. thesis on the ethno-ecology of *Varanus griseus* in Israel. Daniel requested several clarifications on *V. griseus* (I can't recall the details). I replied promptly, catered to his inquiries and forgot about the whole thing. Several years later I met him at a herpetological conference in Europe. At that time I was already working on my Ph.D. thesis at TAU on the eco-physiology of snakes. He introduced himself, reminded me of our correspondence and we had a brief and pleasant *Varanus*-chat. I was impressed that he was an exceptionally ardent *Varanus* enthusiast. Daniel was not the only varanophile that I had been corresponding with but he was the youngest. By that time I had already been corresponding extensively with many other *Varanus* researchers and varanophiles – most of them older than me. Later on I have been in contact with many "second and third generations" of varanophiles – most of them younger than me.

Throughout the years since our first letter-exchange, Daniel sent me his recent publications, *Varanus*-oriented letters and e-mails, as well as his various literary *Varanus* projects of which I can recall the project of translations of non-English *Varanus* publications – mainly German and Russian papers. I have to admit, that at that time I was fully immersed in my snake-study, hence *Varanus* matters were pushed aside and given second priority. After the completion of my Ph.D., I returned to my old love of monitor lizards. Daniels's literary varanophilia culminated with his "*Little Book of Monitor Lizards*" (published in 1995) that later on evolved into his second and third books "*Monitor Lizards, Natural History Biology and Husbandry*" and "*Warane der Welt, Welt der Warane*" – both of them published by Edition Chimaira in 1995 and 1996, respectively. A more recent book – "*The Savannah Monitor Lizard Varanus exanthematicus*" was published with Ravi Thakoordyal in 2003. Daniel's books are very informative and contain many tidbits pertaining to *Varanus* natural history.

Especially noteworthy was his thorough survey of the *Varanus* literature citing many old, elusive and hard-to-get-publications, all of which were valuable for my *Varanus* studies. In that context, sometimes a sporadic observation of *Varanus*, is beneficial for reaching the right conclusion or even more so - evading a wrong conclusion. In summary, in my opinion Daniel's books are exactly what varanophilic books ought to be.

Daniel started his undergraduate biological and zoological education relatively late in his life. Relevant to this biographical clause - both of us attended the Second World Congress of Herpetology held in Adelaide, South Australia in 1994. I remember that during the congress he spent time studying for a biochemistry examination and inquired around "Does anybody happen to have Lehninger?" – the classical textbook of biochemistry that every biology student knows. During the congress he demonstrated solidarity with his fellow varanophile (= me) and attended my non-varanid lecture on snake ecology, but then came the real "whack" of the congress. There were two sessions held at the same time: (1) on monitor lizards and (2) on reptilian thermoregulation – commemorating half a century of herpetological research since Cowless & Bogert's (1944) classical publication "*A preliminary study of the thermal requirements of desert reptiles*" (Bull. Amer. Mus.Nat. Hist. 83: 265-296). I wanted to attend both sessions but had to choose only one. It was one of those decisions in life that whatever decision you make you are likely to regret it for the rest of your life. Since (2) was embedded in the very essence of my Ph.D. thesis, I chose the reptilian thermoregulation session. Needless to say that Daniel chose the *Varanus* session. I don't think he ever forgave me for that varanophilic betrayal. Nevertheless, it seemed that he did appreciate my snake-lecture as well.

A Friend and Mentor: A Short Reflection on Daniel Bennett

Matthew D. Yuyek

The late William Oliver of Flora and Fauna International said to me, "Hey, you ought to meet this guy Daniel Bennett. He is the famous 'Monitor Guy' from England and he is currently doing a study on the butaan (*Varanus olivaceous*) on Polillo Island. He has heard about your successful breeding of the species and is more than excited to meet you. Ever heard of him?" "Not in person; I think I have come across his name somewhere on the internet," I replied. "It'll be a privilege if you could arrange for him to come visit Avilon Zoo on a weekend." The day finally arrived for me to meet the "Monitor Guy". We were introduced and it was indeed a pleasure for me to have finally met Daniel Bennett. Somehow, I had a hard time catching up with every word he was saying. Eventually I was able to get used to his "Old English" accent.

Enthusiastic to see the zoo's captive-bred butaan hatchling, I accompanied Daniel to the rearing department where all the animal offspring in the zoo were cared for. Astonished upon coming face to face with the hatchling, Daniel repeatedly uttered the word "brilliant". To this day Daniel's "brilliant" still resonates in my mind. That was the beginning of our friendship.

Apart from a number of manuscripts that Daniel provided me with for my research, he also gifted me two books – Auffenberg's (1981) *Gray's Monitor Lizard*, and Bennett and his and Ravi Thakoordyal's (2003) *The Savannah Monitor Lizard: The truth about Varanus exanthematicus*. These two books in particular are treasured dearly to this day.

Daniel was a man full of surprises. One day he surprised me by informing me that I was going to be

Daniel and Matt at Avilon Zoo, 2005.

a part of a documentary film about the butaan he was working on. Shortly thereafter, he and a film crew visited the Avilon Zoo to shoot segments for the 2006 documentary, *Butaan: The Lost Dragon*.

In the following years, Daniel would often pay me a visit at the zoo to monitor the progress and growth of the butaan hatchling or we would meet up in Manila over dinner for more discussions about reptiles, frogs and bats. On one occasion, he brought a few varieties of wild fruits butaan are known to feed upon in their natural habitat all the way from Polillo Island, Quezon Province to the zoo in Montalban, Rizal Province for a feeding trial with the captive butaan. Daniel's support of my work with the butaan was invaluable and from him I learned more about the ecology of the lizard.

When the Butaan Project on Polillo Island came to an end, Daniel would no longer be returning to the Philippines. So our communication became limited to the internet where most times we discussed topics on monitor lizards, or just dropped in to say hello to each other. Daniel never mentioned to me that he had been seriously I'll until I came to learn about it from another source. His untimely passing saddened me in knowing that I have lost a dear friend and mentor forever. But the precious memories I've had with Daniel, though short, will live on forever in me.

Fellow Varanophiles

Eric R. Pianka
University of Texas, Austin, USA

Daniel Bennett was a dedicated and talented student of varanids. He wrote to me in 1991 offering to pay his own way from the United Kingdom to Australia to assist me in fieldwork. Dan wanted to gather information on as many species of *Varanus* as possible for his "Little book of Monitor Lizards." At that time Dan was an amateur, but he went on to earn his Ph.D. and became an expert on two species of arboreal herbivorous Philippine monitors. He discovered and studied a magnificent new species, *Varanus bitatawa* (more on this species below).

I told Dan that I could guarantee he'd see and be able to photograph about half a dozen desert species. We worked for about a month and were able to find seven: *V. brevicauda, V. caudolineatus, V. eremius, V. giganteus, V. gouldii, V. panoptes, and V. tristis.* Our most exciting find was a hatchling *V. tristis,* the only one I've ever seen in the wild. We also tracked down and exhumed a medium-sized perentie.

I was bitten by this perentie while helping Daniel photograph the lizard. He wanted to get a picture of the perentie on the ground as I stood by, watching. The lizard dashed behind me and began to climb up the back of my leg. I had visions of it climbing up to my head and scratching my face with its large, sharp claws. Dan, who could see the lizard and could have grabbed it, stood by doing nothing (he could have gone around behind me and removed the lizard). Reflexively, I reached my left arm around behind my back to try to get the lizard off. It chomped down on my left wrist with its 6-8 mm serrated cutting teeth. Daniel remained frozen as I began bleeding profusely. Then I reached around with my right arm in a continuing effort to try to extricate the lizard, whereupon it clamped down on my right thumb and began to chew. It hurt! By the time Dan finally came to my rescue, I was slashed up and bleeding like a stuck pig. Fortunately for me, no tendons were severed.

I washed the bites in alcohol and bandaged them to keep the flies out. They healed over, and I thought I had recovered. But a few days later, I was bitten again on the same poor thumb by a much smaller *V. tristis* (teeth about 3-4 mm), which also chewed. My thumb got infected, and then my left wrist went sympathetic and

Eric and Daniel at the Interdisciplinary World Conference on Monitor Lizards, Bangkok, Thailand, 2015.

got infected, too. Luckily, we had some antibiotics, and after taking them for a couple of days, the swelling went down and I thought I was going to be O.K. (Aussies and Aborigines say that "a goanna bite never heals"). But my thumb swelled up again a month later to twice its normal size. Apparently, blood-born antibiotics do not easily reach poorly vascularized synovial joint capsules. Five prescriptions of different antibiotics later, the infection was still not completely cured.

This story has two morals: (1) don't stand still around a monitor lizard, and (2) if you should ever be so unfortunate as to find a monitor lizard climbing up your your back side, whatever you do, don't put your arms around behind your back to try to get it off. Instead, lay down on your belly, and let it walk or run away by itself. Isn't twenty-twenty hindsight great?

At night, Dan and I listened to the news of the Iraq-Iran war on a shortwave radio. All went well for the first few days, but then an American pilot misidentified and bombed a British vehicle causing considerable friction between the two of us. Dan was a high-strung and complained that I did not feed him enough (he was also a chain smoker).

Dan was adamantly opposed to killing and studied both *V. olivaceus* and *V. bitatawa*, primarily using cameras and scat samples. He was finally convinced to sacrifice an adult *V. bitatawa* for a type specimen in 2010 but had to carry along eight co-authors.

In my last conversation with Daniel at the Bangkok conference, he said that he wanted to study *V. eremius* in the Great Victoria Desert.

Remembering Daniel Bennett

Sam Sweet
University of California, Santa Barbara, USA

I first learned of Daniel's interests via his *Little Book of Monitor Lizards* soon after it appeared in 1995, shortly after I had returned from a year of fieldwork radiotracking monitors in tropical northern Australia. The species I had studied (*Varanus glauerti*, *V. glebopalma* and *V. baritji*) were comparatively little-known, and Daniel was keen to incorporate my findings into a revision that somehow never got completed. We had many discussions at first via letters and later via email about monitor biology in general and radiotracking in particular. Daniel was quite opposed to radiotracking or essentially any contact with the animals, since he felt that butaan (*V. olivaceus*) were so physiologically fragile that any manipulation would kill them. Since I had met with no issues in working with two very high-strung species I felt he was missing a vast amount of information by relying only on fecal samples, camera traps and later thread trailers, but Daniel would have none of it. In short he was very opinionated and outspoken; as some would say, he was a difficult colleague, often dropping out of collaborations or discussions when it probably did not help him to do so. Daniel stuck to his guns, and I valued his unwillingness to take the easier but less compromising route.

Two instances where I backed him up as strongly as I could stand out as emblematic of the difficulties that stalked Daniel. He was enrolled in a Ph.D. program in Britain with his butaan project, and one of the core features of his work on their ecology involved scouring the forest floor for fecal samples, which he carefully collected and dried for later analysis. These contained mostly seeds and could be extremely informative. There were two large hessian sacks of many hundreds of bagged, labelled samples in his university office, and at some point while he was the field someone directed that they be discarded. The university stonewalled his complaints, and as far as I know there were no consequences to anyone but Daniel, who lost much of the database for his dissertation.

More recently Daniel had used a clever bit of knowledge to support the rumored existence of a third large frugivorous monitor in the hill forests of northern Luzon. Butaan are fond of *Pandanus* fruits, and as they travel they defecate piles of seeds that freely germinate. Clumped *Pandanus* are therefore a sign of monitors being present, especially where Daniel's surveys showed no mature trees toward the crests of hills. The presence of patches of small plants whose seeds had to be dispersed by some agent convinced him that an unknown species occupied the area. After considerable effort, Daniel was very pleased to share with me some photos from a Negrito hunter's hut showing a dismembered large yellow and black monitor lizard

quite unlike the allopatric Butaan and black *V. mabitang*. He had used his knowledge of butaan biology to assess the existence of an undescribed large monitor species. Whether independently or by some other means a field party from the University of Kansas learned of this, and succeeded in securing a specimen that became the holotype of *Varanus bittatawa.* Daniel was among the authors of this description, but he did not learn until the manuscript was in press that the other authors had gotten a specimen of *V. olivaceus* for comparative purposes by going to his study site, where some of the locals who had assisted him for years were convinced to catch his largest and longest-studied animal. Daniel quite properly blew his stack at this atrocity, and filed formal complaints with KU. The university basically dismissed the incident, although the butaan that had been illegally exported to KU and cataloged there went back to the Philippines immediately. The violation of trust by his Philippine assistants caused Daniel to abandon his entire field program in that nation, and most of his findings were never published.

Daniel eventually returned to his first love, studying the breeding biology of *Varanus exanthematicus* in west Africa. Savannah monitors are a staple of the exotic pet trade, and are "farmed" by locals who seek out gravid females in their nesting burrows and put them or their eggs in fenced compounds from which the hatchlings are gathered and exported. This is a somewhat unusual reproductive mode for monitor lizards (though apparently shared with the Australian *V. spenceri*) and Daniel's work was beginning to bear fruit when his health most unfortunately declined.

Daniel operated on a shoestring, with a fund based on his Mampam Conservation organization. His enthusiasm and energy could have accomplished a lot more if he had been able to attract funding in keeping with the importance of his projects. Utterly resourceful, I recall that Daniel arrived at the Third Varanid Conference in Bonn penniless, having essentially hitchhiked from Britain, and daily convinced some one of the toney ministry staffers walking past Museum Koenig to take him in for a meal and place to stay. I am sure they were well-rewarded, for Daniel had a great many stories and could be quite the raconteur.

I will close by saying that I am acutely aware of the detail and significance of Daniel's decades of work with butaan, and it is a real loss that he did not have time (or perhaps the heart, given his betrayal) to get this information published. Many of his findings challenge or alter conclusions reached by Walter Auffenberg's work on *V. olivaceus*, and few people anymore have Daniel's tenacity and dedication to undertake difficult field research projects.

A Visit to Daniel Bennett's Study Site in the Philippines Becomes a Life-changing Experience

Timothy N. W. Jackson
University of Melbourne, AU

"Fly to Manila, take the bus to Real port, get the ferry to Polillo, ask for Enteng's house." Daniel would later confide in me that a famous herpetologist, having been given those instructions, had declined to accept the invitation to visit the butaan (Gray's monitor – *Varanus olivaceus*) research project Daniel was conducting on Polillo Island, in the northern Philippines. "With instructions like those, you clearly didn't want me to come," was the complaint. In 2002, I received the same invitation and the same instructions – I followed them and had an adventure that became one of the defining experiences of my life. I was 17 at the time (I lied and told Daniel I was 18). After a daunting day and night in Manila, which included a visit to the black market to see juvenile butaans in wire cages waiting to be shipped off to wherever their fates took them, I eventually boarded the early morning bus for Real port. I'd intended to take the midnight bus but was told that it was too dangerous for a tourist travelling alone. During a phone call to my mother from the bus depot the connection was lost immediately after I'd relayed that titbit – it was the last she heard of me for 3 weeks (sorry mum).

Eventually, I made it safely to Polillo and Enteng's house and from there was taken, perched with my huge

Having made its contribution to the project, this wild butaan (*Varanus olivaceus*) is being released back into the rainforest. I took this photo with Daniel's SLR, having dropped my own into a stream the day before whilst trying to convince a vine snake to pose for a photo.

The author at 17 years of age, in the rainforest of Polillo Island - filthy, sweaty, happy. I am sitting with Mang Perio, one of several highly competent local guides that Daniel frequently employed to assist the project.

backpack on the back of a trail bike, to Mang Kuto's house on the edge of the forest. I'd arrived just in time for the afternoon's scat collecting mission. At the time, the methodology of the study was based on trapping butaans and attaching spools of fine thread to the base of their tails, as well as opportunistically collecting their faeces. On that first walk into the forest, we had the first of several wild butaan sightings I'd be blessed with during the trip. It was an encounter I'll never forget. We were strolling along, chatting about life, the universe and everything (a common theme for Daniel) when we spotted a Gray's monitor basking on the trunk of the tree. This was extraordinary luck for my first day as it was the first butaan the team had seen for a fortnight and sightings of them in the open were considered rare. Kuto quickly fashioned a noose and began to shimmy up a nearby tree, whilst Daniel and I, resuming our conversation, started to make to the base of the tree the lizard was basking in. We were recalled to reality by shouts of "Daniel! Daniel!!!" and looked up just in time to see the dark blur of a two-metre-long lizard falling through the air to land right at our feet. It had jumped from ten metres up. We were more stunned by its crash landing than it was and before we could react it had charged off into the forest at top speed.

Over the course of five weeks, I spent dozens of hours in the rainforest with Daniel following lines of thread and collecting scats full of the huge and indigestible seeds of the forest fruits the butaans feed upon, as well as fragments of snail shells and hermit crab claws. We installed the project's first camera traps and started using a new kind of trap made from a vertical PVC pipe, which replaced the noose traps that were previously favored. I had so many direct experiences of nature that I retain vibrant memories of. Perhaps the most enduring impacts of the trip, however, were made through the endlessly fascinating conversations I had with Daniel. He was a deep thinker and a deeply generous spirit. A lifetime of fieldwork in exotic locations had furnished him with a plethora of anecdotes, but he always used derived deeper lessons from the specific experiences he related. His stories were fables – not in the trivial sense of being "make believe"; in the sense that they had morals. Daniel thought a great deal about human nature and the fact that humans are *of* nature. He was a deeply committed conservationist, but he scorned the notion that the world would be "better off without humans" – a misguided idea that has become more and more prevalent as the conservationist impulse has become more widely shared. Certainly, the fact that more people care about the environment today than ever before (at least in modern western history), is something to be celebrated. But we must always be conscious of what it is we are celebrating – the uniqueness of a species which has the capacity to care deeply about the fate of other species. That's something Daniel believed in deeply and it's something I continue to believe. I mourn his passing but cherish the impact that he had on me and so many other young (and not so young) scientists and thinkers.

1989 meeting of the Oklahoma Herpetological Society, Oklahoma City Zoo. From left to right: Dave Blody, Daniel Bennett, Walter Auffenberg, Sean McKeown and David Grow.

A gathering of varanophiles in Germany, 1989. Top row (from left to right): Hans-Dieter Philippen, Hans-Georg Horn, Robert Sprackland, Klaus Wesiak, Daniel Bennett; bottom row (L-R): Dieter Fuchs, unk., Rainer Thissen.

A gathering of varanophiles. Isthmus of Kra, Thailand (Myanmar in background), 2015. From left to right: Mark Auliya, Samuel Sweet, Wendy Knight, Michael Cota, Robert Mendyk, Daniel Bennett, Clay Fischer, Uwe Krebs and Pratheep Meewattana.

Daniel posing with a road-killed *Varanus salvator macromaculatus* in Bangkok, Thailand, 2015.

Daniel Bennett - As I Knew Him

Valter Weijola
Biodiversity Unit, University of Turku, FI

It is fair to say that Daniel Bennett´s work greatly influenced the trajectory of my professional career. My fascination with monitor lizards began as a kid by seeing a monitor in a pet shop and getting the strong urge to keep one at home. In this case it was a Nile monitor, well over a meter long, and I was 12. It didn´t take very long to realize that this was a wild animal that had no business being kept in a cage, and within a few months I had it re-homed to someone hopefully better equipped to care for it. But, it had inspired a deeper interest and respect for these animals.

A couple of years later (late 90´s), while writing a school project I came upon Daniel´s webpage containing an online version of his "A Little Book of Monitor Lizards" together with assorted news about monitors. I recall reading a note about the then newly discovered *Varanus yuwonoi* and how it made me realize how little we still know about these creatures. It sowed the first seed to a future doing fieldwork in the Pacific region.

Although I had exchanged a couple of emails with Daniel in the early 2000´s, we started corresponding regularly in late 2007 or early 2008. At that time there was an IRC chat where Daniel Bennett, Sam Sweet, Dave Kirshner, Robert Mendyk, Michael Cota, and others would meet up almost daily to discuss monitors and related subjects. Sam Sweet was kind enough to invite me to this group and gain access to the experience of people who were doing fieldwork on monitors.

Daniel was always very supportive, helpful and enthusiastic over the idea that someone wanted to do fieldwork on Pacific monitors. He would go to great lengths writing recommendations for grant applications, share advice on field techniques, and really doing whatever he could to help.

I first met Daniel personally in 2015 at the monitor symposium in Bangkok, and the year after I visited him and his family in Glossop. At that time Daniel was breeding praying mantises, which he was selling on eBay (mostly to fund his fieldwork on monitors in Ghana as I recall), and much of the house was filled with cages hanging from the ceiling containing different life stages of these insects, as well as the flies they fed on. This was one example of Daniel's more-or-less successful, but very creative ways of fundraising. The praying mantis project would later end, in part because the things stopped reproducing, and in part because the vast amount of feeder flies being sacrificed each day was starting to weigh on his conscience.

During my stay in Glossop Daniel also took me along while practicing another new hobby of his – church-bell ringing. In addition to monitor lizards, both his personal and professional interests were diverse and often unusual. By the time he was 35, Daniel had already published several books on monitors, bats, frogs, and herpetological field techniques. He had also published a paper on the hippos of Bui National park.

In 2017, Daniel visited Turku to attend the defence of my PhD thesis and evening party. True to his frugal nature he had dressed up for the occasion wearing a rather antique suit he had found in his late father´s wardrobe. He jokingly pointed out that his daughter often said he looks like a homeless person - which wasn´t a completely inaccurate description. It was great fun and a privilege having Daniel as a guest, not least considering his role in unknowingly pointing me to the topic of the thesis almost 20 years earlier.

We met again the year after in Denmark where we started talking about the possibility of setting up a joint field study on *Varanus salvadorii* in Papua New Guinea. We continued planning and preparing this after Daniel received the cancer diagnosis only a few months later, hoping that he would see a full recovery. By late fall 2019, Daniel had responded well to the treatments and was in remission with a fairly small chance of relapse. We had received research permits, enough funds to cover the first field trip, and we were set to leave in a few months.

Tragically, the cancer did return and Daniel passed away in late February. During the time he was at the hospital, he continued to provide input and advice for the upcoming study. He never complained about his illness, but would always turn the discussion to things he was passionate about, or express how grateful he was towards his caretakers.

Daniel was an unusual scientist in the sense that he seemed to completely lack any interest in a normal academic career. Instead, his motivation and drive stemmed entirely from a genuine curiosity, interest and concern for the animals and people he was working with. I always found this admirable, refreshing and something to aspire for. As a close friend and colleague I will miss him dearly.

In Memory of Daniel

Uwe Krebs[1] & Michael Cota[2,3]

[1]*University Nuremberg-Erlangen, DE*
[2]*Natural History Museum, National Science Museum, TH*
[3]*Institute for Research and Development, Suan Sunandha Rajabhat University, TH*

At the age of 53, an insidious disease tore the life of one of our most experienced field researchers from us. The English zoologist Daniel Bennett was also zoologically active outside of herpetology, but we limit ourselves here to his great contribution to the research of monitor lizards.

The international family of monitor lizard researchers and enthusiasts has suffered a painful loss. In his work, Daniel Bennet combined great herpetological expertise with extensive experience in field research, especially on monitor lizards. Field research on monitor lizards is generally more difficult than with many other reptiles due to the low population density and shy and alert nature of monitor lizards. Research on monitor lizards in deserts or savannas already demands a lot: in addition to expertise in monitor lizards, patience, tenacity and a certain lack of comfort are essential. In rainforest biotopes, additional difficulties such as high humidity, very poor visibility and pronounced three-dimensionality of the monitor lizards' habitat are added. It is no wonder that monitor species of rainforests, such as *Varanus rudicollis*, *V. beccarii* or *V. salvadorii*, although in some cases known for more than 100 years, have so far remained unexplored in the wild, while savannah species and desert species have been better researched in the field.

Daniel Bennett was not afraid of these challenges. On the contrary. His monograph on the rainforest dweller *V. olivaceus* - known as a species since 1857 and only partially known in its way of life - is a milestone in monitor research. Daniel Bennett's research has always focused on the autecology of the species. In *V. olivaceus*, for example, he was able to demonstrate for the first time in the rainforest how they eat and also showed that this species spreads its essential nutritional base, oil-bearing tree fruits, via digestion, more than the plant itself can.

Together with Michael Cota, Sunchai Makchai and myself, Daniel wanted to research *V. rudicollis* in the rainforest of Thailand. We had planned the project together, but it had to be postponed for financial reasons due to an incorrect expert decision. With fundraising, Daniel therefore started a research project on *Varanus salvadorii*, which despite its size, also leads a hidden and unknown life in the rainforests of New Guinea. It is no exaggeration to say that Daniel Bennett was probably the most experienced rainforest specialist among the full-time herpetologists in monitor research and that his death creates a large gap.

The results of his field research and his herpetological knowledge are reflected in several books and numerous articles. The best known is probably his (1996) work "*A Little Book on Monitor Lizards*", which was published in a very modest design. It combines field research, systematics and physiology to answer questions about keeping and breeding monitor lizards in captivity. The title and layout of the book already showed Daniel Bennett's personality traits: modesty and restraint. Because the book was by no means "a little book," it was therefore translated into German very soon by Thomas Wilms, somewhat expanded in content, and appeared in significantly better quality in 1996 under the apt title "*Monitor Lizards of the World. The World of Monitor Lizards*."

Anyone who knew Daniel personally will painfully miss his fine English humor, his keen intellect, his knowledge and his (too) humble nature. He was

Isthmus of Kra, Thailand, 2015. Left to right: Mark Auliya, Daniel, Michael and Uwe.

completely indifferent to the outward appearance and some will remember what he said was the "very practical" snow-white oriental cloak in which he walked around at the monitor conference in Bangkok.

His passion for monitor lizards made him sacrifice greatly, also financially. Full-time monitor researchers, like other general zoologists, suffer from the fact that the zeitgeist in biology is heavily based on genetics and that funding is therefore more likely to flow there. During his illness, Daniel wrote to me (UK) that the Europe-wide search for a stem cell donor for him had been successful in Germany, and that he received the transplant with confidence, and I jokingly declared him to be 'Partially German'. Unfortunately, the stem cell takeover had not been successful; otherwise, Daniel Bennett would surely have given the global family of monitor lizard friends many more years of successful field research.

Daniel was among the first 10 or so herpetologists that I (MC) was ever in contact with and among the first who worked with monitor lizards that I was in contact with. I was first in contact with Daniel in the time a group of us chatted in a semi-private chatroom on the subject of monitor lizards, back in 2005. I was already very familiar with Daniel's work, and felt privileged back in those days to be in contact with Daniel and the others: Sam Sweet, Mark Bayless, Valter Weijola, Robert Mendyk, David Kirshner, Clay Fischer, Jeff Lemm, and Harold De Lisle. It was before some of us on that list made any contribution to science. When first in contact with Daniel, he was still going back and forth to the Philippines, which was a topic we could also chat about, since I spent a great deal of time in the Philippines in the mid-1980s. Since it was so close, I always hoped that he might stop by while he was on his way to or from the Philippines, but it was not until his field work in the Philippines was really at an end that he would come to Thailand. In the time leading up to defending his thesis to the time after he received his PhD, Daniel went through some very difficult personal times. After he received his PhD, he seemed to be at a very low point in his life. He contacted me about coming to meet me in Udon Thani, Thailand. When he arrived, he said he was not interested in going out to the national parks. Actually, he was very depressed and did not appear interested in doing much of anything. I tried everything to try to lift his spirits; of everything, Thai food seemed to lift his spirits a little bit, and he really enjoyed it. I guess what he needed most was just to get away, and for someone to hang out and talk with, after everything seemed to fall apart at home. I can only hope that he did enjoy his time in Thailand, because we met again, I believe the following year in Bangkok, along with a friend he was traveling with from the UK. Our last time together was in 2015, during the inaugural IUCN/SSC Monitor Lizard Specialist Group meeting, the Interdisciplinary World Conference on Monitor Lizards, and the post-conference trips afterwards. Although I did get a fair amount of time with Daniel, being one of the two hosts and organizers took up a great amount of time. It was a very great privilege to have had so much time with Daniel.

We will not forget him and will miss him greatly.

Remembering Daniel Bennett

Robert W. Mendyk

Department of Herpetology, Audubon Zoo, New Orleans, Louisiana, USA
Department of Herpetology, Smithsonian National Zoological Park, Washington, D.C., USA

Though we lived across the Atlantic from each other and met up infrequently, Daniel Bennett was a close friend, colleague and mentor who played an important part in my own progression as a student of monitor lizards and professional herpetologist.

I first became familiar with Daniel as I began my journey into the world of monitor lizards some 20 years ago, encountering some of the popular articles he had written for British herp magazines, his *Little Book of Monitor Lizards*, and his informative, but remarkably disheveled website, Mampam.com. This was also around the time when there were many heated discussions and debates over the natural history and captive husbandry of monitor lizards on various online message boards and forums. His online spats with American monitor breeder Frank Retes were amusing, yet surprising considering that the two of them had produced a very important paper together a few years earlier calling attention to the remarkably high reproductive potentials of monitor lizards in captivity, which up until then had never been documented before. Never afraid or hesitant to call out nonsense when he encountered it, Daniel regularly sought to correct misinformed claims about the natural history of monitor lizards and openly criticized poor husbandry advice published in popular pet trade books and magazine articles through his own popular articles and several superb books on monitor lizards. Years later, he would call attention to dubious report of captive breeding of the butaan (*Varanus olivaceus*) in the Philippines, as well as denounce the collection and export of one of his Polillo Island *V. olivaceus* study animals through dubious circumstances to a university in the USA in 2009.

I first began corresponding with Daniel via email in the mid-2000s, and then later through an mIRC chatroom that several varanid biologists and enthusiasts frequented. This was also around the time that Mark Bayless and I conceived the idea for *Biawak*, although Mark passed away before its official launch in 2007. Daniel was on board since day one as an associate editor of *Biawak*, and played a vital role in the journal's growth and continued success up until his passing – ever-supportive and always asking for more to take on and help out with. I am also appreciative of the fact that no matter how busy he was or where he was in the world at the time, Daniel was always willing to review drafts of my own manuscripts and offered insightful feedback that has improved my writing.

Regrettably, I never did get to visit him at his *V. olivaceus* field study site in the Philippines as I would have liked. But, in addition to visiting him in his hometown of Glossop a number of years ago, some of my fondest memories of Daniel were spent in the field with him and other friends and colleagues in Thailand in 2015. Following the inaugural meeting of the IUCN Monitor Lizard Specialist Group and Interdisciplinary World Conference on Monitor Lizards in Bangkok, several of us crammed into a van and traveled south to Kui Buri National Park and then on to Khao Sok National Park for some field herping. Whereas many of our colleagues decided to retire early for the night in Kui Buri NP, Daniel and I stayed out late searching the surrounding area for reptiles and amphibians, and had a

Daniel and Robert. Glossop, UK, 2014.

close encounter with a large herd of Asian elephants that wandered right through our base camp and proceeded to forage and bathe in a nearby watering hole. We stayed up watching them for several hours, all while our colleagues slept through the encounter. Later on in Khao Sok NP, Daniel and I broke away from the rest of the group one day to search for *V. rudicollis* using some of the field techniques he'd developed to track and study *V. olivaceus* in the Philippines. We weren't successful in finding any *V. rudicollis* that day, but did manage to turn up a record-haul of terrestrial leeches between the two of us.

One of the things I admired most about Daniel was his ability to carry out important fieldwork without the affiliation or financial backing of a larger conservation organization or academic institution (just about all was done through is own organization, Mampam Conservation), and his creativity and never-ending supply of innovative ideas for funding field projects. One idea that really stood out, but never materialized, sought to find a way for the adult film industry to generate proceeds for funding wildlife conservation projects. While living on Cyprus, he raised funds for his research by breeding and selling mantises, and he also generated funds through the sale of his iconic Mampam bat-logo t-shirts which he's often seen sporting in various photos over the years.

Daniel had a knack for storytelling, and I never tired of hearing some of the remarkable stories he shared about his travels and fieldwork in Africa, Russia and Turkmenistan, India, Malaysia and the Philippines. One of my favorite stories of his didn't involve field research at all, but rather his travels in the United States. Sometime in the early 1990s while conducting research for one of his books, he purchased a cheap round-trip bus ticket around the United States to visit many of the zoos with large monitor lizard collections at the time. I believe it was in New Orleans, my current city of residence, that he decided to walk several kilometers from the bus station to the zoo (Daniel was well known for traveling modestly), which took him right through some of the roughest neighborhoods in the city. As he was walking, a police car pulled up alongside of him. The officers wanted to check to see if he was ok and inquired why he would risk his safety by walking alone through this part of town. Daniel must have struck the right chord with the officers or perhaps they took pity upon him and feared he would not reach his destination safely, as they ended up giving him a free lift to the zoo in their patrol car.

Always complementing his stories and general demeanor were a great wit and sense of humor, and his style of dress was at times equally as amusing. The red Maasai-esque shawl that he wore while in the field in Kui Buri NP had several of us laughing hysterically. I don't think Daniel ever adjusted to my own sense of humor, however, such as the time I jokingly recommended a dark horror-fantasy movie when asked for a "good date movie" which apparently traumatized his partner, or the time I recommended a notorious chilopodologically-inspired horror film as a tasteful cinematic masterpiece that shouldn't be missed. Suffice it to say, it did not take long for Daniel to stop listening to my movie recommendations.

Ever-fashionable. Kui Buri NP, Thailand. 2015.

In late 2019, I had been acting as a liaison between Daniel and Valter Weijola and the Association of Zoos and Aquariums' (AZA) Lizard Advisory Group (LAG), to help them obtain funding support for a planned field study on *V. salvadorii* in Papua New Guinea. The LAG had planned to fly Daniel out to the USA in May of 2020 to give a talk on the project at its annual meeting of zoo herpetologists, but his declining health caused him to cancel earlier that winter. I was then looking forward to visiting him again in March of 2020 when I would be over in the UK attending a conference, but the rapid escalation of the COVID-19 pandemic in late February caused me to cancel my travel plans. I continued to correspond with Daniel and last spoke with him on February 24 while he was in the hospital being treated for sepsis; he died less than 24 hours later.

Biologists can often be dull, boring and phlegmatic – sometimes sacrificing personality for their passion and drive. Daniel was unlike most other biologists, and was one of the most charismatic and likeable characters I've ever known. Though he died early at the age of 53, he

lived a more complete and remarkable life than most people will ever experience. He was an important mentor to many burgeoning field biologists and conservationists in Africa and the Philippines, and his impacts on the study, conservation and keeping of monitor lizards are profound. His passing represents a huge loss to the international monitor lizard, herpetological, and wildlife conservation communities. On a personal level as a friend, colleague and mentor, he will truly be missed.

Interdisciplinary World Conference on Monitor Lizards, Bangkok, 2015

ARTICLES

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Adverse Reactions to the Tawny Crazy Ant (*Nylanderia fulva*) by Komodo Dragons (*Varanus komodoensis*) at the Jacksonville Zoo and Gardens

Emily Fyfe

Department of Herpetology
Jacksonville Zoo and Gardens
370 Zoo Parkway
Jacksonville, FL 32218, USA
E-mail: fyfee@jacksonvillezoo.org

Abstract-The tawny crazy ant (*Nylanderia fulva*) is an invasive species that has been introduced to the United States and is now most prevalent in the state of Florida. Known for their large colony sizes and the damaging effects they can have on agriculture, electrical equipment and wildlife, *N. fulva* has become a pest for humans and other animals in many different environments including zoological parks. In this article, some interesting interactions between *N. fulva* and Komodo dragons (*Varanus komodoensis*) housed at the Jacksonville Zoo and Gardens are explored, specifically the behavioral response of *V. komodoensis* to the ant's formic acid-spraying mode of defense.

Introduction

Creating complex habitats has become a major focus of zoological parks in the past decade to promote animal welfare and wellness (Nolen, 2002). In the southeastern United States, a milder climate allows zoos to build a variety of outdoor enclosures that promote natural behaviors in tropical and subtropical species. However, open, outdoor habitats also come with their own set of unique challenges. For example, the Southeastern U.S. is home to many native and introduced species that pose potential threats to collection animals in a zoological setting. At the Jacksonville Zoo and Gardens in northeastern Florida, predators such as raccoons, otters, foxes, rats, snapping turtles, snakes, herons, and vultures have been documented wounding, fatally injuring or predating collection animals. Disease transmission from raccoons, feral cats, and rodents is another potential hazard for some collection animals. Additionally, mitigating invertebrate pest species such as cockroaches and ants in and surrounding animals' enclosures is an ongoing and ever-evolving challenge.

The tawny crazy ant (*Nylanderia fulva)* is an introduced, invasive South American species that has persisted in the southeastern United States for several decades (Trager, 1984) and now occurs in 27 counties in the state of Florida (Oi *et al*., 2016). Due to its extremely large colony sizes, usually with multiple queens and a footprint that can span entire neighborhoods, this insect can be very difficult to control (Sharma *et al*., 2014). Although *N. fulva* lacks a stinger, it is a formidable opponent to other insects such as the fire ant (*Solenopsis invicta*) by using its own venom, which is formic acid-based (Touchard *et al*., 2016), to detoxify itself after sustaining a sting from *S. invicta* (LeBrun *et al*., 2014). Instead of being injected through a stinger, the formic acid is sprayed and then spread over its body for defense (LeBrun *et al*., 2014).

The Jacksonville Zoo and Gardens is currently home to a large *N. fulva* population. Although they are

found throughout the zoo's 100+ acres (ca. 40 ha), their highest concentration occurs at the southernmost end of the park, particularly in the Asia section, which includes exhibits for Komodo dragons (*Varanus komodoensis*) and various bird and mammal species including, but not limited to rhinoceros hornbills (*Buceros rhinoceros)*, Babirusa (*Babyrousa celebensis*) and Sumatran tigers (*Panthera tigris sumatrae*).

While physically harmless to humans, *N. fulva* can be a pest to zoo guests and staff; when standing still in areas of high concentration, the ants will begin to crawl up and onto peoples' shoes and legs. *Nylanderia fulva* have also shorted out various types of electrical equipment on zoo grounds including fire alarm beacons and digital photo booths. Modifications have been made to how keepers present food items to certain animals, so that ants do not swarm and cover food before it can be consumed. Although previously just a persistent pest to humans at the zoo, here I describe observations that suggest that *N. fulva* may be causing adverse reactions and behavioral changes in a group of *V. komodoensis*.

Observations and Results

The Komodo dragon exhibit complex at the Jacksonville Zoo and Gardens is comprised of two habitats on public display including an indoor and outdoor exhibit (Fig. 1), and several off-exhibit areas including an outdoor holding yard and three indoor holding stalls. All habitats and holding areas feature a sandy soil substrate, various natural furnishings including dead fall tree trunks and live plants, as well as large plastic corrugated tubing for refuge in off-exhibit areas. The complex currently houses three *V. komodoensis* including a 17-year-old male (M1), a 9-year-old male (M2), and a 7-year-old female (F1). Animals are housed individually and rotated through these areas on a daily basis, with some exceptions that are discussed below.

Nylanderia fulva colonies are known to have explosive population booms, followed by an eventual reduction in numbers and disappearances from areas altogether (Sharma *et al*., 2014). In the summer of 2018, the *N. fulva* colony near the *V. komodoensis* exhibit complex seemed to be more prominent than in years' past. As is routine during scheduled public feedings for the *V. komodoensis*, the dragons are shifted off-exhibit while their food is scattered on the ground throughout their habitat for them to find, providing natural foraging opportunities while also showcasing their acute sense of smell to zoo guests.

In early July 2018, M2 was observed approaching a food item (a chick) that was placed along the edge of the outdoor exhibit's pool closest to the viewing window (Fig. 2), but when opening his mouth to pick up the item, he became hesitant, drew his head back, and held his mouth open in a gagging-like reaction (Fig. 3). After several minutes, he eventually picked up the item and consumed it without issue. As the summer progressed, herpetology staff noticed other adverse and/or distressed behaviors in this male as well as in M1 once feedings had commenced. After walking and tongue-flicking through the narrow strip of land between the interior exhibit viewing window and the edge of the exhibit pool (Fig. 2.), both dragons would suddenly begin to display signs of agitation (tail-curling) followed by a

Fig. 1. View of outdoor *Varanus komodoensis* exhibit at the Jacksonville Zoo and Gardens.

Fig. 2. Location of exhibit where negative interactions were observed.

Fig. 3. Gagging response observed in *V. komodoensis* after tongue-flicking a prey item that had been swarmed with *Nylanderia fulva*.

burst of full-speed sprinting around the exhibit (Fig. 4). Episodes lasted from a few seconds to several minutes in duration. Staff also observed a general avoidance of this area, especially by M1. Although he would initially tongue-flick and approach the area, he would eventually back up and turn around.

Fig. 4. *Varanus komodoensis* sprinting across exhibit in response to negative stimuli.

Herpetology staff noticed that the area in which the *V. komodoensis* were avoiding had substantial clusters and trails of *N. fulva* leading through it (Fig. 5.). This trail also led directly out into the guest area, where ants are regularly observed in large numbers on the ground directly below the exhibit viewing windows.

Following a winter dormancy, we began to see increased activity from *N. fulva* as daily temperatures increased in the spring of 2019, and in early April we observed a minor adverse reaction in M1 during a feeding event. That summer proved to be much milder than the previous year, with ants visibly lower in numbers on both the exhibit and guest sides of the Komodo habitat, although mild ant reactions were still observed during and after feedings. It is unclear what has caused the reduced numbers; however, observations of *N. fulva* in other areas of the zoo have increased.

Discussion

Nylanderia fulva are encountered in all exhibits and holding areas of the *V. komodoensis* building, but adverse reactions have only been observed in the outdoor exhibit. In the presence of a food source, *N. fulva* are naturally attracted to, and swarm the area. It is hypothesized that when a large disturbance such as a *V. komodoensis* walks through an area with a food item that has attracted *N. fulva* or an area where a food item had previously been located, the ants defensively release their formic acid into the air. The formic acid is then picked up by *V. komodoensis* through olfaction, subsequently causing discomfort and adverse reactions.

Fig. 5. Abundance of *N. fulva* near the site of the observed interactions, leading in and out of the *V. komodoensis* exhibit

Since the concentration of ants in this area is greatest, the formic acid released when the ants are disturbed may be more abundant and concentrated.

Historically, our female *V. komodoensis*, who due to her smaller size has only been given limited supervised access to the open-top outdoor exhibit, had not exhibited any adverse reactions. However, with her increase in body size, she has recently been given more frequent access to this area and for longer periods of time. In September 2019 and March 2020, mild ant reactions were observed in F1 in the form of tail curling and slight mouth-gaping after tongue-flicking. In order to confirm that these adverse reactions in *V. komodoensis* are associated with *N. fulva*, we are hoping to increase our observations during non-feeding times and perhaps even initiate a study to determine the potential concentration of formic acid and *N. fulva* in the immediate area.

The Jacksonville Zoo and Gardens' herpetology staff and pest-control specialist have experimented with several chemical and natural management techniques to control *N. fulva.* In guest and non-animal areas we have tried InVict Blitz™ ant granules, Talstar® P professional insecticide, Suspend® SC Insecticide, Eco PCO® D-X Dust, MaxForce® Ant Bait gel, and Advion® Ant Bait Gel, whereas in animal habitats and holding areas, we have tried hot soapy water, cinnamon powder, cinnamon water, lemon juice, vinegar, baby powder and dish soap. Although a decrease of ants is typically seen after administering these treatments, within a few days the ants have usually returned to their normal numbers. Continued integrated pest management will be implemented.

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A Note on Longevity in the Quince Monitor in a European Zoo and Potential Needs for Maintaining a Sustainable Population Under Human Care

Anna Rauhaus[1,2] & Thomas Ziegler[1,3]

[1]*Cologne Zoo*
Riehler Str. 173
50735 Cologne, Germany

[2]Email: aquarium@koelnerzoo.de

[3]Email: ziegler@koelnerzoo.de

Abstract – We report on a large male Quince Monitor (*Varanus melinus*) that had been held at Cologne Zoo for 12 years and reached 20 years in age. We further describe the *V. melinus* group held at Cologne Zoo, which includes another very large male that hatched at the zoo in 2009 and measures 152 cm in total length. The importance of long-term collection planning is discussed as being crucial for managing monitor lizard species in zoological parks. According to the Zoological Information Management System, the current European zoo population of *V. melinus* consists of 14.5.9 individuals (male.female.unsexed) that are held in nine institutions; however, five institutions keep single animals and only three zoos currently keep females. To sustainably manage the ex situ population of *V. melinus* in the future, it will be important to develop a network of institutions with sufficient keeping capacities. As a first step, a Mon-P (monitoring program) for the species was established within the European Association of Zoos and Aquaria (EAZA) four years ago. Centrally coordinated and regulated cooperation with private keepers, as already successfully practiced in Europe by "Citizen Conservation" for amphibians, could be an additional promising approach to maximize available space and combine forces. *Varanus melinus* is a comparatively easy to keep member of the *V. indicus* complex with usually calm behavior and a high exhibition value.

On 24 December 2019, a large male Quince Monitor (*Varanus melinus*) died at Cologne Zoo. This individual had been kept in Cologne Zoo`s terrarium section since January 2007 and was hatched in 1999 according to its previous owner. When we measured the male in 2010, it was one of the largest known individuals at that time with a snout-vent length (SVL) of 51 cm and a total length (TL) of 118 cm, together with our former breeding male which had a TL of 128 cm (see Ziegler *et al*., 2010). Unfortunately, this male did not produce offspring at Cologne Zoo; the female it was paired with laid eggs at least twice but without signs of fertility, and died in October 2008 from bacterial sepsis. Nevertheless, with its impressive body size and bright yellow color pattern it served as a valuable ambassador for its species right at the entrance to the zoo's terrarium section, where it was housed in a large exhibit (300 x 180 x 250 cm [l x w x h]) for several years. Here, the *V. melinus* was the starting point for many guided tours that highlighted recently discovered monitor lizard diversity and the threats and conservation needs of island endemic monitor species, while our breeding pair and offspring were kept behind the scenes.

In 2015, the male was moved behind the scenes as it began to show signs of aging (*i.e.*, decreased activity and impaired vision). Although we assume that it was nearly blind during the last few years, it never had problems navigating its enclosure besides sometimes needing several attempts to find moving prey items such as locusts.

Fig. 1. *Varanus melinus* male which reached an age of 20 years and died in December 2019 at Cologne Zoo. Photographed by **Thomas Ziegler**.

In August 2019, it underwent surgical treatment due to a small wound on the back. Thereafter, a bacterial skin infection developed on the head and back, which was treated with antibiotics. In December, the animal's general condition suddenly worsened and it died rather unexpectedly within a few days. The cause of death remains unclear, as necropsy revealed no signs of organ damage or abnormalities except for blood congestion in the liver; the skin was in a state of healing. Sepsis initially caused by the bacterial infection seems to be the most likely underlying cause of death. At the time of its death, at the age of 20 years, the male was still in a good nutritional condition and had a weight of 3,795 g, with the abdominal fat bodies weighing 445 g. SVL was 53.5 cm and TL was 129 cm.

Our current *V. melinus* stock at Cologne Zoo consists of one very large (152 cm TL) male that hatched at the zoo in 2009 which is currently kept on public display, and 2.2 individuals maintained behind the scenes, of which 1.1 were acquired from two different confiscations and 1.1 are captive bred offspring from a private collection. As our breeding female, which produced several offspring, unfortunately died in 2011, we decided to purchase four captive-bred juveniles in 2014. Of these four individuals, only one turned out to be female. Being around six years old, our two females are approaching reproductive size and we hope to continue breeding the species in the near future.

The case of *V. melinus* at Cologne Zoo shows that long-term collection planning is crucial for managing monitor lizard species in zoological parks, as it can take several years until individuals can be sexed and reach sexual maturity. Additionally, as shown by our male, individuals can reach old ages. Although the species has been successfully reproduced several times in zoos (*e.g.*, in Prague Zoo), the zoo population remains unstable, in part due to the limited number of institutions keeping the species and a general lack of space in zoos. On the one hand, there is limited availability, particularly of females; on the other hand as we have experienced, it can be difficult to place surplus individuals (male or unsexed juvenile) in zoos. The limited availability of adult breeding females may lead zoos to acquire other

Figs. 2 & 3. Large *V. melinus* male on exhibit in the public facility at Cologe Zoo's terrarium section. This individual was bred at Cologne Zoo in 2009 and measures 152 cm in total length. Photographed by **Anna Rauhaus**.

species. Thus, some individuals might disperse outside of the zoo community's reach, as there are faster ways to transfer surplus individuals to private collections. According to the Zoological Information Management System (ZIMS, 2020), the current European zoo population of *V. melinus* consists of 14.5.9 individuals (male.female.unsexed) that are held in nine institutions; however, five institutions keep single animals and only three zoos currently keep females. The loss of just one of the few reproductively active females can set back breeding efforts for the species several years, as was the case at Cologne Zoo, where we first had to raise females from juveniles in order to start over when our breeding female died. Prague Zoo recently experienced breeding success with its own offspring, but also reported to have surplus males (P. Velensky, pers. comm.).

To sustainably manage the ex situ *V. melinus* population in the future, it will be important to develop a network of institutions with sufficient keeping capacities. As a first step, a Mon-P (monitoring program) for the species was established within the European Association of Zoos and Aquaria (EAZA) four years ago. Besides breeding, which requires multiple spacious facilities for males and females, keeping single males for exhibition purposes could be an important contribution to maintaining the population and would be a feasible option for zoological institutions that can only provide one enclosure.

Perhaps centrally coordinated and regulated cooperation with private keepers, as already successfully practiced in Europe by "Citizen Conservation" for amphibians (https://citizen-conservation.org/?lang=en), could be an additional promising approach to maximize available space and combine forces. *Varanus melinus* seems to be bred quite regularly in private hands in Europe; however, data on wild population numbers are still lacking and it is assumed that there has been a severe decline due to over collecting for the live reptile trade (Koch *et al*. 2013). Increasing the number of captive-bred individuals and building up a stable captive breeding stock could also help to take pressure off the wild population. Of course, *V. melinus* is just one of several geographically restricted monitor species which are underrepresented in zoos (Ziegler *et al*. 2016), but as there is already a considerable number of individuals kept in Europe both in zoos and private collections it would certainly make sense to continue efforts for this species - especially since *V. melinus* is a comparatively easy to keep member of the *V. indicus* complex with usually calm behavior and a high exhibition value.

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The Trade of Live Monitor Lizards (Varanidae) in the Philippines

Emerson Y. Sy[1*] & Antonio N. Lorenzo II[1,2]

[1]*TRAFFIC, Southeast Asia Regional Office*
Wisma Amfirst Tower 1, Suite 12A-1, Jalan Stadium SS7/15, 47301 Kelana Jaya, Petaling Jaya
Selangor, Malaysia

[2]*Department of Biological Sciences, College of Science, University of Santo Tomas*
España Boulevard, Manila, Philippines

*E-mail: emersonsy@gmail.com

Abstract - Monitor lizards (genus *Varanus*) are utilized for their skin, meat and parts, or as pets. Eleven endemic species are currently recognized in the Philippines, including the only three known frugivorous monitor species in the world. We conducted a 30-month online study and reviewed 30 years (1989–2018) of CITES trade data to determine the dynamics of the live monitor lizard trade in the Philippines. A total of 541 individuals representing 13 species were documented for sale from September 2017 to February 2020. *Varanus marmoratus* (n = 266) was the most commonly-traded and least expensive species ($8–29 USD), while CITES Appendix-I listed *V. komodoensis* (n = 1) was the most expensive at $16,667 USD. CITES trade data showed that the Philippines imported 671 live individuals of 20 species from at least 20 countries and exported 144 live individuals of nine species during the period of 1989–2018. Exported non-native species did not have a legal source based on CITES trade data, while some of the endemic species were suspected to be wild-caught and fraudulently declared as captive bred to obtain CITES export permits. Based on these findings, recommendations to authorities include (1) close monitoring and taking action on illegal wildlife traders offering animals for sale online, (2) putting in place a more robust regulatory and verification process to prevent wildlife laundering in the country, and (3) enhancing vigilance to intercept the illegal import and export of wildlife.

Introduction

Monitor lizards (Varanidae) are a group of reptiles that occur in Old World tropics and exhibit diversity in morphology, behavior, and ecology. The adult body sizes and weights of monitor lizards range from a total length (TL) of 23 cm and body mass of 16 g for the smallest species, *Varanus sparnus* (Doughty *et al*., 2014), to 183 cm TL (average size based on 110 specimens) and 54 kg for the largest, *V. komodoensis* (Auffenberg, 1981). They occur in a wide range of habitats including deserts, shrublands, tropical forests, and even agricultural areas (Rajpoot *et al*., 2016). Currently, 81 species of *Varanus* Merrem, 1820, are recognized (Uetz *et al*., 2020).

Monitor lizards are traded for different purposes: their skin for the leather industry (Shine *et al*., 1996; Koch *et al*., 2013; Crook & Musing, 2016), meat for human consumption (Klemens & Thorbjarnason, 1995; Scheffers *et al*., 2012; Koch *et al*., 2013), live specimens for household pets (Sy, 2015; Janssen, 2018), and their body parts (hemipenes) and by-products (dried flesh, body oil) for traditional folk medicine (da Nòbrega Alves *et al*., 2008; Rajpoot *et al.*, 2016; Bhattacharya & Koch, 2018). These usages fuel both the legal and illegal trade (Nijman & Shepherd, 2009; Scheffers *et al*., 2019). Some of the most sought after monitor lizards for the pet trade are from Southeast Asia, particularly Indonesia and the Philippines where several new species had been described in recent years (Koch *et al*., 2010; Weijola & Sweet, 2010; Welton *et al*., 2014).

As currently understood, the Philippines harbors 11 endemic *Varanus* species comprising the only three known frugivorous monitor lizards in the world (*V. bitatawa*, *V. mabitang*, and *V. olivaceus*) (Gaulke & Curio,

2001; Welton *et al*., 2010) and eight members of the *V. salvator* complex (*V. bangonorum*, *V. cumingi*, *V. dalubhasa*, *V. marmoratus*, *V. nuchalis*, *V. palawanensis*, *V. rasmusseni*, and *V. samarensis*) (Koch *et al*., 2010; Welton *et al*., 2014; Auliya & Koch, 2020).

In the Philippines, all wildlife, including non-native species, is protected through the Wildlife Resources Conservation and Protection Act of 2001, or the Republic Act No. 9147. This law prohibits the collection, possession, transportation, and trade of wildlife without permits from the Department of Environment and Natural Resources (DENR). The Philippines is also a signatory of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which requires import or export permits for international wildlife trade in CITES-listed species.

The Philippine wildlife authority has not issued permits to collect and trade native wild reptiles for commercial purposes since 2001. However, previous physical and online trade studies (Welton *et al*., 2013; Canlas *et al*., 2017; Sy, 2018) have documented eight endemic monitor lizards traded illegally in the Philippines, including the most recently described frugivorous *V. bitatawa* (Welton *et al*., 2010; Sy, 2012). Some of these endemic monitor lizards have been successfully smuggled or laundered through falsified paperwork and exported legally to Europe, Japan, and the US (Auliya *et al*., 2016; Sy, 2018; Sy, in prep.; Ziegler & Vences, in press). The illegal wildlife trade in the Philippines has shifted from a physical to online presence in recent years particularly on Facebook, a popular social networking site (Canlas *et al*., 2017; Sy, 2018). This market shift is not unique to the Philippines; in fact, it has also been observed in several other Asian countries (Chng & Bouhuys, 2015; Krishnasamy & Stoner, 2016; Nguyen & Willemsen, 2016; Phassaraudomsak & Krishnasamy, 2018).

Empirically, the trade dynamics of live monitor lizards in the Philippines are poorly understood due to limited studies. This study was undertaken to determine the species, magnitude, trends, and value of monitor lizards in the Philippine pet trade.

Methods

We conducted a 30-month online survey, from September 2017 to February 2020, by documenting reptile posts in 20 pre-selected Philippine Facebook groups that specialized in the trade of live reptiles. The groups were selected based on active wildlife trading activities six months prior to the start of this study. All posts offering to sell or trade reptiles were recorded, with those offering monitor lizards for sale then extracted and analyzed. Duplicate posts offering the same monitor lizard individuals were removed from the dataset to avoid inflating the total number of available animals within the study period. Posts that did not indicate available quantity or provide photos were counted as a minimum of one individual each. In instances where a trader was known to use multiple accounts to post, those accounts were combined to form one account for analysis. Relevant information such as the trader's Facebook account name and location, price, source, and life stage (*i.e.* hatchling, juvenile, adult) of the animal were documented as well.

To determine possible legal sources of non-native monitor lizards offered for sale in the Philippines, we retrieved import data from the CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora) Trade Database from 1989–2018 (the latest year with available data in the database) and used exporter-reported quantities for analysis. We also analyzed importer-reported (Philippines) data to determine differences in reported species and quantities.

We calculated the market value of monitor lizards based on the advertised prices. Posts that did not indicate prices were assigned the lowest known prices of the specific species within the study period. For the species advertised with no recorded price during the study period, they were assigned the lowest known retail price in the Philippine market. The exchange rate of the Philippine Peso (PHP) to United States Dollar (USD) fluctuated between PHP 49.81 and PHP 54.27 to $1 USD during the study period according to www.freecurrencyrates.com. For consistency, the exchange rate of PHP 51 = $1 USD (29 February 2020) was used in this study.

Results

A total of 359 monitor lizard posts by 187 unique accounts involving 13 species and 541 individual animals were documented during the 30-month online survey of 20 Facebook groups (Table 1). The quantity of monitor lizards per individual post ranged from 1–40 individuals. Trade activities were most active in the second quarter (April–June) with the influx of wild-caught hatchlings and juveniles, and were least active in the fourth quarter of the year (October–December). Monitor lizards offered for sale were mostly hatchlings/juveniles (88%; n = 474), and 55 individuals (10%) were adults. The remaining 12 individuals (2%) were of unknown life stages since traders did not include photos with their posts.

The price was indicated on 214 out of the 359 posts

Table 1. Live monitor lizards offered for sale in 20 Facebook groups. IUCN Red List categories: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE).

English Name	Species name	Qty	CITES	IUCN	Status	Distribution
Marbled Water Monitor	*Varanus marmoratus*	226	II	LC	endemic	Philippines
Savannah Monitor	*Varanus exanthematicus*	150	II	LC	non-native	Africa
Cuming's Water Monitor	*Varanus cumingi*	66	II	LC	endemic	Philippines
Green Tree Monitor	*Varanus prasinus*	40	II	LC	non-native	New Guinea, Australia
White-headed Water Monitor	*Varanus nuchalis*	28	II	NT	endemic	Philippines
Samar Water Monitor	*Varanus samarensis*	12	II	NE	endemic	Philippines
Northern Philippine Forest Monitor	*Varanus olivaceus*	10	II	VU	endemic	Philippines
White-throated Monitor	*Varanus albigularis*	2	II	NE	non-native	Africa
Crocodile Monitor	*Varanus salvadorii*	2	II	LC	non-native	New Guinea
Komodo Dragon	*Varanus komodoensis*	1	I	VU	non-native	Indonesia
Nile Monitor	*Varanus niloticus*	1	II	NE	non-native	Africa
Lace Monitor	*Varanus varius*	1	II	LC	non-native	Australia
Common Water Monitor	*Varanus salvator*	2	II	LC	non-native	South and Southeast Asia
	TOTAL	**541**				

(60%) during the 30-month period. Prices were indicated in 73% of the posts in the beginning of the study, but gradually declined to 35% at the end of the study. This may be due to Facebook's policy of rejecting posts of wildlife images with prices. To circumvent this stricter policy on live animal trade on the platform, traders used code words (*e.g.*, intentionally misspelling price in words) or asked potential buyers to inquire by private message. Posts offering *V. salvadorii*, *V. niloticus*, and *V. varius* did not have any price data. The total market value of offered monitor lizards was PHP 3,489,000 ($68,412 USD).

The Philippine endemic marbled water monitor *V. marmoratus* (n = 226) was the only species consistently available throughout the study period and the least expensive. This species is also commonly seen in both forested and disturbed areas in the Philippines. The typical asking price for a hatchling or juvenile ranged from PHP 700–1,500 ($12–29 USD), but could go as low as PHP 400 ($8 USD) per individual. Among the non-native monitors, the savannah monitor *V. exanthematicus* (n = 150), one of the most traded monitors in the world, was available in 22 out of 30 months. We also documented one post made by a convicted wildlife trafficker in the Philippines that offered a CITES Appendix I-listed Komodo dragon *V. komodoensis* for PHP 850,000 ($16,667 USD) in August 2018 (Fig. 1). However, it was uncertain if the animal had already been smuggled into the Philippines at the time the offer was made.

Online Traders

Out of the 187 unique accounts, at least 11 traders had been observed to use at least two Facebook accounts

Fig. 1. Screen-captured photo showing a CITES Appendix I-listed Komodo dragon *Varanus komodoensis* for sale in the Philippines in 2018.

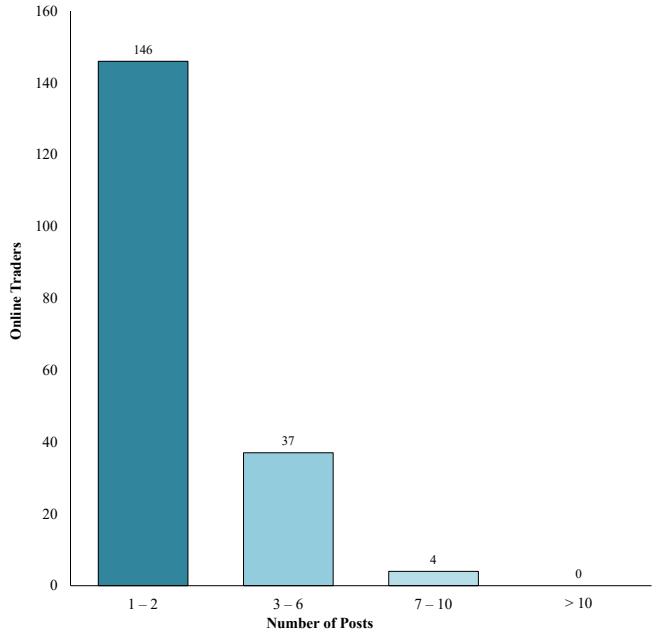

Fig. 2. Number of posts by online traders.

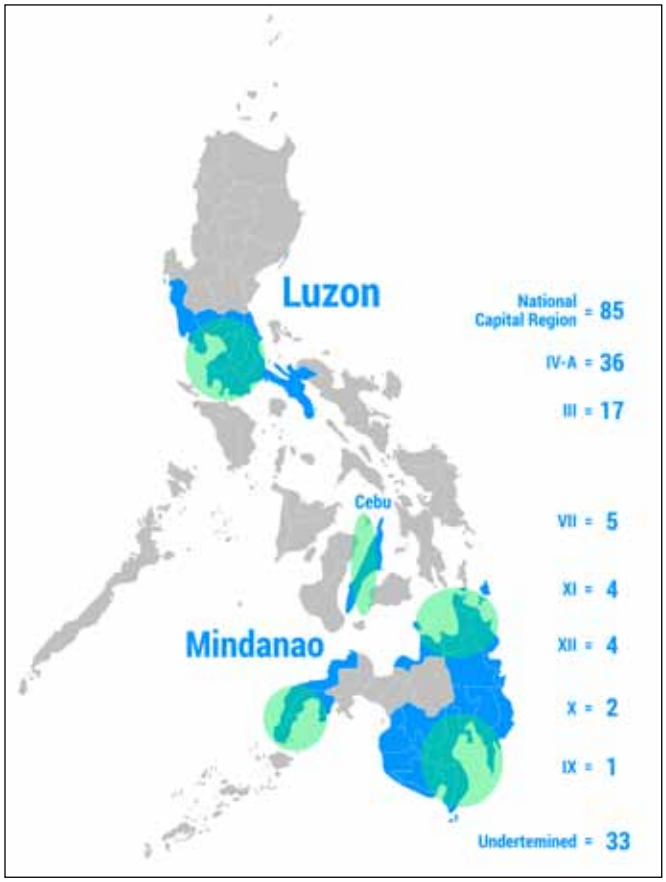

Fig. 3. Location of online traders by region.

to engage in online wildlife trading activities. More than half (57%) of the traders made only one post that offered a single animal each (Fig. 2). However, a few traders in this group made several posts on their own Facebook wall. The 10 most active traders made 51 posts (10%), but accounted for 177 out of 529 individual monitor lizards (33%) in the trade.

The majority of the traders (74%: n = 138), based on location information declared on the accounts, were located on Luzon Island in the National Capital Region (NCR), Region IV-A, and Region III (Fig. 3). Eleven and five traders were based on Mindanao and Cebu, respectively. The remaining 33 traders did not declare their location (Fig. 3).

CITES Trade Data

From 1989 to 2018, there were 47 import records of live monitor lizard into the Philippines, representing 20 species and 671 animals (Table 2). Imported quantities ranged from 0–247 individuals and averaged 22.4 individuals per year between 1989 and 2018. During the 30-year period, records of monitor lizard imports were only reported for 16 years (Fig. 4). However, the year 2016 documented a significant increase in both species (n = 12) and quantity (n = 247) of imported monitor lizards. *Varanus exanthematicus* accounted for 73% (n = 180) of imported monitor lizards in 2016. The vast majority (91%; n = 609 individuals) were declared for commercial trade (purpose code "T") while 60 individuals (8%) were undeclared. Nearly half of imported monitor lizards (48%; n = 319) were sourced from the wild (source code "W") and 220 individuals (33%) were ranched (source code "R") (Table 2). CITES defines ranched specimens as "animals reared in a controlled environment, taken as eggs or juveniles from the wild, where they would otherwise have had a very low probability of surviving to adulthood." The most frequently reported source country was Indonesia, which exported 281 (42%) monitor lizard individuals to the Philippines.

Based on export records in the CITES Trade Database, the Philippines exported a total of 18,863 live monitor lizards (importer-reported quantity) between 1989 and 2018. The quantity was largely due to an export record of 18,719 live Mindanao water monitor *V. cumingi* to Japan in 1989. However, it is very likely that the trade was for skins instead of live specimens since the Philippines was a major source of the commodity during that period. We therefore omitted this record

Table 2. Exporter-reported quantity to the Philippines between 1989 and 2018. Source code C = animals bred in captivity, W = specimens taken from the wild, F = animals born in captivity that do not fulfil the definition of bred in captivity, and R = ranched specimens; Purpose code T = commercial, P = personal, and Q = circus or travelling exhibition.

Species	Total	Source					Purpose			
		C	W	F	R	Undeclared	T	P	Q	Undeclared
Varanus acanthurus	17	17	-	-	-	-	17	-	-	-
Varanus albigularis	3	-	3	-	-	-	3	-	-	-
Varanus beccarii	7	-	-	7	-	-	7	-	-	-
Varanus doreanus	21	-	21	-	-	-	21	-	-	-
Varanus dumerilii	21	-	1	-	-	20	1	-	-	20
Varanus exanthematicus	363	-	142	1	220	-	362	1	-	-
Varanus indicus	5	5	-	-	-	-	5	-	-	-
Varanus jobiensis	14	-	14	-	-	-	14	-	-	-
Varanus macraei	7	-	-	7	-	-	7	-	-	-
Varanus melinus	5	-	-	5	-	-	5	-	-	-
Varanus niloticus	2	-	2	-	-	-	2	-	-	-
Varanus panoptes	3	-	3	-	-	-	3	-	-	-
Varanus prasinus	7	7	-	-	-	-	7	-	-	-
Varanus reisingeri	5	-	-	5	-	-	5	-	-	-
Varanus rudicollis	3	-	3	-	-	-	3	-	-	-
Varanus salvadorii	26	-	26	-	-	-	26	-	-	-
Varanus salvator	138	-	98	-	-	40	97	-	1	40
Varanus similis	6	-	6	-	-	-	6	-	-	-
Varanus timorensis	13	13	-	-	-	-	13	-	-	-
Varanus yuwonoi	5	-	-	5	-	-	5	-	-	

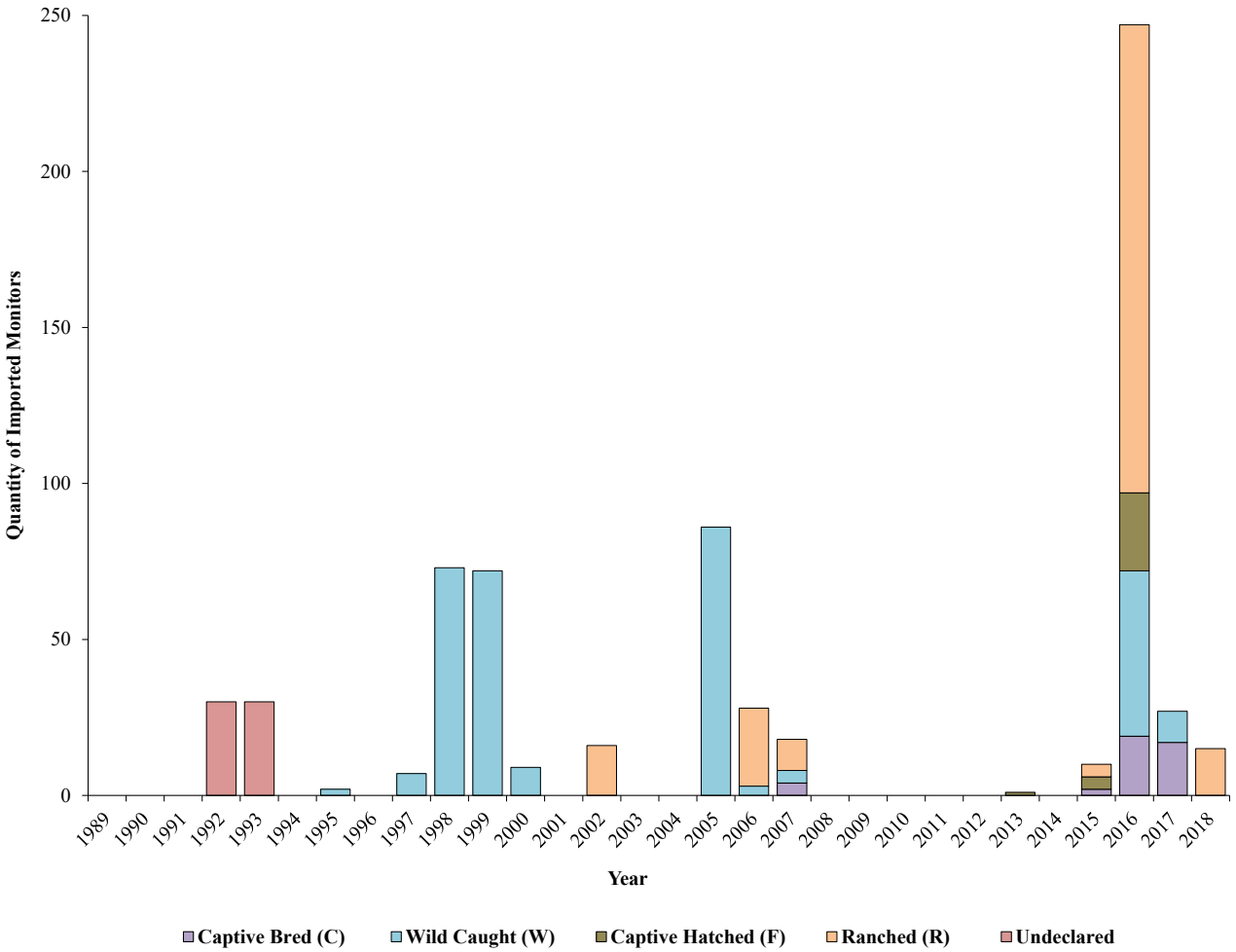

Fig. 4. Quantity and source of monitors imported to the Philippines from 1989 to 2018.

Table 3. Monitor lizard exported from the Philippines between 1989 and 2018. Source code C = animals bred in captivity, W = specimens taken from the wild, and I = confiscated or seized specimens.

Species	Total	C	W	I	Undeclared
Varanus cumingi	4	4	-	-	-
Varanus dumerilii	15	-	15	-	-
Varanus marmoratus	6	6	-	-	-
Varanus nuchalis	3	3	-	-	-
Varanus olivaceus	18	18	-	-	-
Varanus prasinus	41	-	-	41	-
Varanus rudicollis	16	-	16	-	-
Varanus salvadorii	4	-	4	-	-
Varanus salvator	37	-	31	-	6

from the analysis. The remaining 11 export records involved nine species and 144 live monitor lizards (Table 3). Aside from Japan, the other main importers of live monitor lizards from the Philippines between 1989 and 2018 were the United States of America, Germany, and Czech Republic.

Four exported species (*V. cumingi*, *V. marmoratus*, *V. nuchalis,* and *V. olivaceus*) are endemic to the Philippines and were declared to be bred in captivity. The four re-exported non-native species (*V. dumerilii*, *V. rudicollis*, *V. salvadorii*, and *V. salvator*) were all sourced from the wild, while exported *V. prasinus*, endemic to Indonesia, were specimens seized in the Philippines.

Discussion

Non-traditional pet keeping in the Philippines is driven by rarity and novelty. As such, more common and widespread monitor lizards are not in great demand as pets due to being readily available, and having high maintenance costs and large spatial requirements to house them properly. On the other hand, frugivorous monitor lizards were offered at higher prices because of their perceived rarity.

Sources of monitors

The vast majority, if not all of Philippine endemic monitor lizards offered for sale on Facebook were very likely poached from the wild and traded illegally since there are no registered wildlife facilities breeding monitors in the Philippines for commercial purposes. The low asking prices (as low as $8 USD per individual) of endemic species are also a strong indicator that they were not bred in captivity since these prices would not cover the cost of maintaining and breeding carnivorous lizards.

Varanus marmoratus is widespread and found in a range of habitats including urban, semi-urban, and disturbed habitats throughout Luzon Island. Its constant availability in the online trade was not a surprise since 74% of traders were Luzon-based and had easy access to wild-caught specimens. Currently, endemic water monitors are commonly trapped using snares and bamboo traps, and the species are consumed as a snack during liquor drinking session or sold as pets (Welton *et al*., 2012, 2013).

Among the seven non-native monitor lizards documented in the online trade, only *V. komodoensis* did not have import records to the Philippines in the last 30 years. The species is protected by Indonesian law and international trade for commercial purposes is prohibited by CITES. The 40 *V. prasinus* offered for sale were most likely smuggled since only seven individuals were legally imported in 2015–2016 and wildlife authorities have seized smuggled Indonesian wildlife including *V. prasinus* in recent years (Sy, *in prep*.). For instance, a long-time legal wildlife farm permittee in the Philippines was caught smuggling eight species of wildlife including one *V. prasinus* in her luggage upon a return trip from Thailand to the Philippines in December 2018. This incident clearly illustrates the practice by which some permittees illegally acquire and transport additional wildlife and include such wildlife in their registered (*i.e.*, legal) inventory. The lack of exhaustive physical and paper audits by wildlife authorities allows this

fraudulent practice to perpetuate throughout the country. In addition, the fact that the suspect was not charged in court for wildlife smuggling encourages individuals who are involved in wildlife smuggling to continue their illegal activities.

A review of monitor lizard exports from the Philippines between 1989 and 2018 indicated that wildlife laundering was not just a recent occurrence. Five non-native species sourced from the wild, namely, *V. dumerilii* (n = 15), *V. prasinus* (n = 41), *V. rudicollis* (n = 16), *V. salvadorii* (n = 4), and *V. salvator* (n = 31) were exported in 1994. However, based on CITES trade database data, there were no legal importations of *V. rudicollis*, *V. salvadorii* or *V. prasinus* to the Philippines prior to the export of these wild-caught specimens in 1994.

Legality of the trade

During the initial implementation of the Wildlife Conservation and Protect Act in 2004, the Philippine wildlife authority allowed the legalization of all wildlife in the possession of enthusiasts through a registration process without questioning the source of the animals. This action created a larger pool of legal wildlife in the country. Laundering of endemic and smuggled wildlife has been ongoing in the Philippines since many registered wildlife farm permittees benefitted from their newly-legalized wildlife as a cover to continue with illegal acquisitions and fraudulent declarations of poached or smuggled wildlife as captive-bred (Diesmos *et al*., 2012; Sy, 2018; Sy *et al*., in press). There is a growing body of evidence that illustrates that a few wildlife facilities in the Philippines have obtained CITES export permits of purportedly captive-bred wildlife to trade internationally even though they neither had the capacity nor evidence of captive breeding (Sy, 2014; Auliya *et al*., 2016). One such case was the legal export of 14 allegedly captive-bred *V. olivaceus* to the US in 2006 (Bennett, 2014). The wildlife laundering issue persists, allowing illegal online trade to flourish as well, and requires immediate attention from the Philippine wildlife authority to ensure compliance with CITES.

There is a persistent demand for endemic monitor lizards in international markets and some enthusiasts will exert great efforts, even illegally, to obtain specimens. At least six wildlife traders from the Philippines who actively-traded online have been linked to smuggling monitor lizards to Hong Kong, Malaysia, Thailand, Europe, and the US (Philippine Bureau of Customs, unpubl. data). Some key illegal traders were also observed posting in international monitor lizard Facebook groups. Based on seizure records from the Philippine Customs, the most common smuggling method during the study period was concealing illegal wildlife in packages and sending them via courier services. The Philippine Customs and the United States Fish and Wildlife Service had intercepted numerous illegal wildlife shipments sent through this method in the last five years (Sy, unpubl. data). Seven traffickers in the Philippines and Austria (Anonymous, 2017, 2019; Dumaboc, 2017; Ching, 2018; Lopez, 2018) and at least three buyers in the US (USDOJ, 2017, 2019) have been implicated for being involved in international monitor lizard smuggling and trafficking.

Another smuggling method is through airports, as exemplified by an incident involving an Austrian national who flew by commercial airline from the Philippines to Vienna with approximately 90 wild-caught reptiles in his luggage on 7 September 2019. The suspect was intercepted only upon his arrival at Vienna International Airport, where authorities found 22 Philippine endemic species including 18 *V. marmoratus* and *V. cumingi*. The suspect intended to sell the reptiles during the Terraristika Hamm 2019 expo in Germany scheduled on 14 September 2019. The fair is reputed to be the biggest reptile show in the world, but is also a known hub for wildlife traffickers (Hruby, 2019).

Conclusion and Recommendations

The market for monitor lizards in the Philippines is considered to be relatively small when compared to other larger markets such as Japan, Europe, and the US. However, this and previous studies show that poaching, illegal domestic trade, international smuggling, and wildlife laundering do occur and should be addressed expeditiously. The following recommendations are offered to authorities to mitigate illegal trade in wildlife including monitor lizards:

1) Closely monitor and take action on those offering wildlife for sale online, considering that almost all of this trade is illegal by law. Wildlife law enforcement activities should be sustained to become an effective deterrent. The high probability of being caught and prosecuted will discourage would-be poachers and wildlife traders from engaging in illegal wildlife trade.

2) Initiate regular and comprehensive physical and paper audits by wildlife authorities on owners, traders, and those who declare breeding animals in captivity to detect fraudulent addition of illegally-acquired wildlife

into existing inventories and wildlife laundering.

3) Increased vigilance at seaports and airports is encouraged to prevent movement and smuggling of illegal wildlife domestically and internationally.

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Death Investigation: Does Post-mortem Scavenging by Animals Always Make it Difficult?

N.D.N.A. Mendis[1,*] & Y.M.G. Illangarathne Banda[2]

[1]*Department of Forensic Medicine & Toxicology, Faculty of Medicine, University of Colombo, Sri Lanka*

[2]*Consultant Judicial Medical Officer, Teaching Hospital Kurunegala, Sri Lanka*

* E-mail: asela@fortox.cmb.ac.lk

Abstract - Animal scavenging activity on human corpses plays an important role in maintaining the food chain. However, when human bodies are found outdoors, scavenging activity by animals often affects the death investigation process. Scavenging by Asian water monitors (*Varanus salvator salvator*) on human corpses is relatively common in Sri Lanka. Here, we present an unusual case where eight deceased *V. s. salvator* found at the site of a 51-year-old man's scavenged body helped determine the probable cause and circumstances of his death.

Introduction

Animal scavenging activity on human corpses plays an important role in maintaining the food chain and constitutes an integral part of the taphonomic process experienced by the body after death (Saukko & Knight, 2004; Tsokos, 2005). Many animal species belong to this food chain, and the odors pervading from human corpses due to the natural putrefaction process can attract the attention of many species, including the Asian water monitor (*Varanus salvator*) (Colard *et al*., 2015).

When a body is found outdoors, the effects of scavenging by animals can affect the death investigation process. Corpses may be attacked by many scavenging animals and exposed to complete destruction, with the bones and belongings of the individual scattered over a large area (Beck, 2015; O'Brien, 2015). If the corpse is immersed in water, many aquatic animals such as fish, water rats, crabs, and amphipods may attack the body (Jones, 1998; Petrik, 2004; Dumser & Türkay, 2008). If the corpse is in shallow water, additional terrestrial species may scavenge on it as well.

Varanus s. salvator is widely distributed throughout Sri Lanka where it prefers aquatic habitats in wet, dry, and intermediate zones up to elevations of about 1000 m (De Silva, 1996; Gaulke & De Silva, 1997; Karunarathna, 2008). It is an opportunistic generalist carnivore that predates and scavenges on a wide variety of species including fish, amphibians, rodents, birds, reptiles, and large invertebrates such as crustaceans (Karunararhna, 2015). Scavenging by *V. s. salvator* on human corpses is a fairly common occurrence in Sri Lanka (Gunawardena, 2016; Gunethilake & Vidanapathirana, 2016).

Generally, post-mortem scavenging on human bodies raises many medico-legal issues including identification and injury interpretation, and many published case reports and reviews have addressed these issues (Gunethilake & Vidanapathirana, 2016). However, it is rare for animal scavenging activity to aid in determining the presumed cause and circumstances of death. Here, we describe a case of post-mortem scavenging activity by *V. s. salvator* that led to the discovery of a probable cause of death of the individual.

Case History

A 51-year-old man from Kurunegala in the North Western Province of Sri Lanka with a history of insomnia and probable depression went missing on 6 December 2018. There was no information about his whereabouts for almost two weeks. Many people searched for the missing individual, but all efforts were unsuccessful and discontinued after 10 days. Twelve days after his disappearance on 18 December, the partly mutilated body of the missing individual was found by a roadside with shrubs nearby. The police initiated an investigation at the scene where the body was discovered.

The body was in an advanced degree of putrefaction

Fig.1. Body with an advanced degree of putrefacation and deceased *Varanus s. salvator* nearby.

Fig. 2. Bodies of three additional water monitors (*V. s. salvator*) lying close to the body.

with partial skeletonization of the face (Fig. 1). The body had apparent injuries, with both upper limbs partly missing. A multi-coloured sarong was seen over the lower limbs with black underpants in situ. Part of a decayed brownish shirt was seen tucked under the body. The skin was sloughing off the abdomen. There were several dead flies seen on the body of the deceased.

The bodies of five deceased *V. s. salvator* were found in the immediate vicinity of the body (Fig. 2). Body lengths of the dead water monitors were not measured, although all appeared to be adult individuals. Each of them was in a different stage of putrefaction. Further searching of the area revealed an additional three deceased *V. s. salvator* within the nearby shrubs. There were no signs of injuries on any of the water monitors found, although the heads of some of them were already putrefied. The discovery of several dead *V. s. salvator* raised a very likely possibility of a common cause of death which prompted another search of the area that turned up an empty bottle of Marshal 20 – liquid Carbosulfan, a common pesticide (Fig. 3).

Discussion

Post-mortem scavenging by *V. s. salvator* on human corpses is a known phenomenon in Sri Lanka (Gunawardena, 2016; Gunathilake & Vidanapathirana, 2016). The odors pervading from the corpse usually attract various wild animals including water monitors (Colard, 2015). However, finding several deceased specimens in close vicinity to the human body and the presence of dead flies on the body raised the suspicion that some form of poisoning was involved. Further investigation yielded additional information, revealing that the victim purchased a bottle of Carbosulfan from a pesticide shop in the nearby town a few days before his disappearance. The body's advanced degree of putrefaction made it impossible to obtain samples for toxicology, but the absence of any injuries apart from scavenging indicated that the cause of death was non-traumatic in origin. A natural cause of death cannot totally be excluded, but the presence of eight dead water monitors in the vicinity of the corpse raised the possibility of a common cause of death.

Fig. 4. Pesticide bottle found at the scene.

Although animal scavenging usually renders investigations of death difficult, on this occasion the task was made easier by the scavengers. However, before arriving at a conclusion the observations and findings of this case must be carefully analyzed.

If the *V. s. salvator* in this case died as a result of some kind of poisoning, was it due to scavenging on the human body? Did the human body they are believed to have fed on contain a poison? The discovery of an empty Carbosulfan bottle in the vicinity and evidence of the victim buying it from the town makes it highly possible that the victim's death was due to self-ingestion of the pesticide. While most of the body remained intact, the upper limbs and tissues close to the axilla were devoured by scavengers. It is noted in many case studies where scavengers died following feeding on dead bodies that they were more likely to die after devouring the gastrointestinal tract and its contents (Allen *et al*., 1996).

Lizards can become exposed to insecticides both directly and indirectly. For example, lizards can inhale the insecticide, consume insects poisoned with the chemical, drink contaminated water, and absorb the insecticide through their skin. There is little information available on the susceptibility of lizards and other reptiles to pesticides (Hall & Clark, 1982). However, it is noted that reports of reptilian mortality events following pesticide applications are numerous enough to establish some sensitivity of reptiles to these chemicals (Hall & Clark, 1982).

Carbamate pesticides are used widely for agricultural and residential applications as insecticides and fungicides. Their worldwide annual usage is estimated to range from 20,000 to 35,000 metric tons (Muhammet *et al*., 2007). This family of chemicals has replaced organochlorine pesticides, which have been banned throughout the world (Muhammet *et al*., 2007). Unlike organochlorine pesticides, carbamate insecticides do not persist long in the environment, and they tend not to bioaccumulate (Muhammet *et al*., 2007). Nevertheless, carbamate pesticides can be toxic to non-targeted wildlife, with fish and birds appearing to be more sensitive to these pesticides than mammals (Grue *et al*., 1983).

There have been no local studies done to determine the effects of pesticides on reptiles in Sri Lanka, and most instances of scavenging by *V. s. salvator* on human corpses are unknown outside the forensic community. Therefore, the possibility of 'accidental' poisoning of these lizards by pesticides must be considered based on studies done outside Sri Lanka. Carbamate is a poison which uses a mechanism of action similar to organophosphate pesticides (Fukuto, 1990). Parsons (2000) observed the effects of organophosphate and carbamate pesticides on non-targeted wild animals, showing that these pesticides inhibited cholinesterase activity. Khan (2002) studied the effect of permethrin and biosal in the Indian Garden Lizard (*Calotes versicolor*) and reported that cholinesterase activity decreased following treatment with permethrin (Khan, 2002). Secondary poisoning of raptors has been documented in cases where Carbofuran was used on crops (Mineau, 1993; Elliot *et al*., 1996), and the compound has been used to deliberately poison raptors (Mineau, 1993, Mineau *et al*., 1999). Carbofuran has been shown to cause direct and secondary poisoning of animals for at least 60 days after agricultural application under autumn conditions in Kansas and may have persisted even longer under colder conditions (Allen *et al*., 1996).

Measurement of Anticholinesterase (AChE) activity is an accepted method for diagnosing poisoning by pesticides that affect AChE activity. In a study done in Canada where eagles fed on coyotes that died from carbamate poisoning, AChE activity was inhibited (Wobeser, 2004). This type of testing is currently difficult to perform in Sri Lanka, but had such testing been conducted on the dead *V. s. salvator*, it could have determined the cause of death and thereby confirming the possibility of carbamate poisoning. Brain AChE activity is commonly used to identify anticholinesterase poisoning, but the interpretation is difficult for specimens collected in the field because chemicals have a variable

effect on AChE (Tattersall, 2018) and the level of exposure, time period, and conditions between death and specimen analysis are highly variable (Morais *et al*., 2012).

One important question remains. If the *V. s. salvator* fed only on the limbs of the deceased individual, does that mean the 'poison' ingested by the victim had already diffused into peripheral muscle tissues? This possibility would indirectly suggest that the victim lived for some time after the consumption of the poison, or that there was post-mortem diffusion of the chemical into peripheral body tissues.

Conclusions

Although scavenging by animals usually interferes with death investigations, in some rare instances it might be useful for determining certain important aspects of the case. Scavenging by *V. s. salvator* on human corpses is a common phenomenon in Sri Lanka. It would be useful if studies related to their actions could be carried out to obtain more confirmative data for future use in forensic investigations.

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Notes on the Role of *Varanus griseus* as a Likely Top Diurnal Predator

Michael Stanner

Faculty of Education, Naresuan University
Phitsanulok 65000, Thailand
E-mail: malpolon2000@yahoo.com

Abstract - In the southern coastal plain of Israel, adult *Varanus griseus* have been inferred to be the top diurnal predators and ecological equivalent of the Egyptian mongoose (*Herpestes ichneumon*). These assessments have both supportive and unsupportive argumentations, all of which are discussed.

Introduction

Monitor lizards are often referred to as the ecological equivalents of mammalian carnivores (*e.g.*, Pough, 1973; Wood *et al*., 1977a, Pianka & Sweet, 2016). In this context, small-medium sized varanids (total length up to 150 cm) might be considered as the ecological equivalents of small predatory mammals such as viverids (Pianka & Sweet, 2016), and *Varanus komodoensis* – as the ecological equivalent of a leopard, tiger or lion (Auffenberg, 1981). In my study of the desert monitor (*V. griseus*; Stanner, 1983), *V. griseus* was considered to be the ecological equivalent of the Egyptian mongoose (*Herpestes ichneumon*; see below).

The ecological equivalence of monitor lizards to mammalian carnivores relies on several morphological, physiological and behavioral characteristics typical of monitor lizards:

1) Large body size.

2) Considerable strength, agility and aggressiveness.

3) The ability of several species such as *V. komodoensis* and *V. salvator* to rip large prey apart with their jaws and forefeet (*e.g.*, Auffenberg, 1981; Stanner, 2010).

4) A well-developed cardio-pulmonary system (*e.g.*, White, 1968; Kirchfeld, 1970; Hanemaaijer *et al*., 2019); aerobic metabolic capabilities superior to those of most other reptiles (*e.g.*, Wood *et al*., 1978); efficient blood physiology (Millard & Johnson, 1974; Wood *et al*., 1977a,b, 1978; Hanemaaijer *et al*., 2019), and comparatively high levels of myoglobin in the skeletal muscles (Bennet, 1973).

These features enable monitor lizards to sustain high levels of activity for prolonged periods, as well as to hunt and subjugate comparatively large and strong prey.

Observations

The ecological equivalence of *V. griseus* to the Egyptian mongoose was inferred during my study of *V. griseus* in Israel between 1979 and 1981 (Stanner, 1983). My field work was conducted in the inland sand dunes between the cities of Holon and Rishon Lezion in the southern coastal plain of Israel. The sand dunes of the coastal plain of Israel are a comparatively young formation (ca., 6000 years old) that was formed by alluvial sand from the Nile River washed ashore by currents in the Mediterranean Sea (Eig, 1939; Nir, 1973). In terms of soil, flora and fauna, the coastal plain of Israel, as well as the adjacent (to the south) northwestern Negev (Israel) and northern Sinai (Egypt) might be considered as an extension of the Sahara Desert (*e.g.*, Yom-Tov, 1988; Yom-Tov & Mendelssohn, 1988). The faunal composition in my study area consisted of a mixture of both Mediterranean and Saharo-Arabian species. In the coastal plain of Israel the ratio between the numbers of the Mediterranean and Saharo-Arabian species changes along a north-south gradient – in the northern parts the Mediterranean species outnumber the Saharo-Arabian species, and vice versa - in the

southern parts. The largest of the Saharo-Arabian reptile is *V. griseus*. At present, large stretches of my former study area are covered by concrete and have been turned into residential areas. The reminder is crisscrossed by tracks from off-road recreational vehicles, littered with building debris and affected by other environmentally-unfriendly activities, and it is highly doubtful that desert monitors still exist there. More details on the study area can be found elsewhere (*e.g*., Stanner & Mendelssohn, 1987).

Herpestes ichneumon is both diurnal and nocturnal (Shalmon, 1993). *Herpestes ichneumon* is sympatric with *V. griseus* in the southern coastal plain of Israel, but not syntopic with it. The two species do not share the same sand-dunes habitats in the southern coastal plain of Israel, and mongooses were completely absent from my study area. In summary, the ecological equivalence of *V. griseus* to *H. ichneumon* can be depicted as follows: mongooses were not present in the study area, both species are diurnal (though, *H. ichneumon* is also nocturnal), and both species prey on the same type of prey, including large venomous snakes (Stanner & Mendelssohn, 1986/1987).

The red fox (*Vulpes vulpes*) was the only mammalian carnivore present in my study area. Red foxes are mainly nocturnal, though activity during dawn and dusk is also common (Shalmon, 1993); hence, their daily activity patterns do not overlap those of *V. griseus*, which is completely diurnal and not active during dawn or dusk (Stanner & Mendelssohn, 1991). In this study, as well as in other studies, there were no indications that red foxes prey on adult desert monitors. Once I observed a *V. griseus* entering the burrow of a red fox but that might have been an escape behavior (Immelmann & Beer, 1992) triggered by the observer. Furthermore, on several occasions I saw *V. griseus* tracks leading into and out of burrows of red fox burrows, which may indicate that the two species have no predator-prey relationships.

In my study area, as well as in the study area of Vernet (1977) in the Grand Erg Occidental in Algeria, *V. griseus* was inferred to be the top predator, but contrary to this study, Vernet (1977) makes no distinctions between diurnal and nocturnal predators. The terms "top diurnal predators" vs. "top nocturnal predators" are occasionally encountered in the ornithological literature, especially in connection with "diurnal raptors" vs. "nocturnal raptors" (*e.g*., Glue, 2004). It should be emphasized that the status of *V. griseus* as a top diurnal predator refers only to adult monitors. Juveniles occupy a lower level in the food web and might be preyed upon by many species of vertebrates, including larger conspecifics (Vernet, 1977). In this context, *V. griseus* has several defensive capabilities that may deter potential predators, as follows:

1) *Varanus griseus* is strong, aggressive and has a powerful bite, and can hold on forcibly and fiercely with its jaws, as well as inflict painful tail whips.

2) Its comparatively long neck enables *V. griseus* to swing its head sideways in a wide angle thus enhancing its biting capabilities.

3) The teeth of *V. griseus* are bilaterally compressed at the distal aspects and serrated along the posterior edges (Fig. 1). Less distinct serrations may also occur along the anterior edges (Fig. 2). Thus the teeth may also have cutting capabilities - thereby exacerbating the damage of the bite and may cause bleeding.

4) The saliva of *V. griseus* was found to have venomous properties (Sopiev *et al*., 1987; Ballard & Antonio, 2001; Zima, 2019). Longitudinal grooves along proximal aspects of the teeth (Fig. 3) may facilitate the flow of venomous saliva into the bitten animal (cf., Fry *et al*., 2009).

In spite of the aforementioned, the status of adult *V. griseus* as a top diurnal predator might be thwarted by certain factors, mainly anthropogenic factors, including

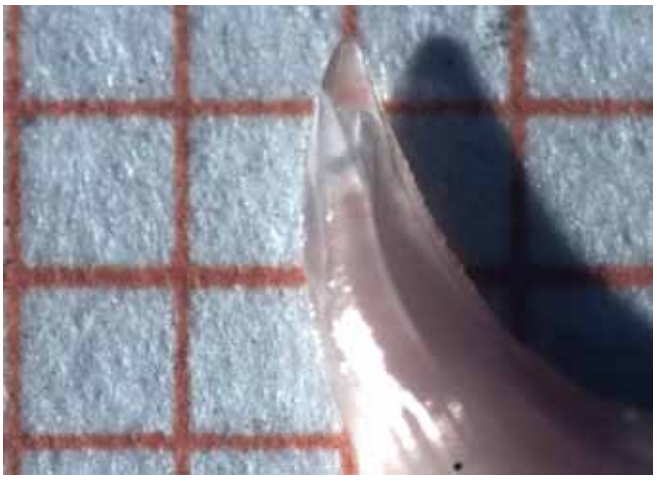

Fig. 1. Stereo-microscopic photograph of *Varanus griseus* tooth extracted from the left maxilla, showing bilateral compression at the distal aspect of the tooth and serration along the posterior edge. In background - 1 mm squared paper. Specimen: R.16780, Steinhardt Museum of Natural History, Tel Aviv University (STMH); 25+34 cm (Snout Vent Length + Tail Length). Photographed by **Michael Stanner**.

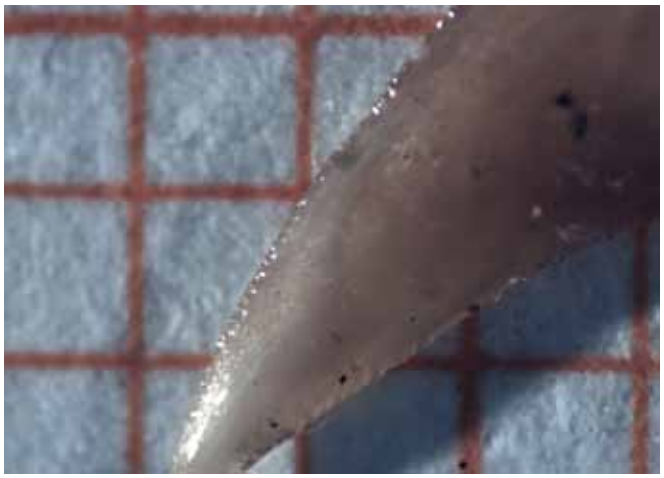

Fig. 2. Less-distinct serration along the anterior edge of the tooth. Tooth extracted from the left mandible. Specimen: R.13044 (STMH); 43+55 cm. Other details and abreviations as in Fig. 1. Photographed by **Michael Stanner**.

Fig. 3. Maxillary tooth showing longitudinal grooves at the proximal aspect of the tooth. Same specimen as in Fig. 2. Other details as in Fig. 1. Photographed by **Michael Stanner**.

the first two in the following list:

1) Road kills, as well as deliberate killings by humans (Stanner, 1983). Moreover, in many places throughout their range *V. griseus* were hunted extensively for their meat, traditional medicine, and especially – their skins which were targeted in large numbers for the international skin trade. Since 1975 *V. griseus* has been included in CITES Appendix I. Thereafter, since the beginning of the 1980s, a decrease in *V. griseus* skins was reported. (Vernet, 1977; review, Stanner, 2004), and in CITES meeting in 1989 a proposal was submitted to move *V. griseus* from Appendix I to Appendix II , which was not accepted.

2) Intrusion of the sand dunes (southern coastal plain of Israel) by domestic and feral dogs that occasionally kill adult desert monitors (Stanner, 1983; Perry & Dmi'el, 1995).

3) Birds of prey. Tentatively, large raptors might be capable of hunting adult desert monitors. Short-toed eagles (*Circaetus gallicus*), buzzards (*Buteo* sp.) and harriers (*Circus* sp.) were the only large raptors that were seen in my study area. It is doubtful that even *C. gallicus*, the largest of the three, is capable of hunting adult desert monitors. There are no reports of direct observations of raptors preying on adult desert monitors, though the following three circumstantial evidences may indicate that raptors do prey on adult desert monitors:

a) Tsellarius & Cherlin (1991) report that in the western Kyzykum Desert in Uzbekistan more than half of the Caspian desert monitors (*V. griseus caspius*) had scars and fresh wounds on their dorsa, which they attributed to attacks by raptors of the genera *Aquila* and *Buteo* that were prevalent in their study area. However, it is apparent that those presumable predation attempts were eventually unsuccessful. Besides, the scars and wounds might have been caused by aggressive intra-specific interactions (Vernet, 1977; Tsellarius & Tsellarius, 1997), as well as by the monitors wriggling through tight crevices (Stanner, 2007; D. Bennett, pers. comm.).

Fig. 4. *Varanus griseus* head found under the nest of a golden eagle (Aquila chrysaetos). Eilat Mountains, southern Israel. Photographed by **Yossi Leshem**.

b) The head of a desert monitor was found under the nest of a golden eagle (*Aquila chrysaetos*; Fig. 4) in the Eilat Mountains, southern Israel, but the monitor could have been scavenged. Golden eagles are formidable predators, but are known to scavenge as well (Inbar, 1977).

c) During an exploration study of the eastern Thar Desert in Jodhpur District of Rajasthan, India, Kumwat *et al*. (2018) observed a Bonelli's eagle (*Aquila fasciata*) feeding on a carcass of a desert monitor on a rock cliff (ca. 15 m high) near the eagle's nest, but the authors attribute this feeding to scavenging rather than predation. Moreover, the desert monitor that was observed by Kumawat *et al*. (2018) belonged to the southern and easternmost subspecies (*V. griseus koniecznyi*), which is the smallest subspecies of *V. griseus*.

4) Albeit not documented yet, occasional predation of adult desert monitors by (mainly nocturnal) large carnivores cannot be ruled out (see below).

a) Rismiller *et al*. (2010) report that females *V. rosenbergi* on Kangaroo Island, South Australia are preyed upon by feral cats. The body size of *V. rosenbergi* is somewhat similar to that of *V. griseus*, but cats (*Felis catus*) are a comparatively recent invasive species to Australia. Hence, endemic Australian fauna (including varanids) are probably more susceptible to predation by cats than elsewhere (Woinarski *et al*., 2019).

Conclusions

The assessment that *V. griseus* is a top predator is incomprehensive. Here, the assessment is downgraded by 2-3 limitations: 1) It applies only to adult monitors; 2) It concerns only diurnal predators, and maybe 3) only terrestrial predators (vs., aerial-avian predators). Within the framework of these limitations the status of *V. griseus* as a top predator seems to be plausible. However, lack of knowledge from many areas within the distribution of *V. griseus* may downgrade this assessment even more, or even invalidate it locally, *i.e.*, it may not necessarily be valid throughout its entire distribution area. The main reservations to this assessment are associated with anthropogenic factors. Other reservations are either speculative or based on equivocal circumstantial evidence. As far as community ecology in *V. griseus* habitats in the Saharo-Arabian zoogeographic sub-region is concerned, the status of adult *V. griseus* as the top diurnal predator seems to be the firmest. Natural (non-anthropogenic) predation on adult *V. griseus* in such communities (if at all) might be attributed only to non-endemic predators (such as large raptors) whose distribution areas are wider and may encompass several zoogeographic regions. Furthermore, inferred from my study area in the southern coastal plain of Israel, future studies of community ecology in various places within the distribution area of *V. griseus* ought to focus more on syntopic species (rather than sympatric species) because diurnal carnivores (especially non-endemic ones) are likely to avoid the extreme conditions that prevail in the hot, dry and unstable sand-dunes that are favored by *V. griseus*, especially in places where these habitats may spread over wide stretches of land such as in north Africa.

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A Case of Arboreality in an Adult Water Monitor (*Varanus salvator macromaculatus*)

MICHAEL STANNER

Faculty of Education, Naresuan University, Phitsanulok 65000, Thailand
E-mail: malpolon2000@yahoo.com

Abstract – During a brief observation in Lumpini Park in Bangkok, Thailand a ca. 170 cm long (total length) adult water monitor (*Varanus salvator macromaculatus*) was observed descending head-first down the trunk of a portia tree (*Thespesta populnea*). During the descent the monitor encircled its tail around ca. ½ of the tree's circumference. Encircling the tail around the trunk was presumed to be useful to the monitor in two ways: 1) securing its body tightly to the trunk, thus preventing it from falling to the ground, and 2) slowing down the speed of descent, in which case the tail might have functioned as a friction pad.

Introduction

It is well known that the largest *Varanus* species, *i.e., V. komodoensis* and *V. salvator* undergo changes in their lifestyles through ontogeny – the juveniles are mainly arboreal and the large adults are obligately terrestrial, as well as aquatic (*e.g.,* Auffenberg,1981; Gaulke & Horn, 2004). Subadults are both arboreal and terrestrial. I describe here a case of arboreality in a large adult *V. salvator macromaculatus*.

Observation and Conclusions

The observation was made in Lumpini Park, a fenced 58 ha public park located in the heart of Bangkok, Thailand. The park includes several ponds and canals, as well as sporting and recreational facilities. The park is open to the public during the daytime hours and is usually teeming with people engaged in jogging and other sporting and recreational activities. Lumpini Park is well known world-wide for its dense population of *V. salvator macromaculatus* that are habituated to humans, and thus are easily observed and studied. More details on *V. salvator macromaculatus* in Lumpini Park can be found elsewhere (*e.g.,* Stanner, 2010; Cota, 2011).

At 1155 h on 24 January 2017, I observed a large *V. salvator*, measuring ca. 170 cm in total length (TL; estimated from a distance of ca. 5 m) descending head-first down the trunk of a portia tree (*Thespesta populnea*). The tree was located ca. 3 m from the edge of a pond. The trunk slanted approximately 60 ° and had a diameter of ca. 41 cm and circumference of 128 cm at a height of around 2 m. As the monitor descended down the trunk it encircled its tail around ca. ½ of the tree's circumference. On reaching a height of about half a meter, it detached itself from the trunk, leapt to the ground, ran to the pond, and disappeared into the water. The whole observation lasted 2–3 sec. Due to the briefness of the observation I was unable to photograph the event. Looking up the tree, I saw no evidence of prey or any other incentive that might have motivated the monitor to climb the tree, though that does not mean that such incentive might have existed beforehand. During previous observations of *V. salvator* in Lumpini Park, I have tried to approach juveniles and sub-adults (TL < 90 cm). In most cases,

Fig.1. Portia tree trunk (*Thespesta populnea*) in Lumpini Park, Bangkok. Scale: 15 cm blue and white pen.

the monitors escaped by climbing up trees that grew close to the water's edge; in other cases they escaped by diving into the pond. Hence, juveniles and sub-adults may feel more secure climbing up trees than swimming or diving in the water where they might be vulnerable to attacks or preyed upon by larger conspecifics.

Encircling the tail around the tree-trunk might have been useful for the monitor by 1) securing its body tightly to the trunk, thus preventing it from falling to the ground, and 2) slowing down the speed of the descent, in which case the tail might have functioned as a friction pad. It is noteworthy that the bark of the Portia tree is rough (Fig. 1) and thus might facilitate ascent and descent of monitors along the trunk.

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Occurrence of the Asian Water Monitor (*Varanus salvator* Laurenti, 1768) in Faridpur, Bangladesh

Naim Khandakar[1,*], Delip K. Das[1] & Ashik Jahan Galib[1]

[1]*Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh*
[*]E-mail: naim.jnu.2014@gmail.com

Abstract - Two sightings of *Varanus salvator* in Faridpur District, Bangladesh are reported. These two localities represent an extension of the known distribution of the species in Bangladesh.

The Asian water monitor (*Varanus salvator*) is a vulnerable species according to IUCN Bangladesh (2015) and the largest monitor lizard found in Bangladesh (Khan, 2008; Hasan *et al*., 2014). It is a water-depndent species and has been known to cross large stretches of water, explaining its wide distribution (Taylor, 1966), and occurs in terrestrial habitats adjoining water bodies (Koch *et al.*, 2013). Its natural habitat is declining due to various anthropogenic factors such as habitat fragmentation, human settlements, the discharge of domestic sewage and industrial effluent and dumping of solid waste, and the conversion of wetlands in to barren lands. However, *V. salvator* is flexible in its behavior, allowing it to adapt to some modified human ecosystems (Rahman *et al.*, 2017a). In Bangladesh, they are commonly seen in coastal areas and mangrove swamps of the Sundarbans and rarely in the northeast, southeastern forests, Manikganj and Narayanganj (Rahman *et al.*, 2017b). This species is also found in wildlife sanctuaries of the Sundarbans, Char Kukri-Mukri Wildlife Sanctuary, Nijhum Dweep National Park and Teknaf Game Reserve (Khan, 2008). Published reports on this species in Bangladesh are scarce, and no records of *V. salvator* from Faridpur District have been reported.

On 26 August 2018 at 1107 h, we found an adult *V. salvator* foraging in a grassy area, 5 m from the bank of the Arial Khan River at Duair (23°24′59.9″N; 90°04′17.3″ E) in Faridpur District (Fig. 1). It was readily identified as *V. salvator* based on the yellowish rings arranged in rows across the upper parts of the blackish body.

On 2 March 2019 at 1450 h, a juvenile *V. salvator* was observed basking on the bank of pond at Saresat Rashi (23°27′11.4″ N; 90°01′15.8″ E) in Faridpur District (Fig. 2). The nearest sighting records of the species are about 52 and 55 km, respectively, from the current location in Narayanganj District (23.632285° N, 90.524397° E) (Figs 3 & 4). This represents a range extension for *V. salvator* in Bangladesh.

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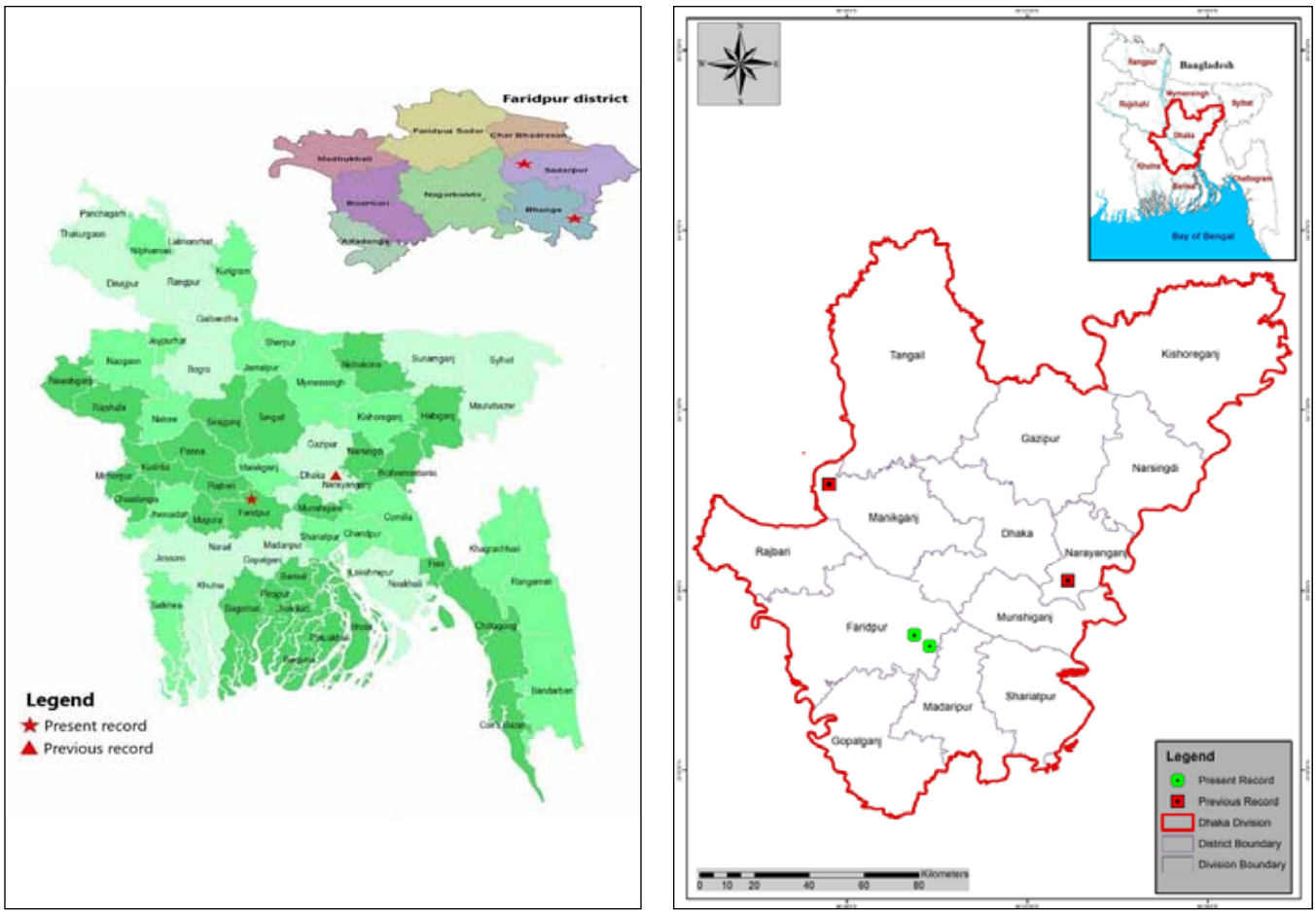
Fig. 1. *Varanus salvator* in its natural habitat at Duair in Faridpur.

Fig. 2. *Varanus salvator* in its natural habitat at Sarasat Rashi in Faridpur.



Figs 3 & 4. Maps depicting the locations in Faridpur District where *V. salvator* was spotted.

support during fieldwork. We are also grateful to Mohammad Shariful Islam for creating the map.

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An Annotated Bibliography of Captive Reproduction in Monitor Lizards (Varanidae: *Varanus*). Part V. *Varanus*

Robert W. Mendyk[1,2]

[1]*Department of Herpetology*
Audubon Zoo
6500 Magazine Street
New Orleans, LA 70118, USA

[2]*Department of Herpetology*
Smithsonian National Zoological Park
30001 Connecticut Avenue NW
Washington, D.C. 20008, USA

E-mail: rmendyk@audubooninstitute.org

Abstract: Popular in zoos and private collections, monitor lizards have been maintained in captivity for nearly two centuries. During this time, but especially over the past three decades, a voluminous body of publications has brought to light important details and perspectives that have helped advance their captive husbandry and reproductive management. This bibliography presents an annotated compilation of publications pertaining strictly to the captive reproduction of species belonging to the *Varanus* subgenus *Varanus*. It is intended to serve as a guide for zoos and private herpetoculturists looking to expand their knowledge and familiarity with this group and introduce readers to different perspectives on their management and reproduction in captivity.

Introduction

Monitor lizards have a long and fascinating history of being maintained in captivity that dates back to at least the early 19th Century. Some of the earliest published accounts of monitor lizards in captive collections reference animals held in European menageries and zoological gardens (Cox, 1831; Knight, 1867; Mitchell, 1852; Sclater, 1877), although private keepers also maintained representatives of this group during this period (Bateman, 1897; Lachman, 1899; von Fischer, 1884). Alfred "Gogga" Brown was probably the first individual to genuinely attempt to reproduce monitor lizards in captivity in the late 1800s (Branch, 1991). Although he received hundreds of eggs (from 33 clutches) from a large group of more than 40 captive *Varanus albigularis* he maintained outdoors in South Africa, he was unsuccessful in hatching any live offspring (Branch, 1991). Eggs had also been received but not hatched by other keepers around this time (*e.g.*, Thilenius, 1898); these eggs were usually scattered by the females who clearly did not have appropriate conditions available for nesting (Branch, 1992; Thilenius, 1898). A poor understanding of monitor lizard biology and husbandry and reptile egg incubation undoubtedly prohibited successful captive breeding from taking place for many decades. This was especially apparent in a 1967 report by Osman (1967), who, while discussing a clutch of *V. komodoensis* eggs that were scattered across the ground of the enclosure rather than buried, suspected that the eggs were to be later buried in the sand by the female after they had been left out in the sun for the shells to harden.

The first documented record of successful captive breeding of a monitor lizard occurred with *V. komodoensis* in 1941 (de Jong, 1944). Unknown to their

caretakers, a pair of adults maintained at the Batavia Zoo since 1938 secretly nested a clutch of eggs in their exhibit which unexpectedly hatched several months later, much to the zoo's surprise. The next documented case of successful captive reproduction in monitor lizards did not occur until 1962, when a wild-caught gravid *V. albigularis* produced a clutch of eggs shortly after arriving at the San Diego Zoo, which resulted in a single hatchling (Staedeli, 1962). Several additional species were successfully bred for the first time in the 1970s (Horn, 1978; Horn & Visser, 1989), with more species hatched in the 1980s (*e.g.*, Bredl & Horn, 1987; Bröer & Horn, 1985; Eidenmüller, 1986; Eidenmüller & Horn, 1985; Horn & Petters, 1982; Horn & Visser, 1989; Irwin, 1996; Stirnberg & Horn, 1981). From the 1990s onward, monitor lizard husbandry continued to advance rapidly, to the point where at least 53 species have now been successfully reproduced in captivity (Horn & Visser, 1997; Eidenmüller, 2007; Husband & Bonnett, 2009; Brown, 2012).

In previous bibliographic installments, I have focused on the *Varanus* subgenera *Odatria*, *Empagusia*, *Phillipinosaurus*, *Soterosaurus*, *Papusaurus*, *Psammosaurus and* the *V. prasinus* complex (subgenus *Hapturosaurus*) (Mendyk, 2015, 2016, 2017, 2018, 2019). Here, the focus is directed towards the subgenus *Varanus*, which is comprised of eight species including the largest living lizard, *V. komodoensis*. Although one species (*V. komodoensis*) is restricted in its distribution to a few small islands in Indonesia, all other species are endemic to Australia and New Guinea where they occupy a wide ranges of habitats ranging from arid deserts to tropical rainforests and riparian environments. All members of the group have been maintained and successfully reproduced in captivity. Excluding *V. komodoensis*, which has only been legally kept and bred in zoological parks, all other species have successfully been reproduced in both zoos and private collections. Documentation of successful reproduction varies widely by species.

The following bibliography, which represents a continuation of what will be several installments on the captive breeding of monitor lizards, focuses chiefly on *V. giganteus*, *V. gouldii*, *V. komodoensis*, *V. mertensi*, *V. panoptes*, *V. rosenbergi*, *V. spenceri* and *V. varius*. Similar works that address other subgenera are forthcoming.

Using this Bibliography

This bibliography covers all aspects of captive reproduction including both successful and unsuccessful attempts. It is largely intended to serve as a resource for zoo professionals and private herpetoculturists working with these species in captivity, but may also prove valuable to conservation biologists, ecologists, veterinarians and general enthusiasts seeking to gain familiarity with existing literature on the reproductive biology of monitor lizards. Species covered in this bibliography are organized alphabetically, with annotations describing the nature and content of each work appearing inside brackets after each reference.

While best efforts were made to document all known publications relevant to the reproduction of these species in captivity, I recognize the possibility and likelihood that some publications may have been missed. Given that bibliographies are perpetual works in progress, I welcome and encourage feedback on publications that may be missing from this bibliography and new accounts as they are published so that they can be added to an updated version of this document in the future.

Acknowledgments – This bibliographic series is dedicated to the late Mark K. Bayless, whose many contributions to the study of monitor lizards have helped advance the fields of monitor biology and captive husbandry, inspire a new generation of enthusiasts, and stimulate new research on this group, including the present bibliography. I am indebted to Kristen Bullard, Richard Green, Michael Hardy, and Polly Lasker of the Smithsonian Institution Libraries for their assistance with sourcing obscure literature, and would also like to thank Ben Aller for allowing access to Mark Bayless's former personal library of monitor literature.

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Varanus rosenbergi

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Brown, D. 2012. A Guide to Australian Monitors in Captivity. Reptile Publications, Burleigh. 263 pp. [describes reproductive management and presents reproductive data]
Eidenmüller, B. 2007. Monitor Lizards: Natural History, Captive Care & Breeding. Edition Chimaira, Frankfurt am Main, 176 pp. [describes reproductive management]
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Husband, G. & M. Bonnett. 2009. Monitors. Pp. 484–583. *In*: Swan, M. (ed.), Keeping and Breeding Australian Lizards. Mike Swan Herp Books, Lilydale. [discusses reproductive management and presents reproductive data]
Irwin, S. Undated. Taxon Management Account: Ground Habitat Group. Queensland Reptile & Fauna Park, Beerwah. 8 pp. [discusses reproductive management]
Irwin, S., K. Engle & B. Mackness. 1996. Nocturnal nesting by captive varanid lizards. Herpetological Review 27(4): 192–194. [briefly mentions successful reproduction at Australia Zoo]
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Varanus varius

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Bennett, D. 1995. A Little Book of Monitor Lizards. Viper Press, Aberdeen. 227 pp. [discusses captive breeding and reproductive management]
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reproductive data]
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Chudleigh, P., K. Bond, T. Bramwell, G. Gilmore, A. McLeod & C. Whitely. 1995. Goanna Farming in Australia. Rural Industries Research and Development Corporation, Barton. 45 pp. [describes the results of a feasibility study on the commercial farming and breeding of *Varanus varius* in Australia]
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Eidenmüller, B. 2007. Monitor Lizards: Natural History, Captive Care & Breeding. Edition Chimaira, Frankfurt am Main, 176 pp. [describes reproductive management]
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Hogston, J. 1997. The jewel of Australia: A look at the Queensland reptile & fauna park. Dragon News 1(4): 7–9. [briefly mentions eggs laid at Australia Zoo]
Horn, H.-G. 1991. Breeding of the lace monitor (*Varanus varius*) for the first time outside of Australia (Reptilia: Sauria: Varanidae). Pp. 168–175. In: Böhme, W. & H.-G. Horn (eds.), Advances in Monitor Research, Mertensiella 2. Deutsch Gesellschaft für Herpetologie und Terrarienkunde e.V., Rheinbach. [describes successful reproduction and reproductive management]
Horn, H.-G. & G.J. Visser. 1989. Review of reproduction of monitor lizards *Varanus* spp. in captivity. International Zoo Yearbook 28: 140–150. [presents reproductive data]
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Nocturnal Hunting Activity of *Varanus salvator* in Goa Lalay Cave, Pelabuhan Ratu, Indonesia

Myke Clarkson & Devon Massyn

Herpetological Conservation International
4001 Inglewood avenue Bldg. 101 Suite 678
Redondo Beach, California 90278
Email: Myke@mykeclarkson.com

Abstract – We describe nocturnal predation of cave-dwelling bats by *Varanus salvator* observed during the filming of a television nature documentary series in the Goa Lalay caves at Pelabuhan Ratu, Java, Indonesia. This account appears to represent the first record of nocturnal predation, and a further example of predation on cave bats in the *V. salvator* complex.

Introduction

While generally considered to be diurnal (Gaulke & Horn, 2004), some nocturnal activity has been reported in *Varanus salvator*, including nocturnal nesting (Biswas & Kar, 1981) and scavenging (Uyeda *et al*., 2013). Here, we describe field observations of *Varanus salvator* hunting and predating on bats at night in the Goa Lalay caves at Pelabuhan Ratu, Java, Indonesia.

Study Site

The Goa Lalay cave system is located approximately 3 km from the rural agricultural community of Pelabuhan Ratu, in Sukabumi, West Java, Indonesia and is best known as a tourist attraction for its large nightly bat exodus. The site is comprised of a main cave situated in the side of a mountain, with many smaller caves occurring along the same cliff face. Our observations occurred in the main cave, which according to the local caretaker is comprised of a main dome covering an area of 1000 m^2, with a shallow lake occupying ca. 70% of the ground space inside of the cave. The main cave system has numerous smaller holes and openings connecting to the outside. The habitat on the mountain above and behind the cave is best described as secondary tropical forest with scattered human dwellings. The area in front of the cave was developed, with an artificial pond, small house and parking area, and the surrounding area leading up to the cave entrance is predominately agricultural land.

We visited the site daily from 16–19 April 2018 during the filming of a natural history television documentary (Dead by Dawn, produced by Love Productions USA for the National Geographic Wild television network). Since the subject matter of the documentary was nocturnal animals, our observations and filming were limited mostly to the evenings and at

Figs 1 & 2. *Varanus salvator* actively foraging in Goa Lalay cave.


Figs 3 & 4. Nocturnal predation by *V. salvator* on cave-dwelling bats inside Goa Lalay cave..

night, with little time spent in the cave between 0500 and 1430 h.

Air temperature at the site during our observations ranged from around 28.9 °C at the start of filming around 1530 h to around 23.9 °C by 0030 h. No rainfall occurred during the observation periods, and most of the region's precipitation seemed to occur in the afternoon hours. Humidity remained at 100% for the duration of our observations.

Observations

Varanus salvator were first observed at Goa Lalay during a film scout on 16 April 2018, with approximately 11 adults (> 1.5 m total length) observed in the cave between 1500 and 2000 h (Figs. 1 & 2). Upon our initial approach, the *V. salvator* were in various locations within the cave and appeared to be foraging along the edge of the interior lake or exploring around rocks and crevices. The presence of the filming crew and cameras did not appear to alter the monitors' behavior. Many smaller *V. salvator* were seen in the large pond outside the main cave, but not in the cave itself or after sunset.

The activity of the monitors appeared to increase at dusk as the bats began to leave the caves. We observed several *V. salvator* preying on bats that fell to the ground while in the process of leaving the cave (Figs. 3–5), recording this activity on film for the documentary (Alpert *et al*., 2019). Observed predation occurred from ca. 1500 h until around 2130 h, with sunset occurring around 2033 h each day. However, due to the depth of the cave, the premises were fully dark by around 2000 h. Over the next three days, we continued to observe crepuscular and nocturnal feeding by *V. salvator* in the cave; no signs of aggression or competition over prey items were observed between individuals. While many other potential prey species were observed in the cave including rats (species unknown) and cockroaches (potentially *Periplaneta australasiae* and/or *Pycnoscelus striatus*; Fig. 6), we only observed

Fig. 5. A large *V. salvator* feeds on a bat that fell to the cave floor at night.

Fig. 6. Although present in the cave, predation on cockroaches by *V. salvator* was not observed.

Fig. 7. Bats inhabiting the roof of the Goa Lalay cave system.

predation on bats which had fallen from the roof of the cave. Identification of the bat species predated on by the *V. salvator* was not possible; several species are known to occur in Goa Lalay including *Tylonycteris* spp, *Hipposideros* spp, *Miniopterus* spp, *Chaerephon plicata* and *Kerivoula picta* (Fig. 7).

The nights when these observations occurred were particularly dark, with 16 April being the first night of the new moon. No moonlight was observed over the course of these observations, ruling out the possibility that this unusual nocturnal activity was facilitated by lunar luminance.

To our knowledge, this is the first documented instance of *V. salvator* hunting natural prey items after sunset, although nocturnal scavenging on human food scraps and a pig carcass have been observed in the species (Uyeda *et al*., 2013). This also appears to be only the second report of a member of the *V. salvator* complex preying on cave-dwelling bats (Tanalgo, *et al*., 2020). The combination of nocturnal hunting of an unusual prey item and use of an unusual habitat highlights the remarkable adaptability of the *V. salvator* complex. Further research into the prey adaptability of other *Varanus* species could have ecological and conservation implications.

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