BIAWAK

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On the Cover:
Varanus pilbarensis

The *Varanus pilbarensis* depicted on the cover and inset of this issue was photographed by **Max Jackson** in the northern Pilbara region of Western Australia on 15 Feburary 2015.

Early searches during the day failed to turn up any wildlife due to the 40+ °C heat. Following a brief, but heavy mid-afternoon storm, a variety of wildlife emerged from rocky crevices to drink water that had collected in puddles on the surfaces of rocks. Among these animals were mammals, skinks, and a *V. pilbarensis* which remained active for around 10 minutes and allowed for a photograph. Also encountered in a rocky crevice in close proximity to the *V. pilbarensis* was a *V. tristis*.

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Journal of Varanid Biology and Husbandry

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 monitor 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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Varanus keithhornei. Iron Range, National Park, Queensland. Photographed by **Jasmine Vink**.

ORGANIZATIONAL NEWS

Onwards and Upwards...

Now entering its tenth year of publication, *Biawak* has played an important role in advancing the study of monitor lizards as well as connecting researchers and enthusiasts from around the world with current information on this unique reptile group. *Biawak* will continue to be released biannually, with new issues appearing around June and December of each year. Submissions of original articles, notes, and photographs are welcomed and encouraged from all varanid enthusiasts. Please direct all submissions and inquiries to the editor.

The International Varanid Interest Group (IVIG) continues to experience growth in both its membership and the international breadth of its readership. The period between June 2015 and July 2016 saw the addition of 47 new members, bringing IVIG membership to a total of 1,047 individuals from 60 countries. New member countries include Bangladesh and South Korea (Fig. 1).

In addition to the informational resources available through the IVIG's website, http://varanidae.org, the discussion group entitled "*Biawak - International Journal of Varanid Biology and Husbandry*" on the popular social media website Facebook.com continues to grow and promote the exchange of ideas, news, and information relating to the biology and husbandry of varanid lizards. All IVIG members are encouraged to join and participate in this open forum. Current participants of this discussion group number 2,080.

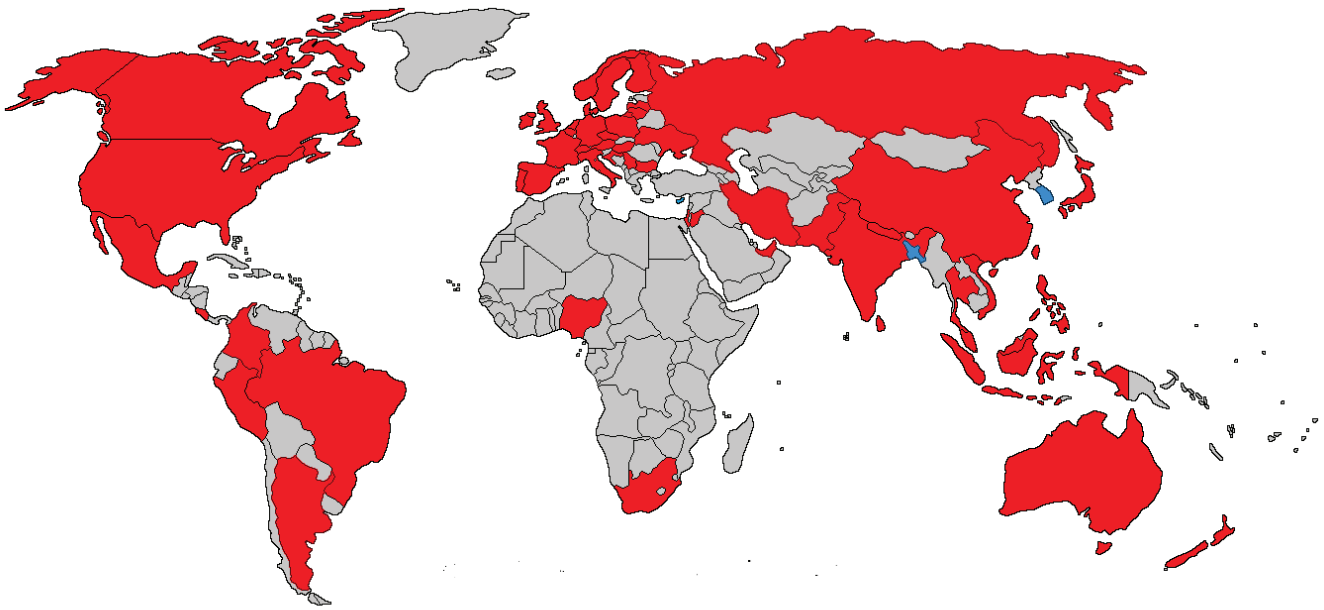


Fig. 1. Current global distribution of IVIG membership (newly added member countries in blue).

NEWS NOTES

Bush Fire Blamed on Monitor

A small scrub fire in South Australia is believed to have been caused by a monitor that had chewed on a powerline. The fire occurred between Melrose and Murray Town and was quickly extinguished. It was centered 12 km south of Melrose where fire crews found the burned remains of a monitor lizard by a powerline pole. No reason was given for why the animal would have attempted to bite the line.

Source: The Flinders News; 25 January 2016

Water Monitors May Be Returning to Hong Kong

Water monitors (*Varanus salvator*) may be re-establishing themselves in Hong Kong after being extirpated from the island some time ago. Exactly when the species became extirpated is unknown, although officials claim that wild animals were seen through the 1960s. Following the loss of wetlands, sightings of *V. salvator* from the 1980s onward are believed to have represented escaped captive individuals, although no further information on this is available. Animals that either escaped or were released from captivity are thought to have begun breeding in parks within the highly urbanized island; however, this remains to be confirmed as young animals have not yet been encountered. Wildlife officials have stated they are hopeful the species will re-establish itself and restore a missing part of the island's ecosystem, although they noted that the origin of captive animals might be a factor in long-term survival. Specimens imported from more tropical regions such as Malaysia may be unable to survive the colder winters of the more northerly location.

Source: South China Morning Post; 25 February 2016

Varanus albigularis. South Luangwa National Park, Zambia. Photographed by **Roisin Morgan**.

Rosenberg's Monitor Spotted in Adelaide Hills

A rare heath monitor (*Varanus rosenbergi*) was sighted in the Adelaide Hills of South Australia. The animal was found on private property in the vicinity of Nairne and represents the first documented occurrence of this species in this area. *Varanus rosenbergi* is a threatened species whose range is highly fragmented and remains to be fully documented. Individuals are encouraged to report all sightings of this species to wildlife officials.

Source: The Murray Valley Standard; 17 May 2016

Komodo Dragon Population Continues to Decline

A recent field survey has shown a continued decline in the Komodo dragon (*Varanus komodoensis*) population within Komodo National Park. The 2015 survey encountered 3,014 animals, which is down from 3,092 in 2014 and 3,222 in 2013. Officials stated that this trend is principally being driven by declines on smaller islands that the dragons inhabit such as Nusa Kode and Gili Motang, as populations on the larger islands of Komodo and Rinca appear to be stable. This overall decline is in contrast to the discovery of several small populations in recent years; all part of the poorly documented Flores population. The cause of the decline appears to be a decline in deer, the dragon's principle prey, and it has been suggested that reintroduction programs aimed at increasing the deer population may be necessary. Other sources of pressure on dragon populations might include a heavy tourist presence in the park as well as disturbance from feral dogs.

Source: The Jakarta Post; 5 March 2016

Los Angeles Zoo Displays Perenties

The Los Angeles Zoo has recently acquired an adult pair of perenties (*Varanus giganteus*) from Taronga Zoo in Sydney, Australia after a two-year planning period. The species is rarely seen outside of Australia due to regulations on the export of Australian wildlife. Both

Varanus giganteus. Captive, Los Angeles Zoo. Photographed by **Nathan Havercroft**.

animals are now on public display in the zoo's Australia wing.

Source: Hollywood Patch; 25 April 2016

Komodo Dragon at Zoo Miami Dies

Khaos, an 18-year-old male Komodo dragon (*Varanus komodoensis*) has died at Zoo Miami. The animal was originally hatched at the zoo and went on to be used as an education animal. Zoo officials stated that he had been a particularly calm and relaxed animal, which made him a great animal ambassador for public outreach events. The cause of death has not been announced, although zoo officials stated Khaos had been suffering from various health issues over the last two years. At one point euthanasia had been considered, but this was dismissed after hydrotherapy treatments resulted in an improved quality of life.

Source: Miami Herald & Sun Sentinel; 24 May 2016

Komodo Dragon's Reproductive Tract Removed

A female Komodo dragon (*Varanus komodoensis*) at the Virginia Aquarium & Marine Science Center has had its reproductive tract surgically removed after an ultrasound indicated abnormalities. The nine-year-old animal named Jude had unsuccessfully mated three times with one of the resident males, twice resulting in eggs that failed to hatch. After laying eight eggs in April 2016, zoo officials noted that her energy and appetite had decreased, and sought a diagnosis. It is unknown whether the animal will remain at the Virginia facility or, since she is no longer able to breed, be returned to San Antonio where she originated. It is also unclear whether a reproductively viable female will be brought in to replace her.

Source: The Virginia-Pilot; 27 May 2016

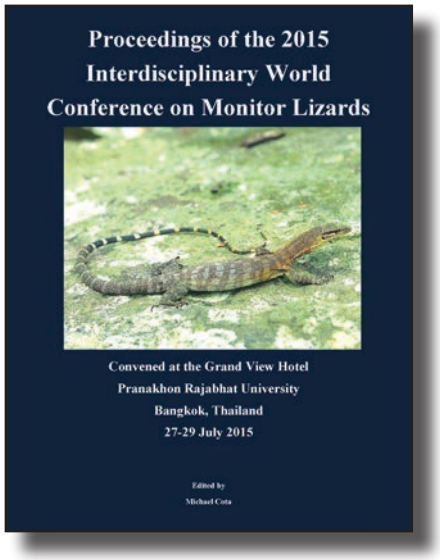
New Species of Blue-tailed Monitor Lizard Discovered

A new species of blue-tailed monitor lizard belonging to the *Varanus* subgenus *Euprepiosaurus* was recently discovered and described from the island of Mussau, northeastern Papua New Guinea in a recent issue of *ZooKeys*. The new species, *V. semotus*, resembles other members of the blue-tailed monitor group, but is distinguishable from related species by morphological and molecular genetic characters. According to molecular analysis, it has been isolated from its most recent common ancestor for one to two million years.

Source: Weijola, V., S.C. Donnellan & C. Lindqvist. 2016. A new blue-tailed monitor lizard (Reptilia, Squamata, *Varanus*) of the *Varanus indicus* group from Mussau Island, Papua New Guinea. ZooKeys 568: 129-154.

Varanus semotus. Mussau Island, Papua New Guinea. Photographed by **Valter Weijola.**

Proceedings of the 2015 Interdisciplinary World Conference on Monitor Lizards



The Proceedings of the 2015 Interdisciplinary World Conference on Monitor Lizards, held in Bangkok, Thailand is scheduled to be published in July 2016. The cost is expected to be no more than $30 US plus shipping from Thailand. There will be a limited number of copies printed, based on interest.

Those interested in purchasing a copy of the proceedings or those that attended the conference that desire extra copies, please contact Michael Cota at Herpetologe@gmail.com.

Varanus gouldii. Glenmorgan, Queensland. Photographed by **Jake Meney**.

"The Trade in exotic Reptiles in Germany Using the Example of Monitor Lizards (Family Varanidae)": A Report on the Interdisciplinary Meeting of the German Federal Agency for Nature Conservation, 18-21 April 2016

Background and Problem

The European Union, and especially Germany, rank among the main consumer countries for exotic reptiles world-wide. This particularly applies to the trade in live monitor lizards and products made from their skins which are protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). There exist, however, no reliable population status evaluations for the majority of the ca. 80 currently recognized species based on IUCN Red List criteria. Moreover, knowledge about the taxonomy and systematics of monitor lizards has advanced considerably in recent years. These circumstances must also be taken into account by the responsible CITES-authorities when making non-detrimental findings for the utilization and international trade in monitor lizards and their products. In light of these issues, experts from research institutes, public authorities, museums, ministries, zoos and nature conservancies were invited to take part in an interdisciplinary exchange on the theoretical fundamentals and practical aspects of the monitor lizard trade in Germany and the EU in order to develop proposals for the sustainable use of this charismatic reptile group. Twenty participants from Austria and Germany attended the workshop, held at the International Academy for Nature Conservation on the island of Vilm, Germany from 18-21 April 2016.

Workshop Schedule

On the evening of 18 April 2016, workshop participants had the opportunity to become acquainted with each other, before being welcomed by Ulrich Schepp (BfN), who together with Harald Martens (BfN) had conceived and initiated the workshop. Cornelia and Axel Paulsch from the Institute for Biodiversity–Network e.V. (Regensburg) jointly chaired and organized the meeting over the following days.

Presentations serving as the basis for later discussions began on the morning of 19 April after a warm welcome address by Gisela Stolpe (BfN). Ulrich Schepp (BfN) gave the opening presentation, entitled "*An Introduction to the Trade in Exotic Reptiles from the BfN's Point of View Using the Example of Monitor Lizards*". It became obvious that Germany – second only to the United Kingdom, but before France, Spain, the Czech Republic, the Netherlands and Austria – is a main importing country for live monitor lizards, and after France and Italy, it is the third largest importer of monitor lizard skins and leather products in the European Union. In addition, Germany has developed into the main hub for the trade in live reptiles in the EU due to the high number of regularly occurring reptile fairs. Germany, therefore, bears a special responsibility in this field. It is particularly conspicuous that newly described island endemics from Indonesia have become focal species of the live reptile trade and are often offered as captive-bred specimens with the source code "F" (= "Farmed") according to CITES. Experience shows that misdeclarations in the source code take place. Consequently, small native populations of endemic monitor lizard species restricted to small islands face serious threats through the trade in live animals. In turn, the reptile leather industry concentrates on large-growing CITES Appendix II species such as *Varanus salvator*. In these cases non-detriment findings (NDFs) have to be adjusted and scrutinized according to novel taxonomic insights.

Unfortunately, the next scheduled talk by Mathias Lörtscher (CITES Switzerland) on "*The Trade in Reptile Leather Products – Activities of the CITES Animals Committee*" was cancelled. Instead, the occasion was used by the participants for a discussion.

Prior to the first coffee break, André Koch (State Natural History Museum Braunschweig/Co-Chair of the IUCN Monitor Lizard Specialist Group) reported on "*Taxonomy and Species Knowledge as Prerequisite*

for efficient Species Conservation based on the Example of Indo-Australian Monitor Lizards". Here, the main emphasis was on taxonomic novelties and developments within three groups of monitor lizards relevant to the trade, namely the *V. prasinus*, *V. salvator* and *V. indicus* species groups. These species groups have experienced considerable additions since the 1990s. This, however, poses enormous challenges for enforcement authorities with regard to the identification and verification of the taxonomic identities of traded monitor lizards. It was shown that the diversity of monitor lizards will continue to rise in the future although only a few international taxonomists specialize in this squamate group. The job insecurity situation of many taxonomists forms an additional obstacle to the advancement of scientific knowledge.

Next, Mark Auliya (Helmholtz Centre for Environmental Research-UFZ/Co-Chair of the IUCN Monitor Lizard Specialist Group) gave a presentation entitled "*Legislative Loopholes and Scientific Uncertainties Threaten Endemic Monitor Lizard Species – the Trade with Monitor Lizards in Europe and Germany*". He argued that current policies regulating the international trade in wildlife (CITES, European Wildlife Trade Regulations), along with national and international management measures, appear ineffective for maintaining viable monitor lizard populations, especially those endemic to eastern Indonesia. Within the EU, Germany imports the highest number of varanid species. Therefore, scientific authorities are encouraged to monitor harvest levels and export quotas and thus ensure sustainability. For this purpose, making non-detriment findings is required for all CITES Appendix II species. However, these investigations and analyses are not in place despite the fact that regular exports are annually documented in the CITES trade database (http://trade.cites.org), and most species are not protected at the national level. In particular, the intense commercial harvest of *V. salvator* ssp. in recent decades for the leather industry requires a precise monitoring system that can trace skins along the trade supply chain, as well as a study of population genetics to examine the taxonomic status of populations involved in the skin trade.

After the lunch break, participants were given a guided tour around the island of Vilm. Horst Korn (BfN) enthusiastically discussed various aspects of the long and dynamic history of the island with its various uses from its origins as a monastery several hundred years ago to the holiday residency of Erich Honecker and his Socialist Unity Party (SED) members during the former DDR regime. After the German reunification in 1989, Vilm was declared a nature reserve and now houses a branch office of the Federal Agency for Nature Conservation (BfN). Each year about 60-70 conferences and meetings are held at the International Academy for Nature Conservation on Vilm.

Following this informative and pleasant walk around the island, Thomas Ziegler (Cologne Zoo) gave a presentation entitled "*The Keeping of Monitor Lizards, Captive Breeding, and the Role of Zoological Gardens*". From the perspective of the Cologne Zoo, which has a primary focus on monitor lizards, he detailed some of the critical aspects and challenges to keeping and breeding monitor lizards in captivity. He highlighted that relatively few breeding programs exist despite the large number of currently recognized monitor lizard species. He also referred to the Meeting of the Reptile Taxon Advisory Group (RTAG) of the European Association of Zoos and Aquaria (EAZA), which would be held in Zagreb, Croatia the following week, intending to develop a Regional Collection Plan (RCP) for the monitor species kept in European zoos, and further breeding initiatives for potentially threatened species, such as *V. macraei*. The 14 monitor lizard species currently kept at Cologne Zoo, as well as the zoo's various breeding successes and further activities involving monitor lizards were discussed. These include the creation of a branding with the World Association of Zoos and Aquariums (WAZA), the initialization and emendation of monitor lizard keeping in wildlife stations and zoos in Vietnam, as well as collaborations with wildlife officials regarding confiscations and training. The participants of the meeting were impressed by the statistics presented on live monitor lizards kept in German and European zoos and in zoos worldwide. Many zoos concentrate on only a few species while other, often threatened monitor species are still under-represented.

Sandra Altherr (Pro Wildlife) dedicated her talk entitled "*Trade and Keeping of Monitor Lizards – Problems with Sustainable Use and Species-appropriate Keeping*" to the exploitation of monitor lizards for the pet trade. At first, the five most commonly sold species of monitor lizard in the international trade in live reptiles were introduced: *V. salvator*, *V. exanthematicus*, *V. niloticus*, *V. rudicollis* und *V. dumerilii*. Within the EU, Germany is the second largest importing nation of live monitor lizards after England. Globally, more than 50% of all monitor lizards traded as pets are still wild-caught. According to the UNEP-WCMC database, nearly the same amount originates from "ranching", while only a very small percentage are captive-bred

Attendees of the Interdisciplinary Meeting of the Federal Agency for Nature Conservation on Vilm Island, Germany, 18-21 April 2016.

or "farmed". Particularly problematic with respect to species conservation aspects are dealers offering wild-caught *V. salvadorii* because exports from Indonesia are only allowed for F2 specimens. There has been a ban on imports into the EU since 1999. The same applies to *V. beccarii*, *V. dumerilii* and *V. jobiensis* that are often sold as adult specimens. In these cases, it seems very unlikely that "farmed" specimens are being offered. In addition, the trade in Indonesian island endemics such as *V. beccarii*, *V. boehmei*, *V. macraei*, *V. reisingeri*, *V. obor* and *V. kordensis* is alarming due to their restricted natural distribution ranges. Despite the fact that EU member states are committed to the precautionary principle and imports are only eligible after conducting non-detrimental findings, this is often not possible due to a lack of relevant information. Therefore, a revision of the current practice of issuing import permits is long overdue.

Uwe Krebs represented the German Society for Herpetology and Herpetoculture (DGHT) with his talk on "*The Keeping of Monitor Lizards in Captivity from the Perspective of the DGHT*". He concluded that official monitor lizard import statistics over a decade (1998-2007) demonstrated that 95% of all imports were monitor skins. Hence, the percentage of live specimens in the trade seems to be too small to be able to threaten natural populations. Island endemics, however, should be excluded from this assumption. Krebs rejected the common criticism of private monitor keepers. Instead, he highlighted the efforts of DGHT members and monitor keepers, such as the DFG-funded international and interdisciplinary monitor lizard conferences. In this context he also referred to successful captive breedings (including world's first captive breedings) of many monitor species over the last several decades. In addition, Krebs pointed out that the reptile leather trade and habitat destruction are the primary threats to wild populations. Therefore, he prompted joint efforts against leather products made of monitor skins and posed the question of creating farms (similar to existing crocodile facilities) which could provide a sustainable approach to produce certified skins of those species in highest demand (i.e. *V. salvator* and *V. niloticus*). In the end, Krebs stressed that the positive and important "human-nature relationship" is not exclusive, and is also developed to a certain degree by reptile enthusiasts and this should not be hindered.

The final talk of the afternoon was given by Stefan

Ziegler (WWF) on "*Stable Isotopes as Markers for Determining the Origin of Reptiles*". He presented partly preliminary results on Chinese crocodile lizards (*Shinisaurus crocodilurus*) and water monitors (*Varanus salvator*) that could be used in the future to keep track of specimens in the pet trade. Hence, for Chinese crocodile lizards it was possible to distinguish between wild-caught and captive-bred specimens due to their δ13C and δ15N stable isotope values. Using additional simulated samples, differentiation between captive-bred specimens and those collected from the wild was possible with high probability. This is due to the fact that under controlled feeding conditions in captivity the ranges of isotopes are narrower and the pattern more homogeneous than in wild populations. These results support the development of a reference frame of breeding facilities, which specimens of dubious origin can be compared with. In contrast, preliminary results of the stable isotopes in water monitors studied from Java and the Lesser Sunda Islands were far less significant. They showed a high variability in the patterns of isotopes. Therefore, determining the origin of wild-caught specimens of widespread species is difficult.

The evening hours were used by the participants for further exchange, and the highlight of the evening was a screening of the television documentary "Lizard Kings", featuring the work of Eric Pianka on Australian monitor lizards.

The second day of the meeting was used to work out recommendations for improving the sustainable use and control of the international trade in monitor lizards. It soon became obvious that enforcement authorities such as Customs and the Federal Agency for Nature Conservation, are often confronted with uncertainties involving the taxonomic identities of monitor lizards in the trade. Therefore, there is a critical need for an easily understandable and well-illustrated identification guide with species-specific characters and information including, for example, reproductive and life span data for the respective monitor lizards. The production and funding of such an ID guide, which already exists in a similar format for the turtles of Southeast Asia, were discussed. The various talks given at the workshop will be published in the BfN journal "*Naturschutz und Biologische Vielfalt*" (= Nature Conservation and Biological Diversity).

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Observation in the Wild of the Poorly-Known *Varanus yuwonoi*

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Abstract - New information on *Varanus yuwonoi* is presented based on an in situ observation. The known range on Halmahera is extended south to Weda and an incidence of nocturnal activity is documented.

Introduction

Varanus yuwonoi is a recently discovered monitor from the island of Halmahera, Indonesia (Harvey & Barker, 1998) that remains poorly known. This species is reported from only a few locations, all on the north-western arm of the island, specifically (1) its type locality near Jailolo and nearby Tanah Putih (between Matui and Jailolo) (Harvey & Barker, 1998), and (2) near the villages of Akesahu and Kao, on the western side of Kao Bay (Weijola, 2010; Fig. 1). The habitat of three specimens was described as primary and secondary lowland forest below 50 m asl (Weijola, 2010), and the holotype was found between 50 – 300 m asl (Harvey & Barker, 1998).

The conservation status of *V. yuwonoi* has yet to be assessed by the IUCN (IUCN, 2015), but is described as rare by Koch *et al*. (2013). This attractive multi-hued monitor is exported from Indonesia for the international pet trade (Koch *et al*., 2013) and is harvested by local hunters (Weijola, 2010), raising concerns about its vulnerability to overexploitation (Koch *et al*., 2013).

There is a great paucity of information about this species in general, and its natural history in particular. Some of its natural history has been described based on interviews with local people (Harvey & Barker, 1998; Weijola, 2010), and Weijola (2010) speculated on its ecology, hypothesizing a preference for ambush hunting based on a low encounter rate in the wild and information from local trappers indicating that the species can be snared around Megapode nests. We are unaware of any first-hand accounts of this species' behavior in the wild.

Here, we detail an observation of a wild *V. yuwonoi* on Halmahera. This observation is significant because it extends the species' known range, contributes information about its habitat, and to our knowledge, is the only first-hand description of its behavior in the wild.

Observation

We encountered a single *V. yuwonoi* on 25 January 2014 at approximately 2100 h. The weather was overcast (typical of the preceding four days) and approximately

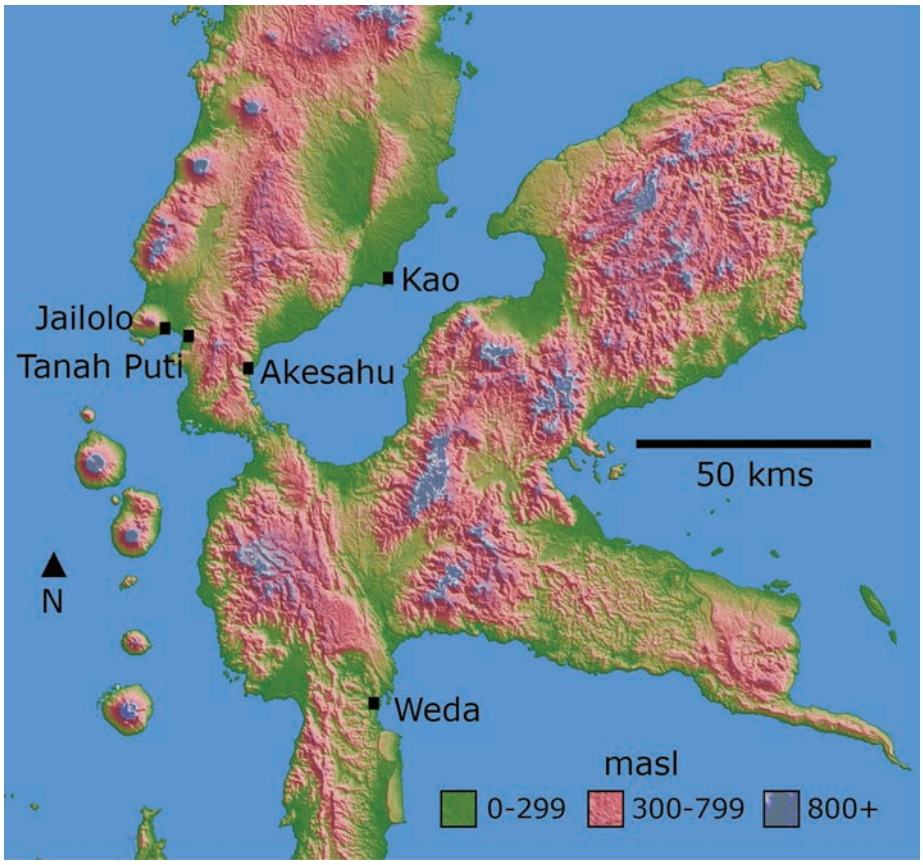

Fig. 1. Map of central Halmahera, showing documented locations of *Varanus yowonoi*.

26 ℃. The location was approximately 12 km north of Weda, on the north-eastern part of the southern arm of Halmahera (0°25′32.93″ N, 127°54′10.02″ E), approximately equidistant along a footpath between Weda Resort and Desa Kobe. On one side of the path the slope dropped a few meters into a low, extensive mangrove forest, and on the other side was a low ridge covered with secondary rainforest, rising and then descending to the coast within about 50 m. The monitor was detected by the sound of its movement and was observed for about five minutes as it walked along the ground from near the mangrove edge upslope through the rainforest towards the ridge top and coast. Its manner was consistent with typical foraging behavior of monitors during daylight, moving leisurely, seeming alert and unalarmed.

The size of the specimen was estimated at SV 450 mm and a number of photographs were taken (Figs. 2-4).

Discussion

The habitat recorded here is consistent with previous findings for *V. yuwonoi* (Weijola, 2010). Since tropical rainforest is the predominant vegetation cover of the island, it is reasonable to speculate that *V. yuwonoi* may be distributed across the entire island of Halmahera. However, until now, all specimens were known only from the north-western arm of Halmahera. Our finding extends the known range south toward the northern end of Weda Bay.

Although all members of the family Varanidae are primarily diurnal (Bennett, 1998), there are a number of reports of nocturnal activity amongst monitors (Irwin *et al*., 1996; Trembath, 2000; Cota *et al*., 2008; Rhind *et al*., 2013). In many cases these appear to document atypical behavior; however, some recent studies have revealed that monitors can incorporate nocturnal activity into their lifestyles (Uyeda *et al*., 2013; Rismiller *et al*., 2010). Two individuals of *V. salvator* on Tinjil Island, Indonesia actively foraged in the hours between 0128 and 0525 h, and this may be a mechanism imparting a foraging advantage over other individuals foraging only by day (Uyeda *et al*., 2013). Most interestingly, Rismiller *et al*. (2010), in their detailed examination of the reproductive biology of *V. rosenbergi*, found that 29 of the 30 females studied oviposited in the first four hours after nightfall. These studies and our observation suggest that some monitors have the ability, both at

Fig. 2. *Varanus yuwonoi*, near Weda, Halmahera, Indonesia. Photographed by **J. Lindley McKay**.

Fig. 3. Head and body of *Varanus yuwonoi*, near Weda, Halmahera, Indonesia. Photographed by **Olga Milenkaya**.

Fig. 4. Head of *Varanus yuwonoi,* near Weda, Halmahera, Indonesia. Photographed by **Olga Milenkaya**.

an individual and population level, to engage in some degree of nocturnal activity.

More research on the ecology and conservation of *V. yuwonoi* is needed. This and other species in the Moluccas are lacking baseline data on which sound conservation and management decisions can be made.

Acknowledgements - We thank Rob and Linda Sinke of Weda Resort for their generosity and ongoing commitment to conservation on Halmahera, and the staff at Weda Resort for extending their warmth and hospitality to us during our stay. We also thank Sam Sweet and Valter Weijola for their reviews and assistance, resulting in the improvement of this manuscript.

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A Nest of *Varanus mertensi* (Glauert, 1951) in Northern Australia

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Abstract – Published records of nesting ecology facilitate the comparison of important life history components of monitor lizards, and can reveal the diversity in their nesting strategies. However, the nesting habits of most monitor lizards are unknown. *Varanus mertensi* is a medium-sized, semi-aquatic monitor lizard that occurs across much of Northern Australia. Knowledge of the nesting habits and reproduction of this species is limited to observations of captive animals, museum specimens and a laboratory analysis of reproductive hormones. Here we report on the first record of a *V. mertensi* nest in the wild; we provide comments on the nesting behavior and timing of reproduction in the species.

Introduction

In oviparous reptiles without parental care, the timing of reproduction and choice of nest site represent key components in a female's reproductive ecology, because they determine the incubation conditions and thus the hatching success and fitness of the offspring (Resitarits, 1996). Previous studies suggest that the reproductive cycle of monitor lizards may be linked to the seasonal patterns of rainfall in the Wet/Dry tropics in Northern Australia. While several explanations have been proposed, the reasons for the diversity in seasonal reproductive strategies in Australian monitor lizards remain largely unknown (Shine, 1986). Unfortunately, the cryptic nesting habits of monitor lizards make locating nests particularly difficult (Doody *et al*., 2014).

One tropical monitor lizard of which the reproductive and nesting biology is still largely unknown is Mertens' water monitor (*Varanus mertensi*). *Varanus mertensi* is a medium-sized semi-aquatic monitor lizard that occupies riverine and other wetland habitats across northern Australia (Christian 2004; Cogger 2014). The species is believed to be in decline due to predation on the invasive and poisonous cane toad (*Rhinella marina*), and is listed as a threatened species in the Northern Territory (Griffiths & Mckay 2007; Doody *et al*., 2009; Doody *et al*., 2014). While previous studies have attempted to locate nests of *V. mertensi* (see Mayes, 2006), the only reference to nesting in the wild by *V. mertensi* is from the secondary literature: Swanson (1976) claimed that the species nests underground and lines the chamber with vegetation. Herein we provide the first detailed record of nesting by *V. mertensi* in the wild and discuss how the observation fits the proposed timing of nesting in the species, and how it differs from nesting in other monitor lizards.

Fig. 1. The embankment in which the *Varanus mertensi* nest was located. The location of the nest has been highlighted by the blue circle.

Observation

On 6 July 2015, a nest chamber was accidentally disturbed during excavations near Humpty Doo in the Northern Territory, Australia (-12.5826; 131.1583, WGS84). The nest was found in the side of an embankment approximately 1.5 m above the water line (Fig. 1). The nest chamber was located at a depth of ~30 cm below the surface and contained ten eggs. The burrow entrance and excavations leading to the chamber could not be located due to the long period that had elapsed since oviposition. The embankment was located next to a seasonally inundated pond that was lined with spear grass (*Sorghum* sp.), and was made up of a sandy clay soil, which appeared to have been previously disturbed, possibly during construction of the embankment. The location of the embankment was situated approximately 150 m from an ephemeral stretch of the Howard River and approximately 70 m from the edge of the riparian vegetation.

As the clutch was excavated, two eggs were accidentally ruptured and the embryos were later used for species identification and staging (Figs. 2 & 3). The two embryos had snout-vent lengths of 106 and 110 mm and total lengths of 239 and 245 mm, respectively. The presence of juvenile pigmentation, the shape of the head and the location of the hemipenes within the cloaca indicated that the embryos were 'near hatching' (Gregorovicova & Zahradnicek, 2012). Unfortunately, the lack of an egg tooth and loss of the yolk sac during collection, meant that a more accurate staging of the embryo was not possible.

Results and Discussion

Timing of reproduction in monitor lizards in the Wet/Dry tropics of northern Australia suggest a pattern that coincides with seasonal rainfall, but the reason for such seasonality remains unresolved. James & Shine (1985) proposed that the timing of nesting should coincide with the optimal thermal conditions for incubating eggs, while Shine (1986) proposed that by nesting in the dry

Figs. 2 & 3. Dorsal and ventral views of one of the embryos from the disturbed clutch.

season females avoided the potentially catastrophic effects of floods. James *et al*. (1992) suggested that reproduction in some tropical monitor lizards might be timed to ensure optimal prey availability for hatchlings. The precise reproductive phenology of *V. mertensi* is unclear. Our observation broadly supports Shine (1986), who suggested that *V. mertensi* in the Northern Territory nest early in the dry season, based on records of gravid *V. mertensi* that were collected in April (n=2) and June (n=1). However, Shine (1986) also noted that a number of females appeared to be in reproductive condition between December and March. In contrast, Mayes (2006) observed mating *V. mertensi* in December and February and found that *V. mertensi* in the East Kimberley Region of Western Australia were gravid in January (n=2). Mayes (2006) and Mayes *et al*. (2007) also found that *V. mertensi* underwent vitellogenesis in the peak of the wet season and proposed that oviposition occurred late in the wet season (between March and June). Blamires (1999) documented an attempted mating by *V. mertensi* in the Northern Territory in July and proposed that the reproductive period for the species may extend beyond that proposed by Shine (1986) and Mayes (2006). The seemingly contradictory observations of reproductive phenology in *V. mertensi* may suggest a reproductive phenology that is much less seasonal than previously thought. A more comprehensive study targeting nests and gravid females is needed to confirm the reproductive phenology of the species.

There are no records of nests of *V. mertensi* in the primary literature, and while our report is limited to a single nest, it represents a contribution to the cryptic nesting ecology of female *V. mertensi*. As a group, monitor lizards exhibit a remarkably diverse range of nesting patterns that may represent adaptations to local environments. For example, some *V. komodoensis* use megapode mounds as nests (Jessop *et al*., 2004; Ariefiandy *et al*., 2015), while *V. varius* and *V. rosenbergi* are known to utilise active termitaria (Carter 1999, Ehmann *et al*., 1991, King & Green 1979). Some monitor lizards (*i.e*., *V. tristis*, *V. griseus*) construct relatively simple nesting burrows (Thompson & Pianka, 1999; Tsellarius & Menshikov, 1995) while *V. panoptes* and *V. gouldii* construct elaborate nests with helical burrows and nesting chambers that are deeper than that of any vertebrate (Doody *et al*., 2014; 2015;., unpubl. data). Our observation confirms that *V. mertensi* constructs a relatively shallow and simple nesting burrow; however, we found no evidence to support the use of vegetation to line the nest chamber as reported by Swanson (1976). Our *V. mertensi* nest was located 150 m from the Howard River in habitat that would normally be considered suitable for *V. mertensi*. The choice of nest site may have been driven by the need to avoid flooding during the wet season and/or some specific requirements of hatchlings following their emergence. Or, perhaps the mother foraged in the seasonally inundated pond during the nesting period and chose to nest nearby. The female's choice to nest at an anthropogenically disturbed site (an artificial embankment) may be indicative of the species' nesting requirements and explain why the species persists along artificial waterways (Griffiths & McKay, 2007; Mayes, 2006).

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Perceptions of Sundanese Men Towards the Consumption of Water Monitor Lizard Meat in West Java, Indonesia

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Abstract - Water monitor lizard (*Varanus salvator*) meat is occasionally consumed in Java, Indonesia, mainly as a novelty food or because of perceived medicinal properties or health benefits. Islam is the main religion on Java and given its carnivorous diet, *V. salator* meat is generally perceived to be unfit for consumption by Muslims. Discussions with 17 Sundanese men from the southern part of West Java with first or second-hand knowledge of the consumption of *V. salvator* meat showed that the main reasons for consumption are (a) its novelty, (b) perceived medical properties or health benefits, and (c) perceived aphrodisiac properties. Apart from one, the informants did not see any religious, moral or legal reasons not to consume *V. salvator* meat.

Introduction

Uyeda *et al*. (2014) reported on the consumption of Asian water monitor lizard (*Varanus salvator*) meat in two villages in the province of Banten, Java, Indonesia, where 14 informants provided information about its uses. *Varanus salvator* meat was stated to be a remedy for common skin ailments including eczema, and two participants had eaten monitor lizard meat as a source of protein. Uyeda *et al*. (2014) were of the opinion that *V. salvator* meat was seldom used in Indonesia, and singled out three largely Christian ethnic groups (Bataks in Sumatra, Dayaks in Kalimantan and Minahasans in Sulawesi) as ones that did. They were of the opinion that monitor lizards were especially rarely eaten in predominantly Muslim areas due to religious restrictions on its consumption. Nijman (2015), based on a review of the literature and accounts on the Internet, found that the use of water monitor meat was far more widespread in Java than the report from Uyeda *et al*. (2014) indicated, and estimated that at least 50,000 *V. salvator* were consumed annually on Java alone. These contrasting reports suggests that perceptions towards the consumption of *V. salvator* may differ between and within ethnic groups, similarly to what has been found by Bolton (1972) for the Orang Asli in Peninsular Malaysia.

Varanus salvator is not included on Indonesia's list of protected animals (Noerjito & Maryanto, 2001), and thus its consumption by any given individual is legal. However, trade in unprotected species is subject to a quota system (Siswomartono, 1998) and it is highly unlikely that the proprietors of food stalls or restaurants serving *V. salvator* meat have received part of these quotas (Nijman, 2015). This makes the selling of water monitor meat illegal. However, the trade in *V. salvator* meat is open, and to the best of my knowledge no one has ever been prosecuted for trading in it. The Sundanese (*i.e*., the people that live in western Java where both Uyeda *et al*. and I work) are largely Muslim (*i.e*., over 97%: BPS, 2010), and just like all carnivore meat it is generally believed that monitor lizard meat is *haram* (forbidden or proscribed by Islamic law). However, in Indonesia, some imams and Islamic scholars have equated the monitor lizard to the Dhabb mentioned in the Koran, and concluded that its meat is *halal* (permissible for Muslims to eat) (Ahlussunnah, 2013).

Here, a report is given on the perceptions of ethnic Sundanese men living in the southern part of the province of West Java towards the consumption of *V. salvator* meat. The meat is served primarily in specialised 'novelty-food' restaurants or food stalls, which are

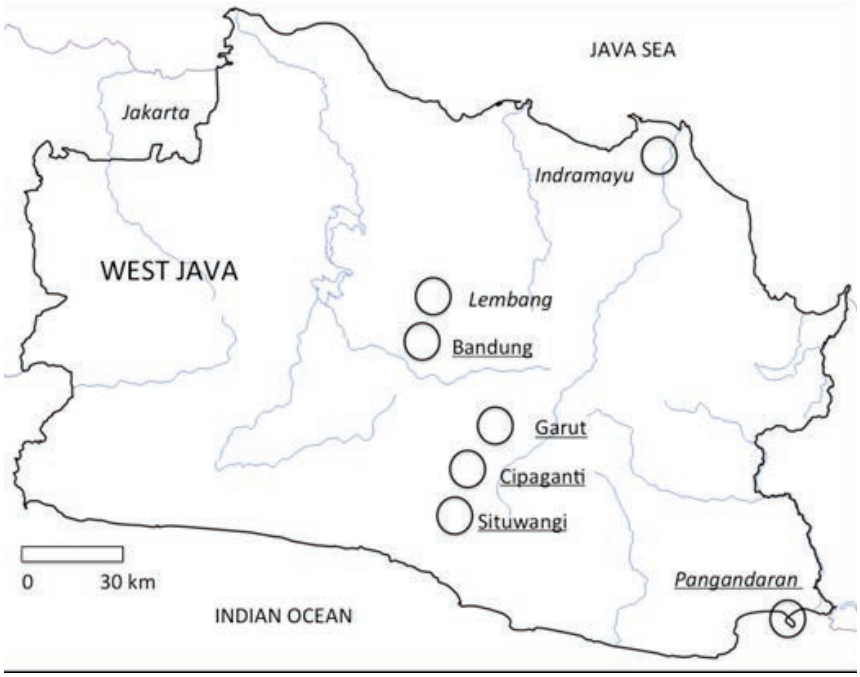

Fig. 1. The province of West Java, Indonesia, with survey locations (underlined) and towns where water monitor lizard meat is sold (Italics) according to local informants.

concentrated in a few geographic localities. Apart from a novelty food, and a remedy for skin ailments, it is widely believed that it can cure asthma and, more commonly, that it acts as an aphrodisiac.

Methods

Between 13 and 22 December 2015 the southern part of West Java, Indonesia, was visited and information was gathered on the use of and perceptions towards the consumption of *V. salvator* (locally known as *biawak* in Bahasa Indonesia or *bayawak*/*biayawak* in Bahasa Sunda). Seventeen men (2 in Bandung, 1 in Garut, 9 in Cipaganti, 2 in Situwangi, and 3 in Pangandaran; Fig. 1), with first- or second-hand knowledge of the consumption of water monitors were located opportunistically. All but two were born in the region, and considered themselves ethnic Sundanese (the exceptions being one man from Palembang in Sumatra, who had lived in Bandung for 12 years and one man from Jakarta who for work travelled through this part of West Java on a regular basis), and all were Muslim. Five men were farmers or farm workers, four were drivers, two were secondary school teachers, two were entrepreneurs, and one was a rickshaw driver; for the other three men their profession is not known. *Varanus salvator* is common in Pangandaran, and, according to informants, is present in Garut, Situwangi and parts of Bandung. None are present in Cipaganti, possibly because it is located at too high an altitude (1,300 m asl), but they are present at lower elevations. Discussions typically started with the topic of *sate kambing* (goat satay, a common dish, comprising of grilled meat on skewers, served with peanut sauce, sweet soya sauce, chillies and shallots) and *sate kelinci* (rabbit satay, a less common dish), after which the informant often brought up the topic of *sate biawak* / *bayawak* when asked about other satay dishes. Discussions were held with informants one at a time, as to ensure independence of the data (Lammertink *et al*., 2003), and lasted anywhere between 5 and 30 minutes (frequently the discussion moved to another topic such as the weather, economics or governance, only for the topic of *sate biawak* to be brought up again later on). All discussions were held in Bahasa Indonesia, with the key words being repeated in Bahasa Sunda. While I had a list of questions, given the informal nature of the discussions, not all were brought up with every informant.

Results

Two of the men had consumed *V. salvator* sate themselves – one in Lembang north of Bandung and one in Pangandaran; the other 15 had second-hand knowledge of the topic. Lembang was mentioned ten times as a place where water monitor meat dishes were offered for sale, Pangandaran three times and Indramayu, a coastal town known for its consumption of wild meat

Table 1. Use of water monitor lizard *Varanus salvator* meat by Sundanese in two provinces in western Java (West Java: this study, Banten: Uyeda *et al*. 2014). Informants often gave multiple reasons for consuming monitor lizard meat.

Reason for consumption	West Java (n=17)	Banten (n=14)
Novelty food	16	0
Skin ailments / eczema	6	12
Aphrodisiac	4	0
General health benefits	3	0
Asthma	1	2
Burns or sores	1	1

(McCarthy & Noor, 1996), and Jakarta, Indonesia's capital, once.

The most common reason for consuming *V. salvator* meat was because of it being different from other meats; *i.e,*. it was perceived as a novelty food (Table 1). In addition, it was widely perceived as a cure for different skin ailments, including eczema. One informant was of the opinion that it would help with the healing of burns, and one mentioned it to provide relief from asthma. Four informants stated that the main reason for consuming water monitor meat was because of its perceived aphrodisiac properties.

All but one of the informants (an Islamic teacher in Situwangi) were of the opinion that there was no religious or moral reason not to eat water monitor meat. It was perceived as a suitable meat fit for consumption, but many pointed out that given its perceived medical properties it was fine to use it, even if it was considered *haram* for normal consumption. The teacher was adamant that *V. salvator* meat was not fit for consumption for Muslims but it would be fine for non-Muslims to eat it. With four informants the legality of the trade in *V. salvator* was discussed. Two explicitly mentioned that given that the species was not protected under Indonesian law, its trade and consumption was legal. The two others likewise did not see any restrictions on the consumption and trade in *V. salvator*, with one adding that it was generally a common species and not in need of any protective measures.

Discussion

This reports adds to two previous reports on the trade of water monitors in Java (Uyeda *et al*., 2014; Nijman, 2015), most likely all referring to *V. s. bivittatus* which is endemic to Java and the Lesser Sunda Islands (Koch *et al*., 2013). The views expressed by Sundanese men in West Java are in part similar to those recorded by Uyeda *et al*. (2014) in Banten, with the difference that theirs was more focused on the meat's medicinal properties. The most common reason for consuming it in this study was that *V. salvator* meat was perceived as a novelty food, worthy of exploring by some. Just as Uyeda *et al*. (2014) reported, the number of informants that had actually consumed water monitor meat was small, *i.e*., between 12-14%, but its availability and its perceived benefits were widely known.

Lembang is well-known for its exotic dishes and the sale of *V. salvator* meat in this montane resort has been covered widely by the Indonesian media (Ahmad, 2013; Mutayasaroh, 2015). Given this, and its close proximity to the interview sites, it is therefore not surprising that Lembang was frequently mentioned as the place to eat *V. salvator* meat. According to Suganda (2011) in 2010 there was just one kiosk offering water monitor meat in the Lembang area, but according to the informants it is more widely available at present. As such, it is part of the trend of eating a wider range of exotic dishes, something that is known in Java as '*kuliner ekstrem*' (Nijman, 2015). A somewhat surprising finding of the present study was the wide acceptance of water monitor meat amongst the Muslim Sundanese. Partially because of its perceived health benefits or medical properties, *sate biawak* was widely seen as an acceptable source of protein for Muslims and non-Muslims alike, at least amongst those familiar with the dish. As indicated elsewhere (Nijman, 2015), trade in monitor lizards in Indonesia is subject to a quota system, and the sale of *V. salvator* meat should be regulated by the Regional Offices for the Natural Resources Conservation Agency (BKSDA) (Siswomartono, 1998), but this apparently is not the case. *Varanus salvator* is heavily exploited

in Indonesia, largely for skins, and the intense and continuous annual off-take levels has led to local population declines (Koch *et al*., 2013). While *V. salvator* is still common in Java (with, however, no information available about declining population trends: Koch *et al*., 2013), it is perhaps prudent for the Indonesian authorities to act upon their own wildlife trade regulations and start monitoring, and if necessary, curbing the unregulated trade in the species.

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A Preliminary Review of Monitor Lizards in Zoological Gardens

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Abstract - To gain an overview of monitor lizards held in zoos, including the species and numbers of individuals kept and the number of keeping institutions, we analyzed collection information from the Zoological Information Management System (ZIMS) database. Our analysis performed in March 2016 revealed that there are 50 species of monitor lizard kept globally in 308 zoos, with 39 of these species kept in a total of 131 European zoos. Eleven globally-kept species were lacking in European zoo holdings, and nine species were found exclusively in European zoos. Of the 79 currently recognized species of monitor lizard, 30 (38 %) are not currently held in zoos. Although ZIMS data are certainly not complete, there is a discernible trend that only a few species are widely kept by the zoo community; whereas most species are poorly represented or not represented at all. As only 22 monitor lizard species are listed in the IUCN's Red List of Threatened Species, there is not only an obvious need for additional Red List assessments, but also a disconnect between the species most frequently kept in zoos and their conservation status. As space and resources in zoos are limited, species selections should be well-planned. The current number of official zoo breeding programs for monitor lizards is comparatively low and there are further species, such as small island endemics, that require support through assurance colonies sustained by *ex situ* conservation breeding programs. We recommend considering a shift from commonly kept species towards species that are in greater need of support through zoo husbandry and breeding efforts. Improved networking between zoos and between zoos and authorities is another important prerequisite that can help zoos assemble breeding groups and exchange species that so far are only rarely kept by the zoo community.

Introduction

On the occasion of a recent workshop entitled, "The Trade in Exotic Reptiles in Germany Using the Example of Monitor Lizards (family Varanidae)", which was organized by the Federal Agency for Nature Conservation (BfN) and took place from 18 to 21 April 2016 at the International Academy for Nature Conservation (INA) on the Island of Vilm, Germany, the senior author was invited to present a lecture on the husbandry of monitor lizards, conservation breeding, and the role of zoos. The Cologne Zoo has a strong focus on the husbandry of monitor lizards, with 14 species currently maintained in its terrarium section. Whereas the lecture primarily dealt with the current situation of monitor lizards in German zoos, several questions

arose, particularly how many species are kept in zoos globally, in what numbers, and in how many zoos? As a preliminary approach to answering these questions, we have compiled respective information from the Zoological Information Management System (ZIMS), an international record keeping database for zoological institutions, which we briefly present in the following account.

Methods

For this study, we analyzed 1) the species of monitor lizards held in zoos, 2) their individual numbers, and 3) the number of institutions currently keeping monitor lizards based on available data on living specimens from ZIMS. Many zoos subscribe to, and enter their collection data into ZIMS; however, not all zoos participate in ZIMS and the completeness of these data cannot be guaranteed, as some data may be obsolete or have not (yet) been entered. Thus, actual counts may be higher than those collected from ZIMS. This is also indicated, for example, by checking species holdings for further institutions in Germany and Europe using the websites, "Verband der Zoologischen Gärten e.V." (http://www.zoodirektoren.de/) and "Zootierliste" (http://www.zootierliste.de/). Here, additional species and holding institutions can be found; however, these websites also include some private zoos and animal rescue facilities. Our analysis examined the current status of monitor lizards maintained in zoos both in Europe and abroad, and was performed in March 2016. Species which were not specified in ZIMS (*Varanus* sp.) were omitted from analysis.

Results

According to our analyses from March 2016, a total of 1,535 monitor lizards belonging to 50 species were maintained globally by 308 zoos (Figs. 1 & 3), with 735 of these individuals representing 39 species kept in 131 European zoos (Figs. 2 & 3). Eleven globally-kept species were absent from European zoo holdings: *Varanus brevicauda*, *V. cerambonensis*, *V. flavescens*, *V. giganteus*, *V. nebulosus*, *V. ornatus* (listed as valid taxon in ZIMS despite recently being synonymized with *V. niloticus* by Dowell *et al*. 2016), *V. rosenbergi*, *V. scalaris*, *V. spinulosus*, *V. storri*, and *V. tristis*. In contrast, nine species were found only in European zoos: *V. auffenbergi*, *V. boehmei*, *V. caudolineatus*, *V. cumingi*, *V. glauerti*, *V. kingorum*, *V. primordius*, *V. similis*, and *V. yuwonoi*.

According to ZIMS, of the 79 currently recognized species of monitor lizard (after Uetz & Hošek, 2016), 30 (38 %) are not currently held in zoos: *V. bangonorum*, *V. baritji*, *V. bitatawa*, *V. bogerti*, *V. bushi*, *V. dalubhasa*, *V. eremius*, *V. finschi*, *V. glebopalma*, *V. hamersleyensis*, *V. juxtindicus*, *V. keithhornei*, *V. lirungensis*, *V. mabitang*, *V. marmoratus*, *V. mitchelli*, *V. nesterovi*, *V. nuchalis*, *V. obor*, *V. palawanensis*, *V. rainerguentheri*, *V. rasmusseni*, *V. samarensis*, *V. semiremex*, *V. semotus*, *V. sparnus*, *V. telenesetes*, *V. togianus*, *V. yemenensis*, and *V. zugorum*. It is possible that some zoos may keep some of these species but have not yet entered this information into ZIMS, or because recently described or resurrected taxa were listed under collective names, as may be the case for members of the *V. indicus* and *V. salvator* species groups.

The ten most common monitor species held in zoos globally were *V. komodoensis* (kept in 83 zoos), *V. prasinus* (61 zoos), *V. exanthematicus* (55 zoos), *V. acanthurus* (49 zoos), *V. salvator* (47 zoos), *V. albigularis* (40 zoos), *V. macraei* (36 zoos), *V. niloticus* (31 zoos), *V. salvadorii* (27 zoos), and *V. beccarii* (25 zoos) (Figs. 1 & 3). The greatest numbers of individuals held globally were of *V. komodoensis* (n = 205), *V. prasinus* (n = 152), *V. acanthurus* (n = 146), *V. macraei* (n = 117) (Figs. 4 , 6 & 7), *V. beccarii* (n = 84), *V. exanthematicus* (n = 84), *V. salvator* (n = 77), *V. salvadorii* (n = 60), *V. varius* (n = 60), and *V. albigularis* (n = 54). The rarest species in zoos on a global scale were *V. auffenbergi*, *V. boehmei*, *V. brevicauda*, *V. caudolineatus*, *V. cerambonensis*, *V. flavescens*, *V. kingorum*, *V. primordius*, *V. similis*, *V. spinulosus*, *V. storri*, and *V. yuwonoi* (each kept by only a single zoo), and *V. caerulivirens*, *V. pilbarensis*, *and V. scalaris* (each kept by only two zoos). The lowest numbers of individuals held globally were of *V. brevicauda*, *V. cerambonensis*, *V. flavescens*, *V. kingorum*, and *V. storri* (just single individuals), and *V. auffenbergi*, *V. caudolineatus*, *V. spinulosus*, and *V. yuwonoi* (two individuals each).

The most commonly kept species among European zoos were *V. prasinus* (kept in 30 zoos), *V. acanthurus* (29 zoos), *V. komodoensis* (26 zoos), *V. exanthematicus* (23 zoos), *V. macraei* (23 zoos), *V. salvator* (20 zoos), *V. niloticus* (19 zoos), *V. albigularis* (16 zoos), *V. indicus* (16 zoos), and *V. salvadorii* (15 zoos) (Fig. 2 & 3). The greatest numbers of individuals held in European zoos were of *V. acanthurus* (n = 87), *V. komodoensis* (n = 86), *V. macraei* (n = 84), *V. prasinus* (n = 69), *V. exanthematicus* (n = 42), *V. salvadorii* (n = 38), *V. beccarii* (n = 37), *V. indicus* (n = 31), *V. salvator* (n = 29), and *V. niloticus* (n = 26) (Figs 5 & 6). The rarest

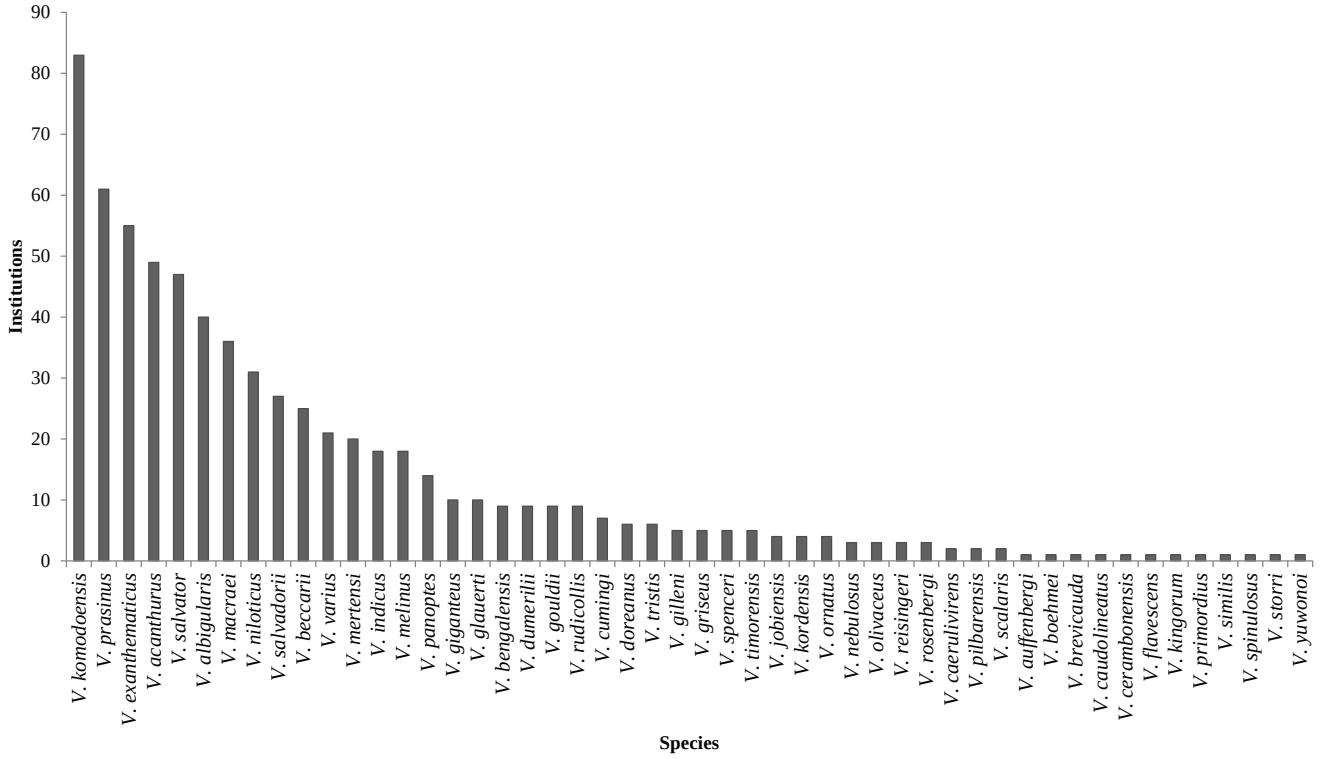

Fig.1. Number of zoological institutions maintaining live monitor lizards globally (after ZIMS).

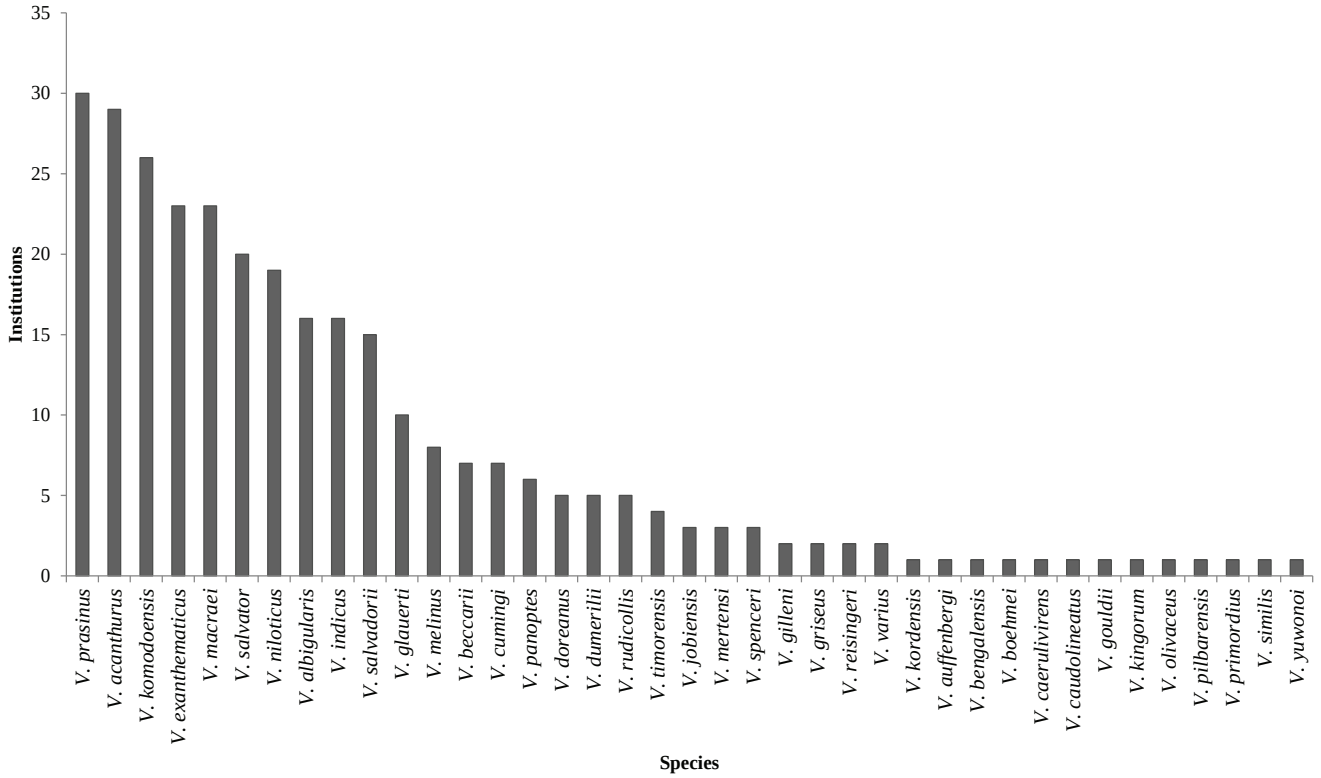

Fig. 2. Number of European zoological institutions maintaining live monitor lizards (after ZIMS).

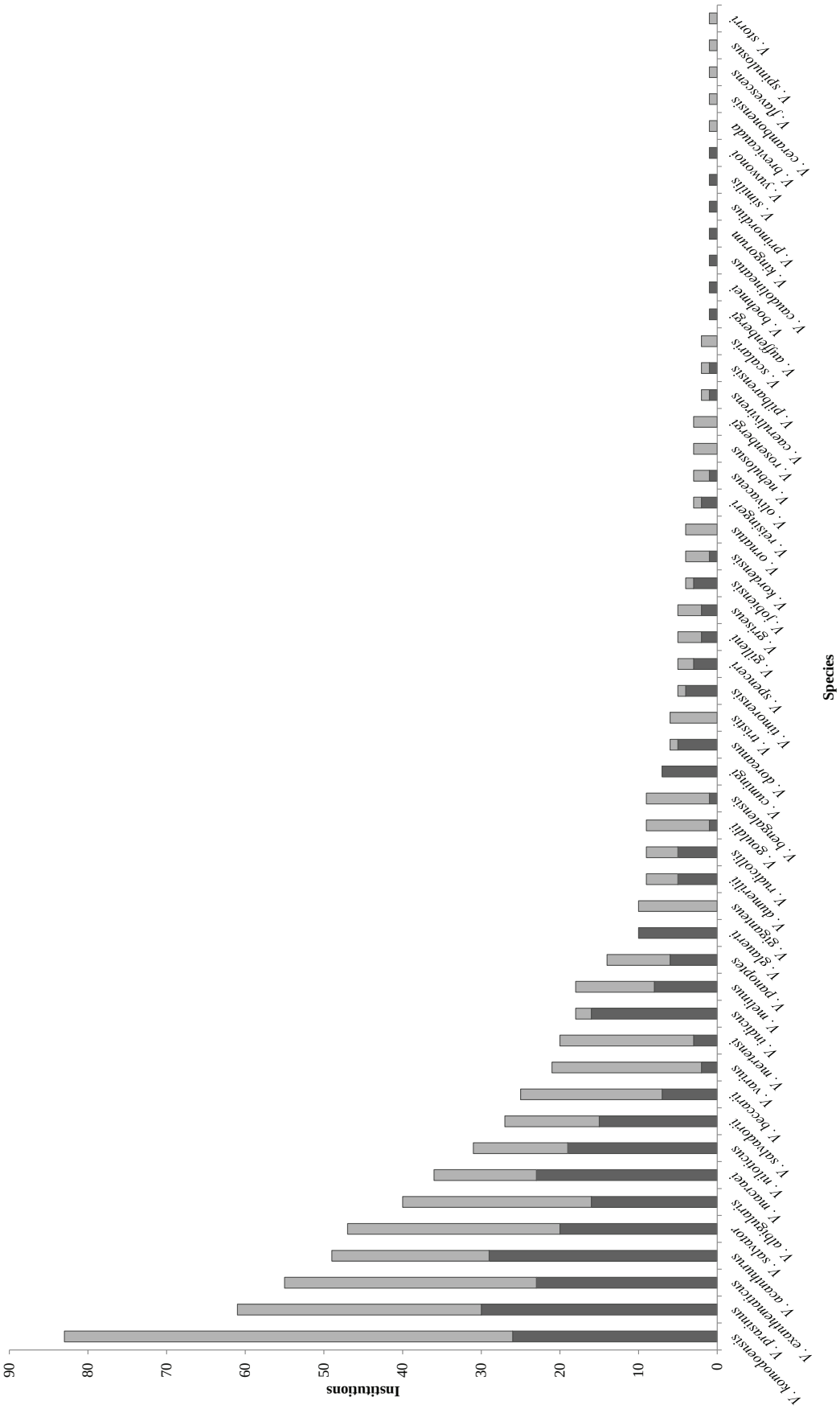

Fig. 3. Total number of zoological institutions keeping monitor lizards globally (light grey column) with European zoos displayed as a subset of the global population (dark grey columns inside light grey columns) (after ZIMS).

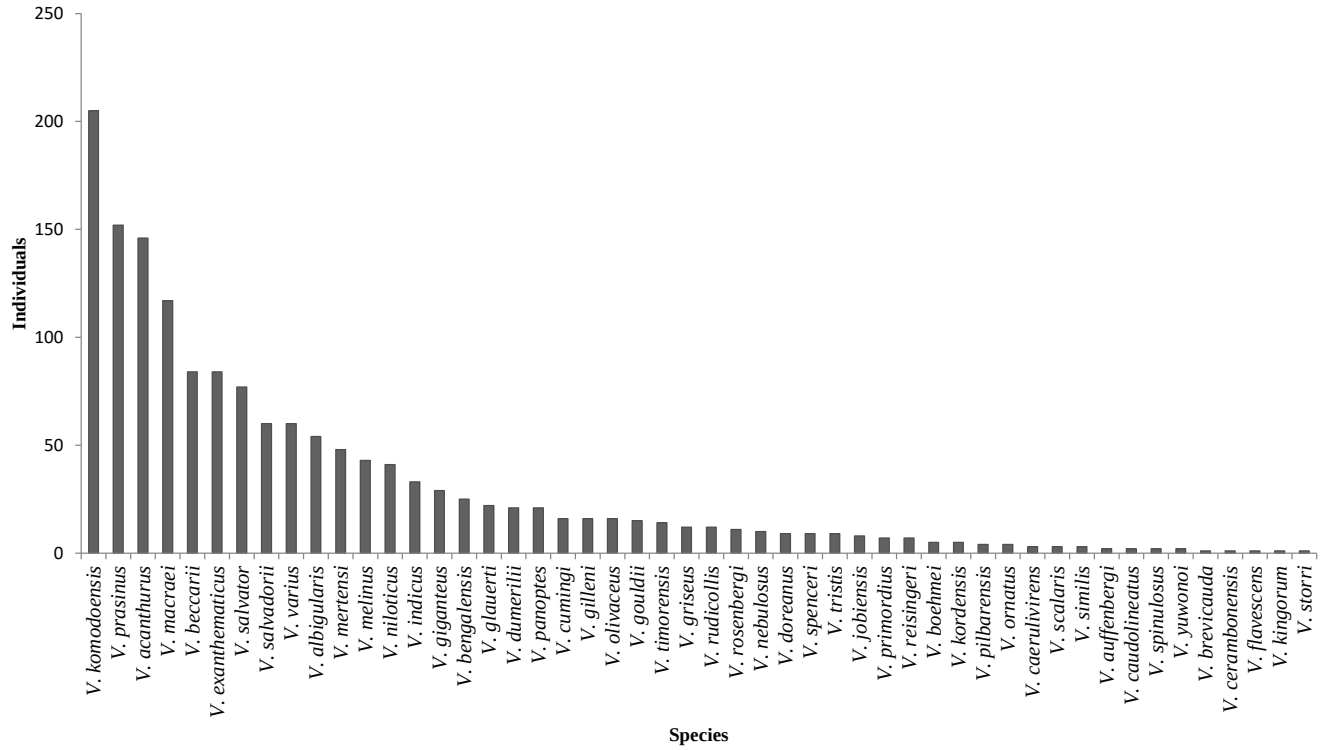

Fig. 4. Individual numbers of monitor lizards kept by zoos globally (after ZIMS).

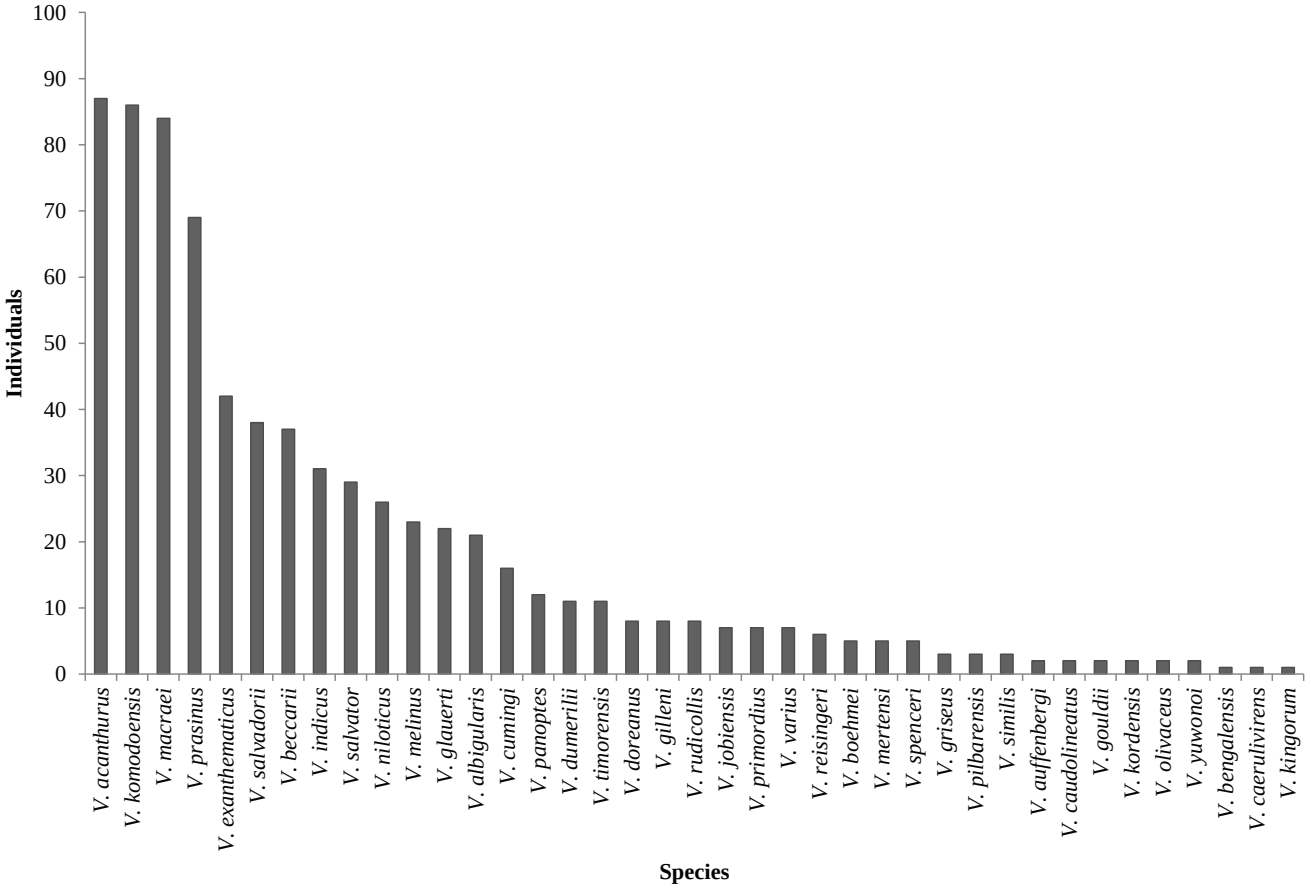

Fig. 5. Individual numbers of monitor lizards kept by European zoos (after ZIMS).

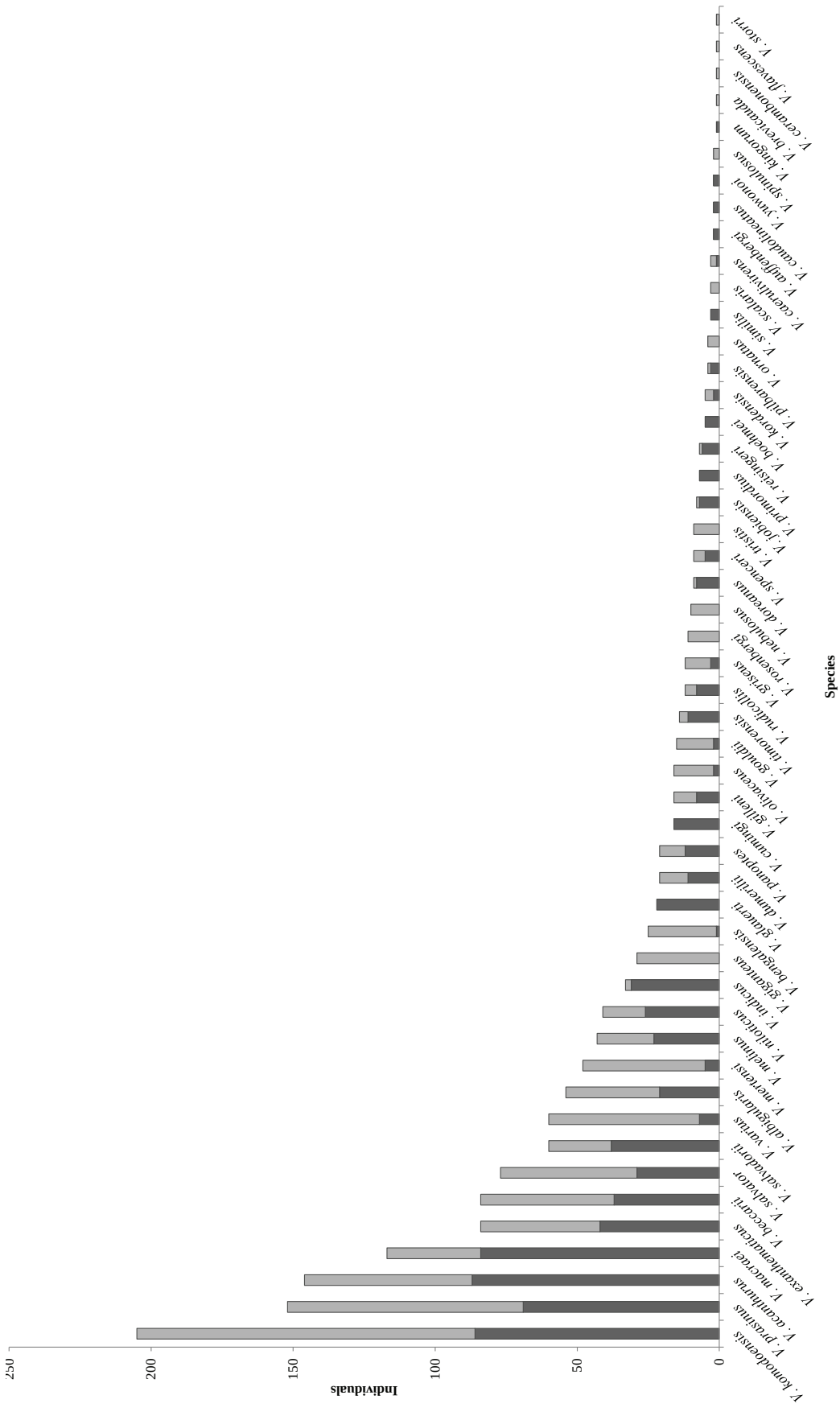

Fig. 6. Total number of monitor lizards kept in zoological institutions globally (light grey column) with European zoos displayed as a subset of the global population (dark grey columns inside light grey columns) (after ZIMS).

Fig. 7. *Varanus komodoensis* (upper left), *V. prasinus* (upper right), *V. acanthurus* (lower left) and *V. macraei* (lower right) are the most commonly kept species (greatest number of individual animals) in zoos both globally and in Europe (after ZIMS). Photographs by **Thomas Ziegler**.

species kept among European zoo holdings were *V. auffenbergi*, *V. bengalensis*, *V. boehmei*, *V. caerulivirens*, *V. caudolineatus*, *V. gouldii*, *V. kingorum*, *V. kordensis*, *V. olivaceus*, *V. pilbarensis*, *V. primordius*, *V. similis*, and *V. yuwonoi* (each kept by only a single zoo). Among European zoos, the lowest numbers of individuals held were of *V. bengalensis*, *V. caerulivirens*, and *V. kingorum* (just single individuals), and *V. auffenbergi*, *V. caudolineatus*, *V. gouldii*, *V. kordensis*, *V. olivaceus*, and *V. yuwonoi* (two individuals each).

Regarding sex ratios, our analysis revealed a high number of individuals with undetermined sexes (n = 521), which probably represent either unsexed mature individuals or juveniles that were too young for proper sex identification. We observed a greater proportion of surplus males at both the European and global levels. Males were more abundant than females in 27 species, and in 14 species (species with just a single individual excluded), the number of males was at least twice that of females (sex ratios expressed as male.female. undetermined): *V. albigularis* (24.7.23), *V. caerulivirens* (2.0.1), *V. caudolineatus* (2.0.0), *V. dumerilii* (7.2.12), *V. exanthematicus* (20.9.55), *V. giganteus* (15.6.8), *V. gilleni* (5.2.9), *V. jobiensis* (5.2.1), *V. melinus* (23.10.10), *V. mertensi* (18.7.23), *V. nebulosus* (4.0.6), *V. ornatus* (2.0.2), *V. spenceri* (3.0.6), and *V. yuwonoi* (2.0.0). For nine species, there were more females than males; in only two of these cases was the number of females at least twice that of males: *V. similis* (1.2.0) and *V. timorensis* (2.6.6). Sex ratios were equal in seven species: *V. bengalensis* (7.7.11), *V. boehmei* (1.1.3), *V. glauerti* (6.6.10), *V. griseus* (3.3.6), *V. reisingeri* (3.3.1), *V. salvator* (22.22.33), and *V. scalaris* (1.1.1). Single individuals were available for five species (*V. brevicauda*, *V. cerambonensis*, *V. flavescens*, *V. kingorum*, *V. storri*), and for two species (*V. pilbarensis*, 0.0.3; *V. spinulosus*,

0.0.2), all individuals were of undetermined sex.

Most of the zoos that have entered monitor lizard collection data into ZIMS were from Europe (131 institutions), North America (112), Asia (34), and Australia (Oceania) (22), with only a few representing Africa (6 institutions) and South America (3). Nevertheless, a trend is clearly discernible from the data; particularly that few species are widely-kept in the zoo community. This may be due to the size, coloration, popularity, or availability of certain species, with regional influences or preferences, but most species are either poorly represented in zoo holdings or not represented at all.

Discussion

All monitor lizards are listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), except for *V. bengalensis*, *V. flavescens*, *V. griseus*, *V. komodoensis*, and *V. nebulosus* which are listed in Appendix I. In contrast, there are only 22 monitor species with IUCN Red List assessments; 15 of these are listed as species of Least Concern, three as Data Deficient, one (*V. nuchalis*) as Near Threatened, two (*V. komodoensis, V. olivaceus*) as Vulnerable, and one (*V. mabitang*) as Endangered. Here, not only does the need for action regarding continued Red List assessment become obvious, but also the current discrepancy between a species' commonness in zoo holdings and its threat status (*i.e*., that rare/threatened species are rarely kept in zoos).

In general, space and resources in zoos are limited, at both the individual institution and global levels. Species selection for zoo collections should therefore be well-planned, particularly in terms of building up *ex situ* conservation breeding programs. For example, in European zoos there are only two official breeding programs for monitor lizards, a European Endangered Species (EEP) program for *V. komodoensis*, and a European Studbook (ESB) program for *V. prasinus*. In North America, there are regional studbooks for *V. komodoensis*, *V. beccarii* and *V. salvadorii*, which are managed by Species Survival Plans (SSP) of the Association of Zoos and Aquariums' (AZA) lizard advisory group. An international studbook is also maintained for *V. komodoensis*. However, there are certainly additional species that need support through the establishment of assurance colonies through *ex situ* conservation breeding programs, especially for small island endemics like *V. macraei*. This species has one of the smallest distributions among monitor lizards, and virtually nothing is known about its ecology and natural history (Ziegler *et al*., 2009). The species is very popular in the pet trade, as are a considerable number of other species from New Guinea (Yuwono, 1998), and commands a high price tag. The restricted range of *V. macraei* makes it particularly vulnerable to overexploitation (Natusch & Lyons, 2012; Bennett, 2015), and it is severely threatened by habitat destruction and collection for the international pet trade (*e.g*., Del Canto, 2013; A. Davis, pers. comm.).

To face such problems, an IUCN Monitor Lizard Specialist Group was recently established, of which the senior and tertiary authors of this account are members. A significant outcome from the group's inaugural meeting held in Bangkok, Thailand in July 2015 was the review of species in greatest need of Red List assessment or reassessment based on conservation priorities (Anonymous, 2015). Additionally, discussions were held on the validity of current and draft assessments for species considered as Data Deficient, as these assessments could potentially misrepresent conservation-dependent species (A. Davis, pers. comm.).

Furthermore, most zoo associations like the EAZA and AZA have taxon-specific focus groups such as Taxon Advisory Groups (TAGs) that identify the priorities and needs of the group of animals they are responsible for. TAGs encourage zoological institutions to identify and select priority species to be kept and managed, based on specific criteria. One of the responsibilities of TAGs is to develop Regional Collection Plans (RCP) that describe which species are recommended to be kept and why. A RCP is not intended to produce uniformity of collections, but rather encourage common themes, collaboration, and the focus of zoo resources where they are most needed. One of the key considerations is the conservation status of a species in the wild; zoos and aquariums can contribute to the survival of species by making informed decisions to keep and breed conservation-dependent species instead of a non-threatened species.

In 2015, the EAZA Reptile Taxon Advisory Group (RTAG) began a review of the Sauria RCP, with the family Varanidae being the first group to be reviewed (by I. Gill). So far, only *V. komodoensis* and *V. prasinus* were included in the RCP as managed species programs. During the EAZA Reptile TAG meeting in in Zagreb, Croatia in April 2016, four species were proposed to be added to the existing varanid RCP: *V. macraei, V. cumingi, V. melinus and V. salvadorii*. These species should initially be monitored by designated individuals (so-called Mon-P [= monitored by designated person]) to assess the future viability of the European captive

Fig. 8. Island endemics like *Varanus caerulivirens* (upper left), *V. yuwonoi* (lower left), and *V.* cf. *rainerguentheri* (right) are often poorly represented, or not represented at all in zoo collections. Photographs by **Anna Rauhaus**.

population for a managed *ex situ* species program, and produce best practice guidelines on how to care for and breed the species in captivity. This is an ongoing process, where additional small island endemic species including several members of the subgenus *Euprepiosaurus* (Fig. 8), but also other species from the Philippines and Solomon Islands, could be included in the future. In addition to the aforementioned criteria, the recent RCP update was also based on the availability of species held in zoos.

In general, we recommend considering a shift away from very commonly kept species, and greater focus towards species that are in greater need of support through zoo husbandry and breeding efforts. Of course, we do not recommend collecting threatened monitor species from the wild, but if such species appear through confiscations, they should be placed in the zoo community so that they can become available for potential *ex situ* conservation breeding. As an example, Cologne Zoo is closely cooperating with German nature conservation authorities (*e.g.*, BfN) and has helped house or place a number of confiscated monitor lizards, which in part have helped found the basis for a breeding program (*e.g.*, Ziegler *et al*., 2010). Improved networking between zoos, as well as between zoos and authorities, is another important prerequisite for bringing together breeding groups and exchanging species that are currently rare in the zoo community. Another challenge facing the assemblage of breeding groups that will have to be addressed is the proper identification of taxa belonging to cryptic species groups which are difficult to determine morphologically. In such cases, genetic comparisons will become more and more important (Ziegler 2015, Ziegler *et al*. 2015).

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Varanus scalaris. Mount Windsor National Park, north Queensland, Australia. Photographed by **Lyall Naylor**.