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# AHN

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# HAA

HERPETOLOGICAL  
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**COVER PHOTOGRAPH:** *Dipsadoboa aulica*  
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## SPECIAL MEMORIAL LECTURE

### THE GIANT ON WHOSE SHOULDERS WE STAND: THE LIFE AND CONTRIBUTIONS OF DONALD G. BROADLEY REMEMBERED

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With the year drawing to an end, it is time to reflect on 2017, as well as look into the future. This year started with the 13th Herpetological Association of Africa conference, held at Bonamanzi Game Reserve in January, with approximately 130 delegates in attendance. The conference was dedicated to the late Don Broadley, who played a leading role in the establishment of the Herpetological Association of Africa and who contributed extensively to the body of knowledge and scientific literature on African herpetofauna. Don's legacy was honoured by the impromptu "field trips" throughout the reserve that resulted in several herps being found, documented and shown to others at the conference, such as the *Dipsadoboa aulica* on the cover of this issue (photo by Nicholas Telford). Additionally, various collaborations were set up and, most importantly, people's research was disseminated. As a means of acknowledging and remembering the quality of research presented in the form of talks and posters, and, possibly, as a way of connecting or reconnecting researchers, this issue is a compilation of all the abstracts presented at the conference. For those who could not attend the conference, this should be a special treat. I hope you all enjoy the read.

Now, looking to the future.....

2018 fills me with much excitement and anticipation. What new sightings will be found? What new behaviours witnessed? What new research are students and veteran researchers involved in? I encourage all of you to continue or start sharing your "short communications, natural history notes, book reviews, bibliographies, husbandry hints, announcements and general herpetological news items" and photographs. I would like to make a special request to all the herpetological students at home and abroad conducting work on African herpetofauna. Whether you are just starting out or finishing your degree, share your work, your observations, your stories.

May we all help make 2018 a fabulous herping year.

*Jessica da Silva*  
Editor

For more than half a century Donald G. Broadley was the dominant figure in African herpetology. His contributions spanned nearly all taxonomic groups and all areas of sub-Saharan Africa, with an emphasis on the Zambesiaca region. Don felt the call of Africa and its herpetofauna at a young age and arrived in Southern Rhodesia in 1954. Though lacking formal zoological training, his innate interest, drive and focus, plus early jobs that provided him access to the field, set Don on the path he would follow the rest of his life. First at the Salisbury Snake Park and later at the Umtali (Mutare) Museum and finally at the Natural History Museum in Bulawayo, Don used every opportunity to collect and ultimately built what would become the second largest herpetological collection in Africa. His research was

focused on revisionary studies at the generic level, often published in the journals of his museum or those whose collections he used. His hallmark style was characterised by concise treatments including lists of localities, quarter-degree square maps, and keys, with short introductions and minimalist discussions. Through these contributions and his many (115) species descriptions, Don transformed herpetology in Africa, using large sample sizes and painstakingly recorded measurements and scale counts to draw his conclusions. In addition to approximately 400 papers, notes, and book chapters, he also applied himself to larger tasks, including his revisions of *FitzSimons' Snakes of Southern Africa* and other books and monographs. The Herpetological Association of Africa (HAA), owes its existence almost entirely to Don Broadley, who founded the Herpetological Association of Rhodesia, the precursor of the HAA, in 1957, and guided it and its journal for twenty years, contributing more than 100 papers to its pages himself. A man of singular focus, Don seemed to look past the many difficulties that life in Zimbabwe posed, content to be able to study reptiles in his adopted continent. Don is sorely missed by his many friends and colleagues, but his influence will be felt for generations.

## KEYNOTE PRESENTATIONS

**ARE RANAVIRUSES GOING UNDETECTED IN AFRICA?**

TRENTON W.J. GARNER

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Ranaviruses are iridoviruses that infect and cause lethal disease in cold-blooded vertebrates. Ranaviruses causing mass mortality and population declines have been described for caudate and anuran amphibians, squamate reptiles, testudines and both fresh and salt water actinopterygians and mortality events have been reported across the Americas, Europe, parts of Asia and Australia. Despite this enormous host and geographic range, almost nothing is known about ranavirus affecting African vertebrates, despite several reports of infection and disease in native herpetofauna. This talk will be a brief introduction to ranaviruses and their impacts, with particular focus on amphibians, squamates and testudines, with some recommendations for research on ranaviruses in Africa.

**FROM TAXONOMY AND NATURAL HISTORY TO -OMICS AND BACK AGAIN: PATTERNS, DRIVERS AND GENETICS OF VENOM VARIATION IN SNAKES**

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Variation in venom composition is ubiquitous among venomous snakes, and found at all levels, from temporal variation in individuals to differences between major clades. The phenomenon has been of intense research interest, with a focus on relationships to taxonomy, the natural selection pressures driving this variation and its underlying genetic mechanisms. A growing body of research testing the action of venom against natural prey has identified natural selection for optimization of venom to diet as an important driver of venom evolution, resulting in patterns of variation incongruent with taxonomic or phylogenetic affinities. The evolution of venom resistance in some prey species leads to the possibility of predator-prey arms races between snakes and their prey. At the genetic level, -omics technologies have provided unparalleled insights into the genetic mechanisms and processes underlying venom composition. Recent data demonstrate that different groups of snakes differ widely in the role of genome-level and postgenomic processes

in controlling venom composition: whereas genomic presence or absence of toxin genes appears to be the basis of most compositional variation in many rattlesnakes, post-genomic mechanisms play a much greater role in at least some Old World vipers. Despite this progress, many knowledge gaps remain. More "genome to fang tip" studies of the genetic mechanisms underlying venom composition are required to detect generalised patterns, and while pairwise relationships between snakes and their prey have received much attention, this is not the case for potential defensive roles for venom, nor for the role of venoms in complex food webs involving

both prey and predators. Modern genomic techniques are clearly essential to address these questions. However, an adequate understanding of species affinities and phylogeny of the snakes in question remains a fundamental requirement, and much further taxonomic work is needed on many groups, including African groups. Finally, rigorous natural history data on snakes and their interactions with prey and predators alike form an indispensable basis for understanding the selection pressures on venom, and their relative paucity is a significant obstacle to understanding the role of venom in snake biology.

## ORAL PRESENTATIONS

**CONSERVATION EFFORTS FOR THE ALBANY ADDER (BITIS ALBANICA)**

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The extremely rare Albany adder (*Bitis albanica*), listed as Critically Endangered in the latest National Red List assessment, is endemic to the Eastern Cape Province of South Africa and is one of the most Threatened reptile species in the country. The Albany adder's distribution lies within the Maputaland-Pondoland-Albany biodiversity hotspot and the species is under severe threat from a number of

activities including cultivation, plantation forestry, urbanisation and sand-mining. Less than a quarter of this hotspot's original vegetation remains in pristine condition. It is believed that the Albany adder has already been extirpated at several historical localities, and no new specimens have been discovered at two historical sites despite extensive surveys. The single known surviving population is currently present at only one known location, and this critical habitat lies completely within an area that is being extensively strip-mined for limestone pavement. All known records of the Albany adder (12 specimens since 1995) are restricted to this region. These snakes are known to occur in only five quarter degree squares (QDS), but they have not been seen in four of these in the last 50



years. The Endangered Wildlife Trust (EWT), in partnership with the Rainforest Trust, has recently developed a project investigating the feasibility of various conservation measures to protect the Albany adder. The primary, long-term aim of the project is the acquisition of appropriate land (habitat) for the Albany adder (and other associated Threatened species) which will be secured as a Protected Area under South African law through the Biodiversity Stewardship process. Due to the rarity of this species, the very real threat of illegal poaching (for the international pet trade) and the uncertainty of its distribution, it was prudent to conduct a feasibility assessment and undertake appropriate, focused surveying for this species. The first round of surveying took place in November 2016 near the town of Addo in the Eastern Cape during a period of six days. The team was successful in discovering two individual specimens of Albany adder (potentially the first official records since 2007).

### A REVISION OF THE EGG-EATING SNAKES (*DASYPELTIS*) OF NORTH-EASTERN AFRICA AND SOUTH-WESTERN ARABIA

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We conducted a morphology-based review of the genus *Dasyzeltis* in north-eastern Africa and south-western Arabia. Ten species were recognised in this region: *D. fasciata* inhabits lowland forest in western and southern Uganda; *D. medici* occurs in coastal forest/savanna mosaic in southern Somalia, Kenya and Tanzania; *D. atra* – in a variety of colour phases/patterns – is widespread in the region but absent from Somalia, occurring in montane forest, moorland, and forest/savanna mosaic, extending eastwards into savanna along the border between Kenya and Tanzania. *Dasyzeltis scabra* is widely distributed in East African savannas, but is replaced by *D. confusa* in parts of South Sudan, Uganda, western Kenya, and Rwanda. We designate a lectotype and paralectotype for *D. abyssina* – previously known only from the type description – and demonstrate that it is a distinct and valid species restricted to open savanna in the highlands of north-western Ethiopia and central Eritrea; the paralectotype is referable to *D. scabra*. In addition, four morphologically discrete and allopatric populations are described as new species. The Horn of Africa, with at least six species, appears to be a centre of diversity for the genus *Dasyzeltis*.

### HISTORICAL CLIMATE CHANGE AND THE EVOLUTION OF THE NAMIB DAY GECKOS (SQUAMATA: GEKKONIDAE: *RHOPTROPUS*)

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The Namib day geckos (genus *Rhoptropus*) are a specialised group of mostly rupicolous gekkonids endemic to the arid regions of western Namibia and southwestern Angola. Previously nine species and subspecies have been recognized on the basis of morphological, mitochondrial, and/or allozymic data. Until recently, political strife in Angola, where the majority of species have all or part of their distributions, has prevented a comprehensive phylogenetic analysis of the genus. We present a phylogenetic analysis incorporating all representative lineages using multilocus data and extensive intraspecific sampling. All nine described lineages as well as two new putative lineages, one from the Kunene Region of Namibia and one from the Angolan Escarpment, are recovered with good support in concatenated and mitochondrial analyses. Support is also found for the elevation of two taxa, *R. benguellensis* and *R. montanus*, to full species status. Macroecological results suggest that *Rhoptropus* may be diverging ecologically although the niches of these

taxa as a whole are largely conserved. Whereas most desert species are extreme outliers of mostly non-arid groups, *Rhoptropus* is one of the few vertebrate clades autochthonous to the Namib Desert Biome. Divergence estimates suggest a minimum age of 36 Ma for *Rhoptropus* and younger than 28 Ma for all included lineages with the majority of diversification taking place from 6-17 Ma. These results suggest *Rhoptropus* may have originated in the early Oligocene, subsequent to the progression of sub-humid conditions in southwestern Africa. Subsequently, the group radiated in the Miocene as the onset of hyper-aridity and a winter rainfall regime provided novel habitat for xeric-adapted lineages. The diversification of this group provides insight into the impact historical climate change has had in shaping regional biodiversity in the Namib Desert.

### ESTIMATING THE GLOBAL POPULATION SIZE OF A SPECIES THAT IS HARD TO FIND: THE CASE OF ROSE'S MOUNTAIN TOADLET

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Rose's mountain toadlet (*Capensibufo rosei*) is endemic to the Cape Peninsula of the Western Cape, South Africa, where only two breeding populations are known at present (Silvermine and Cape Point). Due to the loss of multiple breeding sites since the 1980s, *C. rosei* is under threat of extinction, and estimating its global population size is a conservation priority. However, this species is unusually difficult to detect, due to its lack of a breeding call, cryptic coloration, and small body size (< 30 mm). Some extant populations may therefore remain undetected on the peninsula. To estimate global population size, we therefore (a) determined with confidence the number of extant breeding populations, and (b) estimated the population size of each extant breeding population. Firstly, Species Distribution Models (SDMs) were used to predict suitable localities where unrecognised populations may occur. We then chose 45 sites of 300 m x 300 m that were subsequently surveyed for ground-validation of the model, and to uncover potential new breeding populations. To strengthen confidence in our SDM-based survey findings, factors which may influence the representative accuracy of survey results, such as model predictive performance and detection in the field, were then evaluated using more common amphibian species as proxies. Secondly, the size of each known population was estimated using closed-population capture-mark-recapture models. Animals were marked using visible implant

elastomer tags over a five-day period, by comprehensively sampling individuals from each population and using daily batch marks. Our results show that this species appears to be absent from most of its potential range as we did not find any new populations at sites predicted to be suitable by the models. However, a new site was discovered *ad hoc*, ca. 3 km from the existing site at Cape Point. The total global population size (from the three known sites) was estimated to be just over 3,000 adults (95% CI: 2,534-4,032). Due to the small number of known populations, the small range occupied by the species, and the relatively small global population size, this species may be under greater threat of extinction than previously thought.

**BEHAVIOURAL AND BIOLOGICAL DEFENCE MECHANISMS OF SOUTHERN FOAM NEST FROGS AGAINST AMPHIBIAN CHYTRID FUNGUS**

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Amphibian chytridiomycosis is an infectious disease responsible for major declines and extinctions in amphibian species worldwide. Different amphibian species, and indeed populations within the same species, exhibit variation in their susceptibility to amphibian

chytridiomycosis. A range of factors account for variation in susceptibility across species or populations include host genetics, immunogenetics, host behaviour and environmental factors. southern foam-nest frogs (*Chiromantis xerampelina*) exhibit two rare behaviours, namely basking and the construction of foam nests, offering an ideal opportunity to study the effect of behavioural and biological defence mechanisms against the amphibian chytrid fungus. This hypothesis will be tested by determining the relationship between infection and temperature in wild populations of

*C. xerampelina* and developing experimental trials to test the inhibitory effect of the foam nest on the amphibian chytrid fungus. We expect that infection is inhibited by the ability to elevate skin temperatures to the maximum thermal range of *Bd*, and that foam from the nests of *C. xerampelina* will possess antifungal properties able to inhibit the growth of *Bd* regardless of pathogen lineage.

**NEW LACERTIDS FROM ANGOLA**

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Southern Africa has a diverse lacertid fauna that includes 38 species in nine genera. Whilst only two new lacertid species have been described from the subcontinent in the last 50 years, numerous other species have been revived from synonymy or elevated to specific status. In contrast Angolan lacertids are relatively depauperate, with only 10 species in six genera, most representing wide-ranging forms. *Pedioplains* (12 species) and *Nucras* (8) are the most speciose lacertid genera in the subcontinent, but both contain only few Angolan representatives. Following cessation of the protracted civil war, recent biodiversity surveys in the country have resulted in the description (2010) of two new *Pedioplanis* species. Subsequent morphological and genetic studies based on ongoing collections have confirmed that lacertid diversity in the country is still underestimated. Using newly collected material of *Pedioplanis*, *Nucras*, and *Heliobolus*, we constructed molecular phylogenies that demonstrate multiple additional lacertid lineages within these genera in the semi-arid habitats of the Namibé and Benguela provinces of Angola. These genera are largely absent in the grassland and miombo habitats of central and southeast Angola, where *Ichnotropis* is prevalent and whose taxonomy is the subject of ongoing investigation.

**A PHYLOGENY AND GENUS-LEVEL REVISION OF THE AFRICAN FILE SNAKES**

**GONIONOTOPHIS BOULENGER (SQUAMATA: LAMPROPHIIDAE)**

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The sub-Saharan African file snakes (*Gonionotophis*) currently comprise 15 species, but the concept of this genus is confounded by considerable morphological and genetic differences between the constituent taxa. We therefore sequenced two mitochondrial and one nuclear marker (16S, *cytb*, and *c-mos*) from 43 samples

representing nine species of *Gonionotophis* to construct a molecular phylogeny using Bayesian and likelihood approaches. Four divergent and well-supported clades were recovered, including: (1) *grantii* + *brussauxi*; (2) *poensis* + *stenophthalmus*; (3) *nyassae*; and (4) *capensis*, *chanleri*, *crossi*, and *savorgnani*. Based on these results and morphological analyses, the genus *Gonionotophis* is restricted to the first clade, *Mehelya* is resurrected for the species in the second clade, and new genera are described for the remaining two clades.

**THE COBRA-PRETA FROM SÃO TOMÉ ISLAND (GULF OF GUINEA): HISTORICAL, MORPHOLOGICAL AND MOLECULAR INSIGHTS ON THE IDENTITY OF THE ONLY VENOMOUS SNAKE OF THE LEVE-LEVE ISLAND**

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The Cobra-Preta from Sao Tomé Island (Gulf of Guinea) has been historically referred to as *Naja (Boulengerina) melanoleuca*

(Squamata: Elapidae) and its presence on the island has been traditionally explained as an introduction made by the Portuguese settlers, supposedly to control the rat population affecting the agricultural crops. This explanation has been widely accepted by local authorities and even international conservation agencies. The taxonomic identity of *Naja (Boulengerina) melanoleuca* has also remained undisputed by all of the taxonomists who have published about it with the exception of L. Capocaccia, who in 1961, based on the morphological analysis of some specimens, anticipated that “one day” the São Tomé population would be considered as an “independent geographical race”. The arguments sustaining the human introduction hypothesis are considerably weak and are contradicted by historical, morphological, and molecular data. Also, the biogeographic history of the Gulf of Guinea oceanic islands and the recent insights on the taxonomic identity and evolutionary history of other taxonomic groups occurring there suggest that the Cobra-Preta can in fact represents a distinct lineage of the *melanoleuca* group, endemic to São Tomé island. We here present the supporting evidence to this hypothesis and review all the previous available data on it. As the São Tomé Cobra-Preta is the only venomous snake occurring on Gulf of Guinea oceanic islands, data on its venomology, distribution, ecology, folklore, and conservation status is also presented.

**MOVEMENTS AND ACTIVITY OF NILE CROCODILES IN THE LAKE ST LUCIA ESTUARINE SYSTEM**

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Understanding the movement ecology of a species can have important management implications for its conservation. Despite crocodylians being apex predators, important ecosystem indicators, and sometimes responsible for conflict with humans or livestock, there have been relatively few detailed studies on movement and activity levels. We therefore investigated these aspects for 18 Nile crocodiles (*Crocodylus niloticus*) in the Lake St Lucia estuarine system, from 2009 to 2012. Satellite transmitters were attached to 21 crocodiles, including adult males, adult females (nesting and non-nesting), as well as sub-adult individuals. The mean activity level was 41.3%, and it differed significantly throughout the day. After a period of low activity from 10:00-13:00 (30.0%), activity increased to 36.1% from 14:00-17:00, peaking at 46.7% between 18:00-21:00. From 22:00-01:00 activity decreased to 45.4%



and from 02:00-09:00 to 44.8%. There was a significant seasonal effect in activity levels and we found a strong positive correlation between water temperature and crocodile mobility. This correlation was stronger for sub-adults than adults. Crocodiles were most active in autumn (49.9%) and marginally less in summer (48.1%). During spring, activity decreased even further to 38.9%, with crocodiles being least active in winter (30.5%). Nile crocodile size correlated positively with daily movements and the mean daily movement was 1244 m, which differed significantly between individual study animals. Daily movements of adult males were the largest, but did not differ much from adult nesting females, despite being considerably more than adult non-nesting females and sub-adults. Adults moved more at night, but sub-adults were significantly more mobile during the day. An adult female (2.93 m TL) made the largest daily movements (2853.96 ± 66.45 S.E., Median 2330.8 m) and a sub-adult (2.04 m TL), the shortest (212.75 ± 93.89 S.E., Median 96.9 m). We conclude that size, sex, reproductive status and habitat were all important predictors of Nile crocodile mobility and activity levels. Insights from this study will allow for comparison across populations and species for a more complete interpretation of their movement ecology and activity levels.

### ACROSS RIVER BASINS: EXPLORING THE UNKNOWN SOUTH EASTERN ANGOLA

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The herpetofauna of Angola has been neglected for many years, but recent surveys have revealed previously unknown diversity and a consequent increase in the number of species recorded for the country. The majority of historical Angolan surveys focused on the north-eastern and south-western parts of the country, with the south-east, now comprising the Cuando-Cubango Province, being neglected. To address this gap, a series of rapid biodiversity surveys of the upper Cubango-Okavango basin were conducted between 2012 and 2016. This report presents the results of these surveys, together with a herpetological checklist of current and historical records for the Angolan drainage of the Cubango, Cuito and

Quando Rivers. In summary, 136 species are known from the region, comprising 46 snakes, 39 lizards, six chelonians, a single crocodile and 44 amphibians. The surveys further added seven new country records and a number of novel species.

### EXPLORATION INTO THE HIDDEN WORLD OF MOZAMBIQUE'S SKY ISLAND FORESTS: NEW DISCOVERIES OF REPTILES AND AMPHIBIANS

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We carried out a survey of reptiles and amphibians within Afromontane forest and woodland slopes of three inselbergs in northern Mozambique (Mount Mabu, Mount Namuli, and Mount Ribáuê). A total of 56 species (22 amphibians and 34 reptiles) were recorded during the current survey. Our findings substantially increase the

number of herpetofaunal species recorded from these mountains (Mount Ribáuê 59%, Mount Mabu 37%, and Mount Namuli 11% of the total species), including one new country record and several putative new species.

### REPTILES OF KWAZULU-NATAL, SOUTH AFRICA, A BLOOD PARASITE'S PARADISE

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South Africa and its landlocked countries have a high biodiversity of reptiles and as such much effort has recently been placed in documenting and conserving this diversity. Reptile biodiversity worldwide is threatened by a range of factors from habitat loss to the illegal international trade, the latter allowing for disease dissemination. It is well known that reptiles host a wide array of endo- and ecto-parasites and as such may serve as 'parasite-taxis'. Within the endo-parasites, protozoan blood parasites of the genera *Hepatozoon*, *Haemoproteus* and *Plasmodium* are frequently recorded infecting reptiles. These same genera often cause severe and fatal disease such as Hepatozoonosis and



malaria in other vertebrate classes such as mammals and birds respectively. The same severity of disease has not been reported for reptiles, and as a result species of these parasites infecting reptiles have not received the same attention and knowledge is therefore lacking, particularly baseline knowledge on the biodiversity of these parasites. Protozoan blood parasites have been described from South African reptiles for over a century, many of these from lizards, snakes, and chelonians. However, most were described in the early years of the last century and since then have received no further attention. Over the last four years, an ongoing blood parasite survey of the reptiles of Ndumo Game Reserve, Bonamanzi Game Reserve and surrounds, KwaZulu-Natal, has revealed a high biodiversity of blood parasites, including species requiring redescription and those new to science. The combination of both traditional morphological (morphometrics) and molecular methods (parasite 18S rDNA sequence analysis) in the description of these parasites is allowing for a better understanding of their distributions, ecology, cytopathic effects and host-parasite relationships. Through this baseline knowledge we will be better able to identify probable vectors and parasite species-specificity, in turn allowing us to predict the potential of these parasites being transmitted to novel hosts and ecosystems.

**MONITORING THE TEMPORAL GENETIC DIVERSITY OF A NARROW ENDEMIC AMPHIBIAN, CAPENSIBUFO ROSEI**

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Genetic diversity is the foundation of all biological diversity. Its loss has been shown to increase a species' vulnerability to threats and increase its extinction risk. Given the ever-increasing anthropogenic changes to natural ecosystems, it is imperative that temporal changes in genetic diversity be monitored to help safeguard the future viability of species. *Capensibufo rosei* is a small, range-restricted bufonid from South Africa, believed to have experienced an enigmatic decline likely due to the suppression of natural fires and the loss of grazing animals from some areas. Without these disturbances, their habitat becomes overgrown, minimizing or eliminating the small clearings where breeding pools form. Since the 1980s, four breeding sites have been lost, presumably due to loss of breeding habitat through encroachment of vegetation. Currently, there are only two known populations (Cape of Good Hope [CGH] and Silvermine nature reserves) both within Table Mountain National

Park. Consequently, this species may be vulnerable to stochastic events and genetic erosion through the loss of metapopulation connectivity. To assess the genetic status of this species, genetic diversity within both populations was quantified for two time periods using 11 microsatellite markers. Both populations are genetically stable and have relatively high levels of diversity, with Silvermine having greater diversity than CGH. Despite overall levels of stability within the species, a close examination of the data reveals both populations to be genetically dynamic through time, with the loss and gain of rare alleles. Moreover, levels of genetic diversity increased slightly between sampling periods for both populations. Even though these differences were found to be statistically negligible, they suggest the likely benefits of grazers and fire to the future viability of *C. rosei*.

**INFLUENCES OF GROWTH RATES IN CAPTIVE PUFF ADDERS (*BITIS ARIETANS*)**

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Puff adders (*Bitis arietans*) have been extensively used as subjects to study viper ecology in South Africa. This is

due to their high reproductive rates, high relative abundance, and generalist foraging and habitat life history traits. Previous studies on captive puff adders have used small sample sizes and thus little is known about their relative growth rates and how these might be influenced. Factors such as litter size, maternal condition, sex, and meal size are difficult to measure under field conditions, but can be easily measured and compared in captivity. Our study assessed these influences on the growth rate to evaluate how this may affect their reproductive success in the wild. This was done by measuring the mass of 19 *B. arietans* neonates from 10 litters every second week for two years while under laboratory conditions. Meal size was also recorded and did not differ significantly between individuals. Growth rate varied significantly between litters, but relative meal size, litter size, sex and maternal condition did not influence growth rates. Further studies are proposed under lab conditions to further investigate other influences.

**FROG APP: DIGITAL APPROACH TO FROGGING IN SOUTHERN AFRICA**

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Frogging in southern Africa will never be the same again. It will be better! Based on the 2009 book Complete Guide to Frogs of Southern Africa, the authors developed an App for smart phones and tablets. The app covers all 161 southern African species. For each species a series of photographs, species text, key ID points, distribution map, call and, for most, a video clip is included. By using the “find me” facility on the app the user can narrow down the list of potential candidates to only those known from the specific area. By using a simple key based on pupil shape, expansion of toe tips, and degree of webbing the app will further narrow down the possible candidates. It has a compare function whereby two species can be compared side by side. A new feature to the app is the citizen science facility whereby the public can make a substantial contribution by submitting photographs of observed frogs via the cloud to a centralized FrogMap database at the Animal Demography Unit at the

University of Cape Town. The latest version can be downloaded from Google Play or iTunes (Apple App store).

**TOURISM POTENTIAL OF FROGS IN SOUTH AFRICA**

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South Africa hosts a high diversity of frog species, especially in the eastern regions, and contains numerous endemics. Almost a third of the nearly 7000 known amphibian species are listed as Threatened by the IUCN. Therefore, it is imperative to protect our high frog diversity as it is part of South Africa’s natural heritage. Ecotourism is a phenomenon that has become very popular over the last decade and the experience helps to educate tourists, provides funds for nature and cultural conservation, it raises respect for the environment and cultures and lastly it directly benefits economic development of the local communities. Ecotourism in South Africa can be a powerful conservation tool – one that encourages people to maintain and protect the natural environment. “Frogging” is

a well-known term amongst wildlife enthusiasts, describing the activity of searching for frogs in the wild. We aim to assess the ecotourism potential of frogs in South Africa. By doing so, the project will introduce the wonders and excitement of frogging to the South African community, thereby promoting it as a growing tourism activity in South Africa. In the long run, data gathered by tourists during frogging expeditions can be used by scientists and conservationists for species research and management purposes. Ultimately, tourism activities can contribute towards the conservation of frogs in South Africa and help to highlight the plight of declining amphibians.

**MOVING INTO THE OPEN: SNAKES ON AN AFRICAN PLAIN**

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Sub-Saharan Africa has undergone a shift from pan-African forest during the Oligocene to a widespread African

savanna at present. It is therefore expected that the contraction of forest and development of savanna influenced the distribution of species that are dependent on these habitats. To investigate evolutionary responses of species to forest-savanna biome transformation, we used the widespread snake genus *Philothamnus* as an exploratory taxon. Initial divergence for *Philothamnus* from sister genera occurred in the Oligocene, at a time when forest was extensive. Therefore, we hypothesized that forest was the ancestral habitat for species within the genus, with subsequent diversification of species into savanna. Furthermore, we tested whether generalist species that use both forest and savanna had infiltrated forest secondarily. Species relationships for *Philothamnus* were examined within a phylogenetic context. Genetic assessment involved 125 samples, including 14 out of the 24 currently recognized species and subspecies within the genus. Phylogenies were constructed in a Bayesian and likelihood framework using three mitochondrial markers; 16S, cytb and ND4 and two nuclear markers; c-mos and RAG-1. Ancestral character state reconstruction for habitat (i.e., forest or savanna) were estimated by likelihood using Mesquite, and the ape and phytools packages in R. Results indicated that forest habitat is ancestral for the genus *Philothamnus*, and that species

level diversification occurred primarily in the Miocene when savanna began to dominate the landscape. Widespread generalist species diversified recently, suggesting that forest fragmentation in the Oligocene has not impacted the speciation or distribution of these species. We conclude that generalist species have entered the forest biome secondarily. Given these results, it appears that the development of open habitat (i.e., savanna) facilitated the initial divergence of *Philothamnus* from sister genera, and subsequently the distribution of widespread species within the genus. A fully dated phylogeny is necessary to better understand the impact of forest-savanna interaction on earlier evolutionary trajectories for these species.

present as two parallel lacerations. We investigated the functional dental morphology of the Mole snake using micro computed tomography (CT) and scanning electron microscopy (SEM). The lengths, volumes, shapes, and positions of maxillary and dentary teeth were compared within individuals, between individuals, between sexes, and with other species. The dental morphology of mole snakes is unusual in several respects: large, flat triangular teeth occur at the posterior end of the maxilla and point directly posteriorly, rather than perpendicular to the supporting maxilla as do the more anterior teeth. Several of the posterior teeth on the dentary have sharp posterior edges. These specializations suggest that Mole snakes use the enlarged maxillary teeth to anchor the bite, while the sharp dentary teeth are used to cut. Relative to females, males have a greater degree of dental specialisation, greater variation in the maxillary teeth, more pronounced enlargement of the posterior-most maxillary teeth, and more dentary teeth with sharp posterior edges, strongly suggesting that sexual dimorphism is present. Our comparative research shows that enlarged posterior teeth are also present in the checkered garter snake (*Thamnophis elegans*) and buff striped keelback (*Amphiesma stolata*), both of which are adapted to dispatching struggling prey (Wright et al. 1979; Malnate 1960). However, neither taxon shows similar tooth shape specialisation

### THE CUTTING-EDGE MORPHOLOGY OF THE MOLE SNAKE'S DENTAL APPARATUS

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The Mole snake (*Pseudaspis cana*) is capable of inflicting unusual bites in defence or during male combat which

or sharpness to that of *Pseudaspis*. We hypothesize that Mole snake dental specializations are both adaptations for subduing prey in restricted spaces underground, and for their peculiar form of male combat. These observations lay the groundwork for testing hypotheses involving tooth use in feeding and male combat using behavioural studies.

better clarity in the perpendicular plane, crypsis). Number of scales is possibly also related to foraging mode as a high number of body scale rows and highly fragmented head shields facilitates the ingestion of larger meals in ambush foragers by increasing their capacity for stretch. However, this relationship has not previously been investigated. We used phylogenetically-corrected analyses to compare the impact of activity pattern and foraging mode on pupil shape and number of scales in southern African snakes. Foraging mode had a significant influence on both traits: Ambush foragers were significantly more likely to have elliptical pupils and a high number of scales (more mid-body scale rows and more fragmented head shields). We found no significant correlation between either the pupil shape or number of scales and diel activity pattern. This study provides further evidence that foraging mode has an important impact on the evolution of snakes.

### ACTIVITY PATTERNS OR FORAGING MODE: AN INVESTIGATION OF THE DRIVERS BEHIND THE EVOLUTION OF SNAKE ANATOMY

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Snakes display a wide variety of anatomical traits that may be the result of their phylogeny or recent selective pressures. For example, pupil shape can be either round or elliptic, and rarely-challenged dogma posits that pupil shape is dictated by diel activity pattern. However, there have been suggestions that foraging mode is a more influential driver in the evolution of pupil shape as ambush foragers may derive several advantages from elliptic pupils (e.g., a wider range of apertures, visual acuity,

## QUANTIFYING FEEDING GUILDS WITHIN A STRANDVELD ECOSYSTEM: ARE SNAKES UNIQUE?

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Gaps in our knowledge of the functional roles of snakes within ecosystems limit our ability to predict the potentially cascading effects their removal from an ecosystem might create. Extirpation of snake species could potentially result in losses of ecosystem functionality if those taxa are ecologically unique. We used pitfall and funnel trap arrays, artificial cover object surveys, active searching, and passive camera trapping, as well as pre-existing faunal diversity data to identify terrestrial tetrapod species within the Koeberg Private Nature Reserve. We then gathered dietary information for each species from the literature. Next, using hierarchical cluster analysis, we identified five broad feeding guilds characterised predominantly by the following dietary items: A) tetrapods and occasional invertebrates; B) aquatic vertebrates and invertebrates; C) arthropods; D) foliage and other plant material; and E) insects, fruits, and seeds. Of the 12 snake species recorded, 11 of them (*Dasypeltis scabra* being

the exception) occurred within group A and made up 18.6% of that groups species, along with 13.6% and 67.8% mammal and bird species respectively. All other squamates occurred in group C making up 10% of that cluster's species. Species within group A could be further divided into two sub-divisions: a group comprising predominantly birds and mammals, as well as the snakes *Naja nivea* and *Dispholidus typus*; and a group dominated by saurophagous snakes. *Dasypeltis scabra* was the only exclusively egg-eating terrestrial species in the entire 246 species community, placing it in a unique position outside of the identified feeding guilds. Our findings provide ambivalent support for trophic redundancy by snakes, with certain species exhibiting high dietary overlap with mammals and birds, and other species showing highly specialised diets relative to other organisms within the community. We plan to build on these findings by incorporating other measures of niche diversity in order to better understand niche partitioning and functional redundancy within this system.

## GENETIC ASSESSMENT OF HINGE-BACKED TORTOISES (*KINIXYS*) ACROSS AFRICA

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Hinge-backed tortoises (*Kinixys*) are a genus of tortoises endemic to sub-Saharan Africa. All *Kinixys* species share a unique morphological character, the eponymous carapacial hinge, allowing for, at least, partial closure of the posterior shell. Currently seven species are recognized that ecologically correspond to forest species (*Kinixys erosa*, *K. homeana*) and savanna species (*K. belliana*, *K. lobatsiana*, *K. natalensis*, *K. spekii*, *K. zombensis*). However, a previous study has shown that these ecological groups are not reciprocally monophyletic. The two savanna species *K. belliana* and *K. lobatsiana* are closely related to the forest species *K. erosa* and *K. homeana*, and these four species together constitute the sister group of the remaining savanna species. Using additional sampling, the genetic differentiation of hinge-backed tortoises is currently scrutinized using three mitochondrial genes and three nuclear loci. Our work in progress indicates that genetic differentiation in *Kinixys* is underestimated and a range-wide

assessment will most likely identify unrecognized genetic lineages.

## FRIENDS OR FOES? INVESTIGATING COMPETITION AMONG LINEAGES OF BATRACHOCHYTRIUM DENDROBATIDIS

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*Batrachochytrium dendrobatidis* (*Bd*), arguably the most destructive pathogen of vertebrates ever discovered, has been implicated in the decline, extirpation, or extinction of up to 200 species of amphibian. However, it has more recently become apparent that only one of the five known lineages, *BdGPL* (the Global Panzootic Lineage), has a global distribution, displays hypervirulence with respect to the other lineages, and has been the lineage involved in all known chytrid-driven mass amphibian declines to date. It is not yet known whether the lineages, when they come into contact in the environment or on a host, coexist or compete with each



other, or what impact this may have on host survival. In South Africa, the African endemic lineage, *BdCape*, and *BdGPL* are known to exist in close proximity, but the implications of that in terms of pathogen evolution and amphibian survival are as yet unknown. Presented here are the plans and pilot studies investigating the occurrence and extent of competition between *BdGPL* and *BdCape*.

**A LURE AT BOTH ENDS:  
AGGRESSIVE VISUAL MIMICRY  
SIGNALS AND PREY-SPECIFIC  
LURING BEHAVIOUR IN AN  
AMBUSH-FORAGING SNAKE**

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Aggressive mimic species use signals, typically resembling an attractive or harmless model, to deceive other organisms in order to increase fitness. With the exception of a few brood-parasitic birds that combine two signals, most known cases of aggressive mimicry involve only a single signal. Here, we used fixed videography, a technique which consisted of setting up continuously recording video cameras focused on ambushing animals, to describe the use of two clearly distinct aggressive visual mimicry signals in the same organism,

the puff adder (*Bitis arietans*), for the first time. Puff adders extended their tongues (lingual luring) and waved their tails (caudal luring), presumably to mimic an invertebrate model, in order to lure prey within striking range. Lingual luring occurred only in the presence of amphibian prey, indicating discrimination between prey types. Our study reveals the diverse predatory strategies and complex decision-making process used by 'sit-and-wait' predators, such as ambush-foraging snakes, to catch prey, and indicates that snakes may have higher cognitive abilities than those usually afforded to them.

**FOOD SUPPLEMENTATION  
AFFECTS THE FORAGING  
ECOLOGY OF PUFF ADDERS:A  
LOW-ENERGY, AMBUSH-  
FORAGING SNAKE LURING**

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The effect of food availability on the spatial ecology of animals varies within and across study systems because a multitude of factors can affect the spatial activity of organisms. Low-energy specialists, such as ambush-foraging snakes, feed infrequently and can endure long periods without food. Because

they have low energy requirements, one possible tactic for feeding may be to simply ambush for longer periods when prey availability is low, thereby decreasing the potential costs associated with locating new ambush sites. We used radio-telemetry, supplemental feeding, and remote video cameras on free-ranging male puff adders (*Bitis arietans*) in South Africa to test the hypothesis that food intake affects the foraging ecology of extreme low-energy, ambush foragers, and to quantify their natural feeding rates. Supplementally-fed puff adders improved their body condition, spent less time foraging, and decreased distance travelled compared to control snakes. However, movement frequency and home range size did not differ between the two groups. These findings indicate that control snakes travelled farther within similar-sized home ranges compared to fed snakes, and did so at no survival cost. Further, naturally-foraging puff adders fed primarily on relatively small prey and fed every 10 days on average. Hence, despite their 'sit-and-wait' foraging strategy and their low energy intake/requirements, underfed puff adders travel widely to presumably find appropriate ambush sites that maximise prey capture. Our research provides the first strong evidence that the spatial activity of a terrestrial vertebrate species with extremely low energetic demands is significantly affected by food intake.

**REPRODUCTIVE STRATEGIES  
OF THE ANGULATE TORTOISE  
*CHERSINA ANGULATA*  
(TESTUDINES: TESTUDINIDAE)**

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*Chersina angulata* has an unusual reproductive pattern for a species experiencing pronounced temperature and rainfall seasonality. Females produce single-egg clutches from March to December and can lay up to six clutches per year. Egg retention in the uterus varies from 23 to 212 days and correlates with temperature and rainfall. Prolonged egg retention is considered the first step in a transition from oviparity to viviparity in reptiles, but females still need to overcome the constraints of full embryonic development in the uterus. Conventional wisdom holds that chelonians are strictly oviparous with embryo development in the mother being arrested in the gastrula stage, due to insufficient oxygen diffusion across the calcified eggshell in the wet uterine environment. We measured eggshell calcification of 16 captive *C. angulata* females over 12 months and found that more than 70% of the eggs had relatively thin eggshells at oviposition, a characteristic that would improve oxygen diffusion to developing embryos. We found

evidence from the wild and captivity that *C. angulata* females can retain eggs until embryonic development has progressed to the hatching stage, conforming to the accepted definition of viviparity in reptiles. Hatching in *C. angulata* occurs in March to April at the start of the rainy season. Consequently, early clutches of this species incubate for 12 months whereas late clutches incubate for 3-4 months, the duration required for artificial incubation. Our observations of viviparity were of eggs laid in early autumn, indicating that instead of laying the eggs late in the previous year, the females carried developing embryos until hatching normally occurs for the species. We propose that facultative viviparity in angulate tortoises is limited to late-season clutches that do not undergo developmental arrest, and represent yet another reproductive strategy that ensures this species' success.

**ECOLOGICAL NICHE PARTITIONING, HOMERANGE AND RESOURCE UTILIZATION IN DESERT LIZARDS (*MEROLES ANCHIETAE* AND *M. CUNEIROSTRIS*) FROM THE NAMIB DESERT, NAMIBIA**

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Ecological communities are composed of organisms that co-exist in a particular habitat, and the co-existence of closely related species in an ecological community has intrigued ecologists for a long time. Sympatric species partition resources in three fundamental dimensions, namely: spatial (space), temporal (time), and trophic (food). Within lizard communities, the fundamental niche dimensions are often independent of each other, although they sometimes interrelate. For instance, the mode of foraging (type or way of acquiring food) can influence the three niche dimensions. In this study we compare the morphology, activity patterns, microhabitat characteristics, thermal biology, water expenditure and feeding ecology of two diurnal sympatric lacertid lizard species of the Namib Desert, Namibia: the Shovel-snouted lizard, *Meroles anchietae*, and Wedge-snouted lizard, *Meroles cuneirostris*. Analyses of carbon and nitrogen stable isotope ratios in plant, arthropod, and lizard tissues will be used to estimate trophic levels, and isotopic mixing models to quantify the dietary contribution of various food sources

(arthropods and plant material) across seasons. Lizard diet will be estimated from the abundance and frequency of occurrence of arthropod prey within faecal pellets. The inverse of Simpson's (1994) diversity measure will be used to estimate dietary niche breadth, while Pianka's similarity index will be used to estimate the symmetrical dietary niche overlap. Little is known about how desert lizards maintain their water balance and hydration levels. Do they decrease their water output to conserve water better or do they increase their water input by drinking more water each day? These questions can be addressed by measuring daily water flux rates (in ml/day) in free-ranging animals using isotopic markers. The Benguela current that is responsible for most of the weather patterns in the Namib Desert is warming as a result of increasing climate change thus resulting in less fog production. We will attempt to link the available data on the prediction of climate change (decreasing fog production) along the fog gradient to assess the distribution and abundance of the two species. Home range size reflects various aspects of the behaviour of animals. The two focal species are known to have overlapping home ranges as they have been observed in both habitats. Using minimum convex polygon method, the sites for active lizards will be used to create a map of the movement patterns to estimate the home range size and the degree of

overlap between the two species.

**PREVALENCE OF AMPHIBIAN CHYTRID FUNGUS ACROSS THE CONGO RIVER DRAINAGE BASIN**

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Amphibian chytrid fungus (*Batrachochytrium dendrobatidis*, Bd) has been implicated as an important factor in the decline of amphibian species worldwide. The origin of Bd

remains problematic, but several studies have pointed to Africa as the original source of the pathogen. Nonetheless, *Bd* remains less extensively studied in Africa than on other continents. We tested 807 individuals from 12 amphibian families for the presence of *Bd*, from sites spread across 1,122,237 km<sup>2</sup> of the Congo River drainage basin, all at relatively low elevations (51–775 m.a.s.l.). We found *Bd* to be present in some individuals at most but not all sites. In total, 89 individuals tested positive for *Bd*, for an overall *Bd*-prevalence of 11.03%. We found no correlation between elevation and the presence of *Bd*, no correlation between season (wet or dry) and prevalence of *Bd*, and no higher incidence of *Bd* in individuals from any amphibian family relative to other families. In no instance did we observe signs of acute illness in any individual collected and tested for the presence of *Bd*. We discuss these results in the context of other recent surveys of *Bd* in Africa.

**INCIDENCE OF FIRE-INDUCED REPTILE MORTALITY IN SAVANNA HABITAT**

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Fire-prone habitats such as savanna, grassland, and fynbos harbour high reptile diversity. Extralimital documentation of mortality rates from both directly observed mortalities as well as pre- and post-fire population estimates have shown that anthropogenically modified fire regimes may have dramatic effects on reptile communities. Post-fire mortality surveys were conducted in sparse and open woodland on Tembe Elephant Park to evaluate the influence of different functional species traits on fire-induced casualty. Species specific habitat preference, reproductive traits, diet, ability to move through the environment and daily activity was tabulated from literature sources. Two burns were set in mid-August and a third in mid-October by reserve management to combat *Terminalia sericea* and *Dichrostachys cinerea* bush

thickening. Chelonian specimens were expected but not observed. All samples were composed of squamate taxa. Physical examinations included the post mortem histopathological analyses of samples, external inspection, snout-vent length, and maturity. The mid-October fire had significantly higher densities of mortality specimens than earlier burns. Species utilising fossorial environments made up the majority of all three samples and specimens were associated with woody plant canopy cover and leaf litter. Specimens with SVL less than 100 mm were best represented. External burn damage was uncommon on specimens but occasional oral bleeding was observed in larger individuals. Contrary to smoke inhalation as an expected cause of most mortalities, *post mortem* histopathology suggested that asphyxiation or non-irritant gas intoxication to be considered as important mechanisms resulting in death for some specimens collected after the mid-October fire.

**THE EVOLUTION AND DIVERSIFICATION OF DIET IN ELAPIDS**

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A central goal in macroecology is understanding the factors that have shaped broad-scale patterns within extant natural communities. Diet is widely cited as a key factor involved in shaping snake diversification. Amongst serpents, the adaptive radiation of elapids is unparalleled in terms of their sheer global distribution. We aimed to evaluate the variation in diet and associated trends across the radiation of the elapids. Based on the published natural history data for 303 elapid species, a cluster analysis revealed seven groups of species within which diet types were similar. The broad diet clusters included snake consumption, feeding on fish, ectotherms, endotherms, lizards, a generalist diet and lastly, a terrestrial invertebrate group which was the least prevalent diet type. Maximum Parsimony, Maximum Likelihood and Stochastic Character Mapping were used to reconstruct

the ancestral dietary condition in the Elapidae. Reconstructions demonstrated that starting from an ophiophagous ancestor, elapids have largely retained their early feeding habits. Despite the emergence of novel feeding patterns in the group, the predominantly conserved dietary patterns suggest that niche conservatism has shaped elapid foraging dynamics. Members of the lineage characteristically feed on elongate ectothermic prey (e.g., squamates, caecilians, eels, earthworms) possibly owing to morphologically-mediated gape constraints. Phylogenetically-corrected comparative methods were used to assess the influence of differences in body size, lifestyle, and global scale geographic distribution on diet evolution. While lifestyle and distribution considerably influenced how diet patterns evolved, body size was not a significant determinant of the prey types taken. The lack of body size-diet association may be because larger-bodied elapids also opportunistically supplement their diet with smaller prey items. Overall, our findings indicate that recent ecological factors (e.g., lifestyle) coupled with long established factors (phylogeny, biogeography) have shaped elapid natural history patterns. This study is the first of its kind to offer a family-level, phylogenetically-based analysis on the evolutionary and contemporary feeding dynamics of the world's most widespread snake family.

**PARASITE INTRODUCTION TO THE ENDANGERED WESTERN LEOPARD TOAD: SPILL-OVER OR SPILL-BACK?**

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*Sclerophrys gutturalis* (guttural toad, GT) was introduced into Constantia, WC, South-Africa, from Durban, KZN South-Africa. The toad is spreading at an alarming rate invading the natural distribution area of the Endangered western leopard toad (WLT) (*Sclerophrys pantherinus*). The WLT is endemic to the Fynbos biome and in early spring they breed for a period of one week. Researchers have become increasingly concerned with direct effects of GT on WLT such as predation and competition, however other indirect effects such as interaction with infectious agents and parasites may also have impacts on the WLT. Frogs harbour a variety of parasites such as protozoans, nematodes, acanthocephalans, flukes, cestodes, mites and leeches. They may either be the intermediate or the definite host. Introduced hosts may act as vectors and/or reservoirs for introduced parasites, and when these introduced parasites are transmitted to the native host, this

is known as 'spill-over'. However native hosts can transmit native parasites to the introduced host and this can then be a threat to uninfected native individuals; this is known as 'spill-back'. As we are dealing with different host species, results can differentiate between spill-over and spill-back, as parasite occurrence and infection intensity are determined by numerous factors such as host-infectious agent specificity, host density and invasion pathway. Morphological markers (scanning electron microscopy and light microscopy) and several molecular markers (COI and 28S) were applied to identify parasites in three populations: (1) GT's from Durban, (2) GT's from Constantia, and (3) WLT's from Constantia. It was found that invasive species may lose their parasites in the course of invasion and this is predicted to enhance competitive ability in the new environment. Still the relationship between parasitism and invasion is unlikely to be static, further complicating the prediction of invasive impacts.

**HEALTH STANDARD COMPLIANCE FOR AMPHIBIAN RESEARCH**

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The standard for animal health in South Africa is regulated by the SANS (South African National Standard) document 10386:2008. However, the section dealing with amphibians only focusses on *Xenopus laevis* and does not take into account the needs of species with different modes of life, such as terrestrial, fossorial, or arboreal species. Moreover, no standard exists for amphibian health in research, including a description of humane endpoints. We will be taking a desktop approach to improve the current SANS document on amphibians by comparing health standard compliances of similar documents from other countries that enforce animal health regulation. By studying disease progression in a captive infected model host species, we aim to define the health and welfare standards of amphibians. The most humane procedure for euthanasia will also be tested experimentally. Another outcome of this study will be to develop standard operating procedures (SOPs) for various general research procedures involving amphibians.



**UNEXPECTED DECLINE  
IN A POPULATION OF  
HOMOPUS SIGNATUS**

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Conservation assessments for long-lived, iteroparous species such as tortoises need long-term population monitoring to underpin population trends. Although approximately 25% of the world's extant tortoise species occur in South Africa, very few long-term monitoring studies have been published. Consequently, conservation assessments are often based on surveys, range sizes, and assumptions that suitable habitat within ranges will contain healthy populations. I studied a population of the speckled dwarf tortoise, *Homopus signatus*, in habitat that met the species' known requirements. Two mark-recapture studies, conducted from 2000 to 2004 and from 2012 to 2015, were combined in a long-term population model. Although the habitat in the study site appeared to change little between 2000 and 2015, the initially dense *H. signatus* population shrunk almost two-thirds in size. In 2012-2015, virtually no hatchlings and juveniles were left. Moreover, the initial equal sex ratio shifted to a strongly female-biased sex ratio. The population model indicated that apparent survival was similar throughout the study, but the number of new entrants into the

population (via births and immigration) decreased. Anecdotal information suggests that predation of hatchlings by increasing numbers of pied crows (*Corvus albus*) may have contributed to the population changes. This study demonstrates that conservation assessments should not assume that apparently suitable habitat in the *H. signatus* range will contain populations with a favourable conservation status, and emphasises the need for long-term population monitoring studies.

**DENSITIES OF  
ARTHROLEPTELLA LIGHTFOOTI  
ACROSS THE CAPE PENINSULA:  
PRELIMINARY RESULTS  
FROM ACOUSTIC SPATIAL  
CAPTURE-RECAPTURE**

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The Cape Peninsula moss frog, *Arthroleptella lightfooti*, is a visually cryptic species that is endemic to the Cape peninsula. Traditional capture-recapture techniques are difficult to employ in studying visually cryptic species. Acoustic spatial capture-recapture (aSCR) provides non-invasive means to study vocalizing animals. This technique is used to obtain quantitative estimates of call densities of calling animals. The aim of this project is to use aSCR techniques to compare the densities of calling *A. lightfooti* across their entire distribution on the Cape peninsula. An acoustic array consisting of six microphones and a recorder were set up at sites for 45 minutes to record frog calls. A total of 60 arrays were set up across the distribution range of *A. lightfooti* from August to October 2016 and the recordings were analysed in an aSCR package in R to obtain the densities of calling *A. lightfooti* at each array. We present the first calling density distribution across the entire range of any frog. Reliable density estimates can be a valuable input for the management of natural areas on the Cape Peninsula. This technique can also be of conservation importance and it can be used to investigate and identify factors that potentially influence population densities.

**PHYLOGENETIC  
RELATIONSHIPS IN THE  
PACHYDACTYLUS CAPENSIS  
SPECIES COMPLEX  
(SAURIA: GEKKONIDAE)**

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The *Pachydactylus capensis* species complex includes populations of terrestrial and rupicolous geckos with an extensive distribution in southern Africa. The most recent molecular phylogeny supported the recognition of two primary clades: a *P. capensis*, *P. affinis* and *P. vansoni* clade, and a *P. tigrinus* and *P. oshaughnessyi* clade. We examine genetic patterns within the former clade based on extensive sampling, especially within South Africa, and evaluate the genetic boundaries indicated. Preliminary analysis based on sequence data suggests the existence of several cryptic lineages.

**FIRST AID FOR SNAKEBITE  
– AN OVERVIEW**

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Advice given regarding the first aid treatment of snakebite is often

incorrect, inefficient, and can be outright dangerous. Additionally, published magazines and popular books that often offer advice are not subjected to peer review and can result in widespread misinformation regarding the treatment of snakebite. Here I review several recommendations regarding the treatment of snakebite published over the last 85 years. Fitzsimons (1932) recommended a tourniquet for all bites (despite acknowledging that venom is spread largely through the lymphatic vessels) followed by a cut with a lancet or penknife and the wound being washed out with a saturated solution of potassium permanganate. Fitzsimons (1970) recommended a tourniquet, cutting and sucking, and the application of potassium permanganate. Broadley & Cock (1975) recommend suction to remove venom and the application of a tourniquet for elapid bites. Visser & Chapman (1978) also recommend the use of an arterial tourniquet for all snakebites but warn that it is 'dangerous first-aid'. The Department of Health produced '*Poisonous South African Snakes and Snakebite*' in 1978 in which Reitz recommended the use of a tourniquet and ice packs. An undated booklet published by Dettol, in collaboration with Visser (early 1980s), recommended the injection of an adequate dose of antivenom as soon as possible. Branch (undated) in a booklet *First Aid Treatment for Snakebite* recommended pressure

immobilisation. Marais (1985), in '*Snake versus Man*', recommended the use of a pressure bandage and mentioned suction if only to help reassure the victim. Paolini (1995) stated that the use of a tourniquet is controversial, based on work done on cobras in the Philippines, and recommended the use of a pressure bandage. Spawls & Branch (1995), in the '*Dangerous Snakes of Africa*', gave sound advice – avoid tourniquets, cutting and sucking, but use a pressure bandage. Buys (2003), in '*Medical Management of Snakebite in Namibia*', advocates the use of both a ligature or tourniquet as well as pressure immobilisation. Marais, in '*Snakes and Snakebite in Southern Africa*' (1999), '*A Complete Guide to Snakes of Southern Africa*' (2004), '*Snakes and Snakebite in Southern Africa*' (revised 2014) recommends the use of pressure immobilisation for neurotoxic bites. These cases illustrate the changes in snakebite first aid treatment through time. Current thinking suggests it is best to transport the victim to the nearest hospital with a trauma unit. In severe neurotoxic envenomation victims may need artificial respiration.

## TOWARDS UNDERSTANDING INTERSPECIFIC COMPETITION IN SNAKES: QUANTIFYING THE DIETS OF *NAJA NIVEA* AND *DISPHOLIDUS TYPUS*

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Top-down regulation of populations is widely recognised as an important ecological process in many systems. Despite snakes representing, possibly, the most successful radiation of tetrapod predators, very few studies have demonstrated top-down regulation by snakes on their prey, at least in part because of the paucity of knowledge regarding snake natural history and ecology. In the Kalahari Desert, sociable weavers (*Philetairus socius*) are ecosystem engineers that build large communal colonies used by obligate and facultative commensal species. Sociable Weaver chicks and eggs are heavily preyed upon, and probably regulated, by the snakes *Naja nivea* and *Dispholidus typus*. Surprisingly, despite these snakes being widespread and abundant, their diets have been poorly quantified, limiting our understanding of how these species might be influencing the biology of their prey or even each other. Thus we initiated two studies regarding the diet and foraging ecology of these two

species. Using information derived from the literature, citizen science, and the examination of museum specimens, we reviewed and characterised the diets of these species. We confirm that *N. nivea* consumes a wide range of prey types including snakes, rodents, anurans, lizards, birds and their eggs, and even chelonians. Prey types were relatively evenly distributed, with no single prey type accounting for more than 33% of observations, and four prey types accounting for more than 10% of observations. Conversely, *D. typus*, had a diet dominated by birds and their eggs (48%) and lizards (42%; > 97% of which were chameleons), but that was nearly as diverse as that of *N. nivea* with observations of rodents, anurans, and snakes in their diet. Across their ranges, the two species show 31% overlap in diet, suggesting relatively limited potential for interspecific competition in areas of sympatry. However, at local scales, limited prey availability may drive increased niche overlap and stronger competition, especially around spatially-explicit and temporally predictable resources such as breeding sociable weavers. Moreover, the high frequency of snakes in the diet of *N. nivea* suggests the potential for intra-guild predation as a complex form of interspecific competition in the Kalahari. Indeed, preliminary field observations show high rates of colony occupancy by snakes, suggesting that opportunities for direct

interspecific interactions are likely to exist.

## WHO CROAKED? WHAT THE FOSSIL FROG BONES SAY

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Fossil frog assemblages from archaeological and palaeontological sites frequently remain unanalysed due to a lack of specialist knowledge, and the fact that their potential for the reconstruction of palaeoenvironments is largely unappreciated. Recent results from the analyses of the frog assemblages from a number of fossil sites indicate that frog fossils may provide unique information on past rainfall regimes and environments. The results from an analysis of fossil frog assemblages from the archaeological west coast Holocene site of Dunefield Midden (DFM) and the much older 5.1 Mya palaeontological site of Langebaanweg (LBW) are presented. The frog fossils from DFM provide information on some of the agents/agencies which led to the accumulation of microfauna at the site, while the presence of two *Ptychadena* taxa, and *Kassina*, provide new and compelling evidence for a summer rainfall regime,

or of at least significant summer rainfall, during the Early Pliocene on the west coast of South Africa. Preliminary results from a study of the frog fauna from Cooper's Cave (1.9-1.6 Ma), situated approximately 45 km northwest of Gauteng in the Cradle of Humankind, are also presented.

## COUNTING CHIRPS: ACOUSTIC MONITORING OF CRYPTIC FROGS

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Global amphibian declines have resulted in a vital need for monitoring programmes that track population trends. Monitoring using advertisement calls is ideal as choruses are undisturbed during data collection. However, current techniques frequently rely on trained observers, and/or do not provide density data on which to base trends. This study explores the utility of monitoring using acoustic spatially explicit capture-recapture (aSECR) with time of arrival

(ToA) and signal strength (SS) as a quantitative monitoring technique to measure call density of a threatened but visually cryptic anuran, the Cape Peninsula moss frog, *Arthroleptella lightfooti*. The relationships between temporal and environmental variables (date, rainfall, temperature) and *A. lightfooti* call density at three study sites on the Cape Peninsula, South Africa were examined. Acoustic data, collected from an array of six microphones over four months during the winter breeding season, provided a time series of call density estimates. Model selection indicated that call density was primarily associated with seasonality fitted as a quadratic function. Call density peaked mid-breeding season. At the main study site, the lowest recorded mean call density (0.160 calls.m<sup>-2</sup>.min<sup>-1</sup>) occurred in May and reached its peak mid-July (1.259 calls.m<sup>-2</sup>.min<sup>-1</sup>). The sites differed in call density, but also the effective sampling area.

## MODELLING CURRENT AND FUTURE DISTRIBUTIONS OF THREE AFRICAN ANURANS REPRESENTING DIFFERENT FUNCTIONAL GROUPS: AN ECOPHYSIOLOGY MODELLING APPROACH

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Global climate change is suggested to be one of the leading threats to anuran diversity by the end of the century. This is largely because, compared to other vertebrates, anurans have characteristically small distributions and limited dispersal abilities, thus making them particularly vulnerable to climate change. In order to predict how these changes in climate are going to affect this most threatened group of vertebrates, biologists have used correlative species distribution models (SDMs). However, correlative SDMs have been criticised for their simplistic approach of correlating known distributions with climatic variables, thus not accounting for other process-based variables that determine distributions such as physiology, performance, abundance, and energetic requirements. Recent advances have advocated these process-based, data-intensive models in order to improve on current techniques and accurately predict the impacts of climate change with the aim of saving as much biodiversity as possible. Within anurans, this is further compounded by the variation in functional groups (i.e., breeding habitat modalities) that are



represented within the order. In this study, we use ecophysiology modelling techniques to predict current and future distributions (2080) of three African anuran species representing different functional groups of anurans: i) the principally aquatic African clawed frog (*Xenopus laevis*), ii) the temporary-aquatic common river frog (*Amietia delalandii*) and iii) the semi-terrestrial raucous toad (*Sclerophrys capensis*). We collected data on different physiology (standard metabolic rates and evaporative water loss) and performance (swimming, hopping, and endurance) measures at different temperatures in order to understand the effect of temperature variation on these traits. Lastly, we used the results of these temperature-trait relationships to model current and future distributions of species, which translate these biological parameters into relevant matrices (i.e., predicted hours of restriction and activity). Our results suggest that ecophysiological modelling accurately predicts current distributions. We will show how the distributions of these focal species are expected to change when projecting them to two different future climate scenarios. We will also discuss how different physiological and performance data lead to variations in model outputs.

**OVERVIEW OF THE TRADE, UTILISATION, AND RARITY OF REPTILE TAXA CONSUMED FOR TRADITIONAL MEDICINE ACROSS AFRICA**

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The trade in reptiles for African traditional medicine has generally been highlighted in ethno-zoological studies and it still continues despite conservation calls for sustainable management of biological resources, especially those threatened by the direct harvest. Although most ethno-therapeutic studies have focused more on plant based traditional medicine and charismatic animals used for traditional medicines, reptiles are also used and their trade often proceeds unimpeded. The aim of this study was therefore to fill this information gap by presenting a first step in the quantitative overview of reptile species traded for African traditional medicine by considering and recording species availability in at least one market. A dataset that includes essentially all published ethno-zoological scientific papers and reports that cite or focus on reptiles traded for African traditional medicine has been gathered to extract data for a unified inventory. Web images of African traditional medicine were also viewed to supplement the trade

information. The IUCN statuses of cited species are analysed and incorporated in the study to help coordinate the data and stimulate conservation strategies. To date, 88 traded species from 135 reptile records have been compiled from ±30 plus studies. However, the quantitative findings coupled with paucity or lack of information in certain countries suggest that the data for domestic African trade of reptiles for traditional medicine is incomplete. The initial quantitative results are being analysed further and statistical issues discussed, including cluster approaches to help evaluate the data in a statistical manner in order to unravel useful conservation implications.

**THE EVOLUTION OF DIET IN THE LAMPROPHIIDAE**

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Studying feeding biology in a phylogenetic context helps elucidate factors that significantly influenced evolutionary history. Recently, the deep history hypothesis (DHH) has been used to explain how divergence deep in the evolutionary history of organisms has resulted in present-day niche preferences. Contrary to this is the

competition-predation hypothesis (CPH) which states that current ecological traits are relatively independent of phylogeny and result from recent species interactions. We tested the validity of these hypotheses in the Lamprophiidae, a family of primarily African snakes. Having sourced diet data for ~300 species, a hierarchical cluster analysis was performed to group the prey types into eight clusters. A generalist diet comprised of lizards, aquatic vertebrates, small mammals, snakes and reptile eggs was characteristic of 46% of extant lamprophids. Stochastic Character Mapping was performed to generate 50 possible diet evolutionary hypotheses which showed that the ancestral lamprophid consumed a generalist diet in a terrestrial environment with a relatively small body size (400-600 mm) and possessed back fangs. Body size and fang morphology were correlated with diet indicating that these selective pressures have influenced the variety in prey consumption. Pagel's lambda was used to test for a phylogenetic signal in the distribution of diet, lifestyle, types of fangs and body size. Lifestyle, fang morphology, and body size were all phylogenetically constrained, while current diet patterns in the Lamprophiidae are independent of phylogeny. While this is the case for the Lamprophiidae, studies on other groups of snakes have found that phylogeny determines diet patterns.



The lampbrush provide a new model system for the study of macro-evolutionary patterns of morphological and ecological evolution at a deeper level of divergence and global scale than many well-established adaptive radiation model systems.

**BEHIND ENEMY LINES:  
INTERCELLULAR BLOOD  
PARASITES INFECTING  
OUR FROGS**

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In recent years there has been a strong focus on amphibians as the most threatened vertebrate class leading to increased efforts in documenting and conserving their biodiversity. Frogs are

known to harbour a great variety of parasites including protists, nematodes, acanthocephalans, monogenetic trematodes, digenetic trematodes, cestodes, mites, and leeches. Furthermore, they are severely affected by fungal and viral parasites such as the amphibian chytrid *Batrachochytrium dendrobatidis* and *Ranavirus* species respectively. Due to these parasites or diseases fatal tendencies in amphibians, much focus has been given to these groups. However, despite the increase in known anuran species, and studies on the above disease causing organisms, far less is known about the blood parasites. Recent studies suggest only a fraction of what is likely to exist of the blood parasite biodiversity has been reported, never mind described and studied in detail. Blood parasites recorded from frogs, include haemogregarines, haemococcidians, trypanosomes, viruses, and microfilariae. The most commonly reported blood parasite group however is that of the haemogregarines. Haemogregarines are apicomplexan protozoan parasites that display a heteroxenous life cycle, requiring both an invertebrate and vertebrate host. Haemogregarine genera recorded infecting frog hosts include *Babesiosoma*, *Dactylosoma*, *Hemolivia*, and *Hepatozoon*. Very little is known about the pathological effects these parasites have on frog hosts as well as the ecology of these host-parasite relationships. As such

the biodiversity and phylogenies of these parasites are important as it may provide an indication of the possible invertebrate host/vector responsible for the transmission of the parasitic infection thus aiding in elucidation of these parasites' life cycles, as well as revealing the potential implications of their transmission to novel hosts.

**CONSERVATION GENETICS  
OF THE SUNGAZER  
(*SMAUG GIGANTEUS*)**

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The sungazer (*Smaug giganteus*) is a Threatened dragon lizard, endemic to the Highveld grasslands of South Africa. These grasslands have been extensively modified for the purposes of agriculture, urbanization, and mining, with conservation measures virtually non-existent for this biome and its inhabitants. These processes, along with widespread poaching for the pet and traditional medicine trade, have resulted in a population decline of

~1% per year. Many aspects of the life history of the sungazer are still largely unknown, making conservation action difficult to direct. This study aims to use genetic techniques to investigate the population ecology of the sungazer, in order to further understand the species, and make rational conservation decisions to preserve populations and genetic level diversity. We used a panel of species-specific microsatellite markers and mitochondrial gene regions to investigate the broad-scale genetic structure of the species, and how the current species distribution has been shaped by historical phylogeographic processes. Mitochondrial gene sequences (12s, 16s) did not show clear structuring across the population. However microsatellite results indicated two strongly differentiated populations in the Free State and Mpumalanga provinces, with no recent evidence of gene flow between them. These populations are 40 km apart at their closest points, and are constrained on either side by water systems and mountains. Sungazers have not been recorded in the intervening area between these populations. The discordance between mitochondrial sequences and more rapidly evolving microsatellites suggests that the two populations have only recently been separated, potentially due to human land transformation.

**AMPHIBIAN DIVERSITY AND COMMUNITY-BASED ECOTOURISM IN NDUMO GAME RESERVE, SOUTH AFRICA**

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Amphibians are declining at alarming rates globally. In comparison with other vertebrates, amphibians are at the forefront of the current extinction event. Conservation areas are mainly areas of high species richness and this is evident at Ndumo Game Reserve (NGR). Dense human population generally correlates positively with high species richness, and consequently high human population numbers are associated with increased threat to biodiversity. This trend is also prevalent at NGR as it falls within an area that is characterised by high human activity, and communities surrounding NGR are mostly rural and dependent on the reserve for resources. Pressures resulting from high human population numbers are often cited as factors contributing to rapid amphibian declines. The conflict between conservation and development

hampers attempts at effectively curbing the ongoing biodiversity loss. Community-based ecotourism or a community-based conservation project is a way of achieving development and conservation objectives simultaneously.

**PHYLOGEOGRAPHY OF PELOMEDUSA SPECIES IN SOUTH AFRICA AND BEYOND**

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Recent research has provided evidence that helmeted terrapins (*Pelomedusa*) represent a diverse species complex distributed across sub-Saharan Africa and the southwestern Arabian Peninsula. Using three mitochondrial genes, the phylogeography of helmeted terrapins was examined, in particular to investigate possible contact zones between different species. Within *P. galeata*, widely distributed in and endemic to South Africa, two deeply divergent mitochondrial clades were identified. One is restricted to the westernmost part of the country, whilst the other is distributed over most of the remaining regions. This

widely distributed clade consists of three subclades, one of which is largely restricted to KwaZulu-Natal. In the Kruger Park region, another species (*P. subrufa* s. str.) has been recorded, which also occurs in Namibia, southern Angola, Botswana, the southeastern Democratic Republic of the Congo, Malawi, and the Kilimanjaro region of Tanzania. It has also been introduced to Madagascar and is expected to occur in Mozambique.

**CHYTRIDIOMYCOSIS MONITORING IN THE DRAKENSBURG**

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*Batrachochytrium dendrobatidis* (*Bd*) is a fungal pathogen of amphibians capable of adversely affecting all levels of organisation up to community level. In South Africa *Bd* is widely distributed including in the Drakensberg Mountains, where it infects Phofung river frogs, *Amietia hymenopus*. Our objective was to identify factors driving disease dynamics of *Bd* in *A. hymenopus*. We made use of a 10-year dataset that resulted from monitoring this host-pathogen relationship in tadpoles from the Mont aux Sources region. Tadpoles (n = 10) were collected twice annually from four rivers: Vemvhane, Tugela, Bilanjil

and Ribbon Falls. Presence/absence of *Bd* was determined through cytological screening of tadpole mouthparts. We found no statistical significant difference between the sites, but infection was more consistent between years at sites situated along popular tourist hiking trails. Interestingly, infection prevalence, although higher in summer, did not differ significantly between seasons. High altitude coincides with moderate temperatures resulting in a repressed fluctuation on the pathogen's prevalence between warmer and colder months. Rainfall, however was negatively correlated with infection prevalence. Growth rate ratios of tadpoles indicated that tadpole size and not developmental stage is one of the main drivers of infection. Persistently low to moderate infection prevalence and low pathogen virulence implies that *Bd* acts as an endemic infection in *A. hymenopus*.

**AN AUTOMATED APPROACH TO AMPHIBIAN DIVERSITY SURVEYS: A CASE STUDY FOR NORTHERN ZULULAND**

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Global declines of amphibians refer to the phenomenon of the population declines and extinctions of amphibian species around the world. One of the challenges of these enigmatic declines is to assess and track the scope of global decline. Thus there is a dire need for non-invasive, rapid, and objective monitoring techniques. Kwa-Zulu Natal (KZN) has a rich anuran diversity, boasting over 50 frog species in the northern parts of the province. Historically, there have been few studies conducted to assess the biodiversity of KZN, where the last extensive study on frog diversity was performed more than 30 years ago in the northern parts of KZN. This study aims to evaluate 1) the anuran diversity in northern KZN by using automated recorders set at eight different localities, 2) the effects of atmospheric conditions on the frog communities and 3) the amount of spectral and temporal overlap of calls from sympatric frog communities to test the acoustic adaptation hypothesis. The recorders (SongMeter, Wildlife Acoustics) are equipped with an ambient temperature sensor together with a solar panel and rechargeable Lead-Acid batteries to allow long term powering of the recorders. Data will be analysed in the laboratories using Song Scope analysis software and Kaleidoscope Pro software. The data analysed from the recordings can be used to identify the different species present and their abundance at the different localities

in northern KZN. These data will then be compared with historical data from previous studies done in the same area. Furthermore, the calling activity will also be combined with temporal environmental data to determine the seasonal patterns together with their mating activity. Recordings of the species will also be described in detail to determine the vocal repertoire and call characteristics of each species. Partitioning of species calling at the same time can be determined together with their characteristics and how they react to one another.

### ASPECTS OF THE SPATIAL AND POPULATION ECOLOGY OF TERRAPINS IN NDUMO GAME RESERVE, SOUTH AFRICA

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Movement patterns are an important component of the ecology of all animals. Measures of movements, regularity, distance travelled and home ranges can provide valuable insights into animal behaviour and what is required to ensure populations remain stable. Terrapins are good indicator species of wetland habitat health because of their reliance on only undisturbed or lightly disturbed habitat. South Africa's freshwater systems are under increasing

pressure due to a growing population, land-use change and climate change. It is vital to understand how organisms reliant on wetland systems are coping with these pressures. There is a paucity of general ecological data on terrapins in Africa despite their importance in freshwater eco-systems. Terrapins spatial ecology and home ranges have not previously been studied in South Africa. Furthermore little is known about their reproductive behaviour or population genetics. Consequently we are investigating several aspects of terrapin ecology and natural history using several different techniques, in Ndumo Game Reserve, South Africa. We used telemetry to monitor home ranges and movements. This also permitted location of their nesting sites during the breeding season so we could examine aspects of their reproductive biology. All terrapins trapped or encountered had biometric data recorded, including a small flesh sample to examine individual and population genetics. Trapping is continuing throughout the entire fieldwork period, with collection and sampling continuing after all 16 telemetry tags were fitted. Non-telemetered animals were permanently marked on their marginal scutes using a standardised numbering code system, and their resighting contributes to determining population dynamics via mark resight. We present information on the telemetry system used and aspects

of the spatial and population ecology of terrapins in Ndumo Game Reserve.

### FROG OLYMPICS: EXPLORING THE LOCOMOTORY ECOMORPHOLOGY OF THE PYXICEPHALID RADIATION IN SOUTHERN AFRICA

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Morphological traits determine mechanical properties of a body, which directly influences an organism's performance output, such as the power and speed of movements. Performance output is relevant for many vital tasks, such as predator escape and foraging. Therefore, species are expected to have morphological traits that maximises fitness with regard to the environment they inhabit. In this study we investigated whether morphological traits shown to influence locomotory performance in other frog clades can be demonstrated within a southern African frog radiation. Locomotory performance was tested for 25 pyxicephalid species collected across South Africa. Frogs were filmed jumping, sprinting and swimming to calculate respective velocities, in addition to being chased around a circular track to test both terrestrial and aquatic endurance. Finally, grip performance

was tested by rotating frogs on a non-stick surface. Body size, mass, limb length and finger dimensions were measured for each frog tested. Data were analysed within a phylogenetic framework to correct for phylogenetic history. Species morphology had a significant influence on locomotory performance, which confirmed similar relationships found in other frog clades. Body size explained the greatest variation in performance across species, while hindlimb length was positively related to burst performance but negatively with persistent locomotion. Morphology clearly influences locomotory performance between species within this recent frog radiation, suggesting that these traits have arisen through selective forces that might have been responsible for clade divergence, rather than through accumulated differences over time.

is geographically located at southern Africa's most southern extent of tropical climate, and the most northern extent of subtropical climate, lending to a highly diverse mosaic of habitats in the area in which various frog species can flourish. To assess the current situation of the frog species in this area a multidisciplinary study on the diversity, as compared to historical data, was undertaken to document and barcode as many species in the area as possible. At least two voucher specimens with tissues samples were collected per site per locality during the surveys and used for DNA barcoding, phylogenetic analysis and morphometric confirmation. The mitochondrial DNA barcoding COI (cytochrome c oxidase subunit I) and complementary 16S rDNA genes were used as markers for this study. Data from these surveys and others were also used to assess the change in frog species diversity that has occurred over the past 30 years in the area. Currently, 38 species from multiple localities have been collected and barcoded (COI and 16S), with the focus of future surveys of this area to collect the remaining 19 species.

**AMPHIBIANS OF NORTHERN KWAZULU-NATAL: A PHYLOGENETIC STUDY**

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Northern KwaZulu-Natal is a biodiversity hotspot, comprising the highest diversity of frog species in South Africa. The area

**GLOBAL REALIZED NICHE DIVERGENCE IN THE AFRICAN CLAWED FROG *XENOPUS LAEVIS***

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Although of crucial importance for invasion biology and impact assessments of climate change, it remains widely unknown how species cope and/or adapt to environmental conditions beyond their currently realized niches. The African clawed frog *Xenopus laevis*, native to southern Africa, has established numerous invasive populations on multiple continents making it a pertinent model organism to study realized niche dynamics. In this study, we assess whether the realized niches of the invasive populations in Europe, and South and North America

represent subsets of the species' realized niche in its native distributional range or if niche shifts are traceable. Univariate comparisons among bioclimatic conditions at native and invaded ranges revealed the invasive populations to be nested within the variable range of the native population being, at the same time, well-differentiated in multidimensional niche space as quantified via n-dimensional hypervolumes. The most deviant invasive populations are those from Europe. Our results suggest varying degrees of realized niche shifts, which are mainly driven by temperature related variables. The crosswise projection of the hypervolumes that were trained in invaded ranges revealed the southwestern Cape region as likely area of origin for all invasive populations, which is largely congruent with DNA sequence data.



## UNDERSTANDING THE INVADER: EXPLORING GEOGRAPHIC VARIATION IN THE PARASITES OF THE AFRICAN CLAWED FROG (ANURA: PIPIDAE: *XENOPUS LAEVIS*)

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In our ever-changing natural world, biological invasions account for a large proportion of global biodiversity decline, especially in the case of amphibians, which are globally recognised as the most threatened vertebrate class. One of these invasives is none other than the African clawed frog, *Xenopus laevis*. There are established feral populations of *X. laevis* on four continents, making it one of the most successful amphibian invaders worldwide. Because of its primarily-aquatic lifestyle, *X. laevis*, hosts a myriad of parasites. Thus, aside from negative influences on non-native ecosystems, such as competition and predation, *X. laevis* is also a potential vector for the diffusion of diseases and parasites to native amphibian populations. However, very little is known about the role of *X. laevis* as a potential disease vector. Therefore, the main objective of this study will

be to determine the nature of the parasite assemblages of *X. laevis* specimens sampled across its native and introduced range. The results might be especially interesting, given the fact that what is referred to as *X. laevis* possibly constitutes more than one species. Ultimately, this project aims to shed light on the global phylogeography of *X. laevis* sensu lato, by focussing on the associated parasites of the different taxonomic groups. Naturally, a thorough understanding of the disease ecology of this invasive species in its native habitat will facilitate the effective management of *X. laevis* in its introduced range.

## NEW RECORDS OF THE TOGO SLIPPERY FROG (*CONRAUA DEROOI*) IN THE FOREST AREA OF TOGO

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We present data on the population status of *Conraua derooi* in Togo. Five populations of the species have been identified in the forest area of Togo, four

populations in the Missahohe forest and one near Yikpa village. The size of each population was estimated and habitat parameters assessed. We comparatively studied the morphological and morphometric characters of the five populations. The four Missahohe forest populations are small and isolated from each other, indicating that forest fragmentation led to a fragmentation of the frog population as well. We speculate about the future development of the different (sub-) populations and recommend actions to better conserve this amphibian species.

## MICROSTRUCTURE-MEDIATED OPTICAL EFFECTS IN THE PUFF ADDER (*BITIS ARIETANS*)

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Optical effects enhance the appearance of various botanical structures, insects, birds, and snakes. These effects are often due to structural colours which result from the alteration of incident light by micro-structures present on the surface. The optical effects which result from microstructures on the snake epidermis may offer the animal ecological and physiological benefits. Using electron

microscopy, we examined *Bitis arietans* for microstructure-mediated optical effects. We found significant differences ( $U = 184.00$ ;  $p < 0.001$ ) in the height of microstructures between black ( $40 \mu\text{m}$ ) and pale ( $17 \mu\text{m}$ ) scale regions, but no differences ( $t_{8,0.8} = 0.26$ ;  $p = 0.80$ ) in the density of microstructures on each region. Using spectrophotometry we measured the spectra of dark, pale, and ventral regions. Ventral scales, due to their lack of microstructures, served as a control. Dark regions had the lowest recorded intensity of all, while the spectral intensity of both dark and pale regions was lower than ventralia. Our results show that colour differences correspond to the height of scale microstructure. We conclude that scale colour in *B. arietans* is a product of optical effects. *Bitis arietans* is widely distributed across Africa, and as an ambush forager may remain in ambush positions for extensive periods of time. Thus, there is great reliance on visual and chemical camouflage to avoid detection by predators and prey. We suggest that the optical effects created by microornamentation contribute to the snake's visual camouflage, and thus has an important function in the ecology of this species.

## THE USE OF PHYLOGENETIC DIVERSITY FOR INFERRING BIOGEOGRAPHIC PATTERNS – THE CASE OF SOUTH AFRICAN REPTILES

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South Africa (SA) is a global reptile hotspot. With over 400 reptile species it is the most species-rich African country. Given the number of studies and the momentum of herpetological research in SA it is also the best surveyed country on the continent. The increasing amount of data available on species distributions, in combination with new DNA sequences becoming available for more species, allowed us to analyse large-scale spatial patterns of evolutionary diversity of SA reptiles in the spatio-temporal framework of phylogenetic diversity (PD). PD is a measure of biodiversity that combines the information on species distributions with their phylogenetic relationships. It represents an objective proxy for ecosystem function and can be used for inferring biogeographic patterns, identification of refugia ('museums') and generators ('cradles') of biodiversity, as well as to make informed conservation decisions that capture diversity at the genetic level. To reconstruct the phylogeny

of SA reptiles, we combined available GenBank sequences for SA reptiles and generated new sequences for 61 species or subspecies that have not been sequenced to date. Based on a data set containing 389 of 427 (91%) of terrestrial reptiles in an alignment of 18 genes (20,000 bp), we inferred phylogenetic relationships by maximum likelihood estimation. For the spatial component, we collated over 140,000 distribution records from the South African Reptile Conservation Assessment. Although the distribution of most species is relatively well documented in SA, the sampling is obviously biased by sampling effort around populated areas. To account for this, we modelled the potential distribution of all taxa for the current climate using bioclimatic variables. As an example, we use two species-rich families distributed across SA, the skinks and lacertids, to identify regions that contribute to 1) preserving ancient diversity and 2) generation of diversity. In both families PD is highly correlated with species richness, which could indicate that PD is not a better predictor of evolutionary diversity than species richness itself. However, when corrected for the number of taxa, both families show correspondence in that ancient diversity ('museums') is centred in north-eastern SA. In contrast, recent diversity ('cradles') has arisen in different regions, with the skinks recently diversifying in the arid west and northwest, whereas lacertids have

recently diversified in the Great Karoo. The northeast is also expected to act as a 'museum' across other reptile families, but the 'cradles' may differ based on drivers of evolution for each family.

## GENETIC STRUCTURING OF THE ANGULATE TORTOISE *CHERSINA ANGULATA*

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The angulate tortoise (*Chersina angulata*) is endemic to the southwestern parts of South Africa and adjacent Namibia. Previous studies using three mitochondrial genes revealed two genetically distinct lineages. One of these two lineages is subdivided in two subclades, one from the northwestern Cape and one from southwestern Cape, whilst haplotypes from the southern Cape correspond to the second distinct lineage. Using one mitochondrial marker and 18 microsatellite loci, we examined the genetic structuring of *C. angulata* in the entire range. Our microsatellite results confirm largely the same genetic structuring as previously revealed by mitochondrial DNA with three

distinct clusters. In spite of significant mitochondrial differentiation, our microsatellite data indicate gene flow across contact zones, suggesting that all genetic groups are conspecific.

## THE IMPORTANCE OF BODY POSTURE AND ORIENTATION IN THE THERMOREGULATION OF *SMAUG GIGANTEUS*, THE SUNGAZER

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Body temperature ( $T_b$ ) is the most influential factor affecting physiological processes in ectothermic animals. Reptiles use behavioural adjustments, i.e., shuttling behaviour and postural and orientation adjustments, such that a target  $T_b$  ( $T_{b, \text{target}}$ ) can be achieved.  $T_{b, \text{target}}$  is expected to be close to many of the physiological and behavioural thermal optima for the species. The sungazer, *Smaug giganteus*, is unique amongst the Cordylidae in that individuals inhabit self-excavated burrows in open grasslands, where conductive heating is restricted. Therefore, their  $T_b$ s are more likely influenced by postural and orientation adjustments than by conductive mechanisms. The purpose

of this study was to measure the  $T_{\text{target}}$  of sungazers and to assess the impact of body posture and orientation on thermoregulation. iButtons were modified to function as cloacal probes, set to record temperatures every minute and were inserted in the cloacas of 17 adult sungazers. Sungazers were released at their respective burrows where camera traps recorded photographs every minute of the diurnal cycle to record behaviour. Copper models recorded the range of operative temperatures; an exposed model set up in “sungazing” posture, and a model inserted 0.5 m into an active sungazer burrow. Sungazers achieved a  $T_{\text{target}}$  of  $30\text{ }^{\circ}\text{C} \pm 0.7\text{ }^{\circ}\text{C}$  (Mean  $\pm$  SD) and remained at this range for  $371 \pm 162$  minutes (Mean  $\pm$  SD) per day. Body posture significantly affected  $T_b$ ; the anterior body-up (high) and anterior body-up (low) postures resulted in higher  $T_b$ . Heating rate during the anterior body-up (high) posture was  $1.8\text{ }^{\circ}\text{C} \pm 2.7\text{ }^{\circ}\text{C}$  per 15 minutes. Lizards heated faster when facing away from the sun ( $1.9\text{ }^{\circ}\text{C} \pm 2.1\text{ }^{\circ}\text{C}$  per 15 min) and spent proportionally more time in this orientation in the morning when  $T_b$ s were lower than  $T_{\text{target}}$ . Our data suggest that sungazers would be able to tolerate changes in environmental temperatures by adjusting their thermoregulatory behaviour.

## OVERVIEW OF THE NEMATODES PARASITIZING AMPHIBIANS FROM SOUTH AFRICA

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There are 24 species of nematodes known from more than 30 species of South African amphibians. Although nematodes comprise the biggest part in endoparasite communities of African amphibians (> 70%), their biodiversity and taxonomy are still poorly described. Nematodes known from southern African amphibians include Rhabdiasiade – 8 species; Cosmocercidae – 5 species; Camallanidae – 5 species; Amphibiophylidae – 2 species; Molineidae – 1 species; Hedruridae – 1 species and Capillariidae – 1 species. According to the literature, the most common nematodes are *Cosmoecra ornata* (Dujardin, 1845) Diesing, 1861, reported from 13 amphibian species and *Aplectana macintoshi* (Stewart, 1914) Travassos, 1931 reported from 15 species of amphibians. However, both species of nematodes have an extremely wide host range (77 species of amphibians and reptiles in *C. ornata* and 68 in *A. macintoshi*) and geographical distribution (Palearctic, Oriental,

Ethiopian and few spots in Neotropical region). As it was investigated recently on the examples of European nematodes *Oswaldocruzia filiformis* Travassos, 1917 (family Molineidae) and *Rhabdias bufonis* Schrank 1758 (family Rhabdiasidae), that such polyhostality in most cases is the result of misidentification and authors really dealt with the other, recently described species. In our opinion, the nematode fauna parasitizing amphibians from South Africa might be much more diversified and it will be outlined in future detailed investigations of morphology and molecular studies.

## THE CAPE WHIP SNAKE: A PRELUDE TO RESOLVING THE PSAMMOPHIS LEIGHTONI COMPLEX

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Subspecies of the *Psammophis leightoni* complex (*P. leightoni*, *P. namibensis*, and *P. trinasalis*) were elevated to species status in 2002 on the basis of poorly-defined ecological differences and their allopatric geographic distribution ranges. A 2008 phylogeny of Psammophiidae did not support the

specific status of *P. leightoni* and *P. namibensis* although limited sampling (one sample per putative species) limited phylogenetic inference. *Psammophis leightoni*, endemic to the Western Cape, is currently listed as Vulnerable [B1ab(ii)] and is threatened, largely by habitat loss. However, the current taxonomic uncertainty surrounding the complex poses a significant challenge to the conservation of *P. leightoni* which would not be considered threatened if *P. leightoni* and *P. namibensis* represent a single taxon. Although these species are currently viewed as allopatric, the area separating their ranges is poorly sampled and may represent a sampling artefact. We aimed to assess whether suitable climatic conditions exist between the current distributions of *P. leightoni* and *P. namibensis*. Using MAXENT, we modelled the distributions of each species. Our models provided good fits of the data, producing high area under the curve (AUC) statistics of the receiver operating characteristic (ROC) plots (*P. leightoni* AUC: 0.995, *P. namibensis* AUC: 0.992). We also supplemented the AUC scores with true skill statistics (TSS) to remove sensitivity to area size and species prevalence, and maintained good model performance (*P. leightoni* TSS: 0.993, *P. namibensis* TSS: 0.986). Using conservative model thresholds, we show no species connectivity, suggesting that currently, genetic exchange between these two



taxa is unlikely. Our findings support the elevation to species status, but we note that vicariance between these two distributions might be recent. Thus our results do not preclude these two taxa representing a single species. With the conservation status of *P. leightoni* affected by the clarification of this complex, we recommend these preliminary models be used in conjunction with further phylogenetic analysis for conclusive species delimitation.

**COUNTING EGGS BEFORE THEY HATCH: IMPLEMENTATION OF THE MONITORING AND SURVEILLANCE PROTOCOLS FOR KZN'S THREATENED FROG SPECIES**

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Monitoring is an essential means of detecting amphibian declines and is being increasingly implemented in different parts of the world to gauge trends and spur conservation interventions. Development of monitoring and surveillance protocols was initiated in 2013 for four of KwaZulu-Natal's

threatened frog species using Ezemvelo KZN Wildlife Norms and Standards for Surveillance and Monitoring Plans for Biodiversity. The methods have been tested for two species to date, the Critically Endangered *Hyperolius pickersgilli* (Pickersgill's reed frog) and the Endangered *Natalobatrachus bonebergi* (kloof frog). Some initial work using automated microphone arrays have also been tested to measure densities and special utilisation of the Endangered mistbelt chirping frog, *Anhydrophryne ngongoniensis*. Data were collected seasonally at three sites in KZN for *H. pickersgilli* using both automated and manual audio transect survey methods. *Natalobatrachus bonebergi* was monitored monthly throughout the year at two sites in KZN and three reserves in the Eastern Cape using transect egg clump counts. Data for Vernon Crookes Nature Reserve on the KZN south coast have been collected since December 2013 and provide the most comprehensive dataset of all sites based on egg clump counts. The primary response variable for detecting trends for this species is total number of egg clumps and a secondary response variable is mean number of eggs per clutch, both of which give an indication of breeding activity and potential population size. Data on additional variables were also collected to provide information on habitat preferences and detect emerging threats. Monthly monitoring has

shown the species to have a protracted breeding season (August-June), but that the drought conditions in 2014 and 2015 severely affected breeding activity. In all cases, these monitoring efforts are a joint collaboration between provincial conservation authorities, academic institutions, NGOs and volunteers, demonstrating the valuable contributions of citizen scientists to species conservation.

**A SPATIAL AND TEMPORAL ASSESSMENT OF SNAKE OCCURRENCES IN WINDHOEK, NAMIBIA BETWEEN AUGUST 2015 AND APRIL 2016**

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Conflict between snakes and people in urban areas is a problem Windhoek shares with many cities around the world. Surrounded by farm and conservation land, this capital city of Namibia experiences regular snake occurrence in and around houses, gardens and industrial sites. This study used snake removal data from the city's designated snake removal institution, Snakes of Namibia, in order to record numbers and diversity of snakes occurring in the city during the summer of 2015-2016, and identify possible reasons for conflicts.

It also provides a baseline for annual biodiversity monitoring with snakes as a proxy for ecosystem community dynamics. Over the period August 2015 to April 2016, 182 snakes of 12 species were removed from homes, gardens and industrial sites in the city. Puff adder (*Bitis arietans*) which represented 36% (n = 65) and zebra snake (*Naja nigricincta*) 29% (n = 53) dominated removal incidents. Of the other species, only brown house snake (*Boaedon capensis*) 11% (n = 21) and boomslang (*Dispholidus typus viridis*) accounted for more than 10% of removals. Monthly snake removals correlated highly with monthly total rainfall, with highest number of incidents reported in January 2016 (23%, n = 41). Incidents were concentrated in the eastern and southern suburbs, as a result of garden irrigation although the study could not assess whether reporting diligence was consistent across all suburbs. Although 81% (n = 147) of snake incidents involved venomous species no snakebite incidents were reported during the period. The study provides a baseline for year-on-year monitoring, a useful parameter for the city's biodiversity programme.



### THE RELATIVE TADPOLE VULNERABILITY OF *XENOPUS* TADPOLES TO *X. LAEVIS* PREDATORS

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Predation plays an important role in determining the shape and structure of aquatic ecosystems. In larval amphibian assemblages, predators may impact tadpole communities by showing preference towards a particular species. This can negatively impact population structures and therefore be detrimental to threatened species. *Xenopus laevis* is a voracious predator known to predate on many tadpole species, including its congeners. *Xenopus gilli* is an Endangered species and is thought to be under threat through competition, hybridisation and predation from *X. laevis*. This study aimed to assess the threat of *X. laevis* predation on *X. gilli* by evaluating the relative vulnerability of *X. laevis* and *X. gilli* tadpoles to *X. laevis* adults as a common predator. We designed a factorial experiment in which tadpoles of *X. laevis* and *X. gilli* were collectively and separately exposed to treatments with the presence or absence of a predator over 14 hr. A factorial ANOVA, followed by a Fischer LSD post hoc test, was used

to compare differences in vulnerability to *X. laevis* predation. Results showed that large *X. gilli* showed significantly higher vulnerability to *X. laevis* predation compared to small *X. laevis*. No differences were detected between large and small *X. laevis*. No difference was found between *X. gilli* and *X. laevis* of similar size. Behaviour may be a factor in contributing to large *X. gilli* tadpole's vulnerability to *X. laevis* predation. This will have negative implications for the population structure of the Endangered *X. gilli*.

### HABITAT-DRIVEN EVOLUTION OF BODY SIZE IN *BITIS*

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The genus *Bitis* is particularly diverse in sub-Saharan Africa, where 13 of the 18 species occur. These species have an enormous range in body size, from <300 mm (*B. schneideri*) to >2 m (*B. rhinoceros*). Species richness is highest in the arid and hyper-arid southwestern margin of the continent where many small species occur. In contrast, larger species tend to occur in forest

environments in West, Central and East Africa. Given the high richness in southern Africa, we hypothesised that this region was the centre of origin for the genus. In addition, the large range in body size suggests that selective forces on size may operate differentially in different environments. We tested these hypotheses by generating a comprehensive, dated phylogeny for the genus, using multiple mitochondrial and nuclear markers. The relationship between body size and environment (i.e. aridity, vegetation density) was examined using phylogenetic regression, and ancestral trait and area reconstructions were run. Our results show that the centre of origin for *Bitis* was most likely East Africa, not southern Africa, with a single radiation into the arid southwest beginning about 14 Mya concomitant with the aridification of the region. An additional species radiation of the large-bodied forest *Bitis* probably occurred between 4-9 Mya as the central African forests fragmented. The ancestral condition appears to be a medium-size species. We suggest that the disparate shift in body size in the two clades was in response to large-scale environmental changes on the landscape concerning habitats associated to the aridification of Africa.

### FROG METAPOPULATION DYNAMICS IN THE WESTERN CAPE

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Habitats and thus populations of many species are becoming increasingly fragmented and resultantly threatened. Managing threatened species requires at least some knowledge of the population numbers, their distribution and how the populations interact with each other. Metapopulation models can help deal with the complexity of assessing threats which is formalised through IUCN Red List assessments and also informing the practical management of fragmented populations. We review what is known about Western Cape frog populations and how they may benefit from the application of metapopulation models.

**VARIATION IN THE DAILY ACTIVITY, MOVEMENT AND REFUGIA OF THE CRITICALLY ENDANGERED GEOMETRIC TORTOISE, *PSAMMOBATES GEOMETRICUS*, IN AUTUMN AND SPRING**

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To help assess habitat requirements of the Critically Endangered geometric tortoise, we used thread-trailing to measure daily activity, movements and refugia of adult male and female *Psammobates geometricus* in autumn and spring 2002. We found strong differences between sexes and seasons, and among individual tortoises and days. Female activity was high, and their refugia differed from male refugia, consistent with high nutrient demands for producing eggs in winter and spring, vitellogenesis, and relatively high maintenance costs due to being larger than males. Male activity, long daily movements when active, and refuge use were consistent with thermoregulation,

predator avoidance, and possibly, mate-searching in autumn. Both sexes increased body condition during the rainy season. While male movements were longer and more linear than were female movements, the greater activity of females contributes to their larger home ranges and, probably, food requirements. Cool autumn days limited female activity and warm spring days limited male activity. All refugia were perennial plants, mostly shrubs or grasses, but varied considerably between sexes and seasons, suggesting selection for protection from ambient temperatures and predators.

**DISEASE OUTCOMES OF PHENOTYPIC VARIATION IN SOUTH AFRICAN ENDEMIC AMPHIBIAN CHYTRIDS**

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Chytridiomycosis, a dermatological disease caused by the chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*), is a major global threat to the continued survival of the already highly threatened amphibians. Some studies have shown a correspondence between the phenotypic traits of *Bd* isolates and their virulence. However, these studies did not attempt to measure variance across population. By measuring phenotypes

across a population, more representative data can be acquired on traits, which could more realistically be linked to the pathogenicity and disease outcomes of *Bd*. One major contributing trait could be the macromolecular structures related to the energy maintenance and zoospore motility. In theory, there may be correspondence between the quantity of lipid stored in lipid globules, the quantity and size of mitochondria, flagellum length of zoospores and virulence. We currently lack knowledge about the relationship between *Bd* virulence and a pathologically relevant phenotype. We propose to describe the phenotypic variance within *Bd* isolates from South Africa and evaluate if a pathological phenotype exists. This will enable meaningful assumptions about the virulence of other isolates.

**A NEW SPECIES OF *SCOLECOSEPS* (REPTILIA: SCINCIDAE) FROM COASTAL NORTH-EASTERN MOZAMBIQUE**

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Sand skinks (*Scolecoseps*) are small fossorial lizards that inhabit sandy soils along the East coast of Africa from northern Mozambique to central Tanzania. These skinks are very rarely observed with two of the three currently-recognized species being described from only single specimens. Seven specimens of *Scolecoseps* from the vicinity of Palma on the north coast of Mozambique are compared morphologically with previously recorded material and described as a new species. *Scolecoseps* sp. nov. can be morphologically distinguished from all other congeners by the presence and positions of certain head scales and also by the higher subcaudal scale count. It is found in coastal savanna habitat under leaf litter of *Berlinia orientalis* trees, in sandy soils with close proximity to large wetlands. Its currently known geographic distribution is south of *S. litipoensis* and north of *S. boulengeri* and we discuss its potential geographic distribution based on the prevalence of certain soils. A brief review of all available literature for the *Scolecoseps* genus is provided and the necessity for additional research on these poorly known fossorial skinks is discussed. Finally, we briefly present additional important herpetofauna observations from the Palma district that were made during the fieldwork effort to collect *Scolecoseps* sp. nov. and highlight the conservation potential of this region.

## THE ORANGE RIVER AND CHYTRIDIOMYCOSIS

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Large-scale river systems are often utilized for agricultural irrigation purposes, creating vast networks of canals and dams that could potentially transport biota over vast distances. The Orange River is such a system, stretching approximately 2500 km, traversing the driest regions of South Africa. The general arid nature along this system, results in the creation of a corridor of suitable habitat for amphibians and their associated pathogens, restricted to the area directly adjacent to the river or irrigation systems originating from the river. A major concern for amphibians around the world is *Batrachochytrium dendrobatidis* (Bd) causing chytridiomycosis and leading to major declines in amphibian populations. Tarrant et al. (2013) modelled the potential habitat in a South African landscape and showed that the Orange River provides the necessary microclimate for Bd to survive. Twelve sites, spread over 2000 km of the river were selected and 426 individuals were sampled, belonging to nine species. Of the 266 adults frogs sampled, 66 were positive and upon lineage specific

analyses it was seen that both BdGPL and BdCAPE was present in this system. Chytrid isolated from these sampled individuals yielded 14 cultures from four sites. Due to the fact that BdGPL is usually the causing agent in chytridiomycosis-related declines around the globe, and its ability to displace endemic lineages due to its hypervirulent nature, the potential impact on these restricted amphibian populations could be catastrophic. Although the prevalence level in this system is only 25%, infected individuals were found throughout the entire study area. The danger when a pathogen is present in a restricted corridor of suitable habitat is that the risk of infection is increased leading to a higher rate of transmission and potential for spread. Adding in multiple lineage presence and potential displacement of endemic – potentially hypovirulent compared to BdGPL – lineages, and the dangers as well as challenges to survival in an otherwise inhospitable landscape results in the escalation of the threat to survival. Pathogen presence determination and the understanding of the potential for spread throughout such a corridor habitat are thus essential for the management and conservation of biota. Pockets of pathogen-free habitats could also be further analysed to possibly yield insight as to potentially undiscovered pathogen elimination methods.

## NEVER UNDERESTIMATE YOUR OPPONENT: ADAPTIVE PHENOTYPIC RESPONSE IN A RECENT AMPHIBIAN INVADER

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Invasive species often need to cope with ecological conditions that are dissimilar from those they adapted to, presenting an opportunity to investigate how phenotypes change across short time scales as a consequence of altered genotype-environment interaction. Furthermore, phenotypic comparison between native and invaded ranges not only addresses basic eco-evolutionary questions but also determines management actions helping for example, to estimate species invasion potential. The guttural toad *Sclerophrys gutturalis* is a generalist and synanthropic species naturally distributed in tropical and subtropical Central and southern Africa. It has recently invaded a peri-urban area of Cape Town and despite a sustained extirpation program the invasive range is still in expansion. The ability of the species to thrive and spread across Cape Town is surprising since the area is characterised by a Mediterranean climate that is consistently drier and colder than that of the native range. Moreover, the

introduction is very recent, with the species first being detected in 2001. We measured the field hydration state of guttural toads from the invasive Cape Town population and a potential founder population from Durban. We also obtained from laboratory trials: i) rates of evaporative water loss (EWL) and water uptake (WU), ii) sensitivity of locomotor performance to hydration state, iii) critical thermal minima ( $CT_{min}$ ) and iv) interaction between  $CT_{min}$  and hydration state. In the field, hydration levels of Cape Town toads were significantly lower than in Durban toads. Although our lab experiments showed that the two populations did not significantly differ in their rates of EWL and WU, toads from Cape Town appear to be more efficient than those from Durban in minimising water loss through postural adjustments. Also, the effect of hydration state on locomotor performance varied noticeably between the populations, with Cape Town individuals outperforming Durban individuals when dehydrated but not when fully hydrated. Lastly,  $CT_{min}$  was significantly lower in Cape Town individuals than in Durban individuals and the difference remained noticeable despite the hydration state of the toads. Thus, we found that an invasive population of less than 20 years shows an adaptive phenotypic response that may be due to genetic adaptation or phenotypic plasticity. Our results

have management and conservation implications because they indicate that the invasion potential of this species in Cape Town is already higher than we could infer from its characteristics in its native range.

**REVIEW: CONSERVATION DOGS FOR FROGS?**

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The cryptic nature of frogs often pose challenges to the observer regarding detection probability, thus restricting the amount of data that can be recorded in any given time frame. The use of dogs has been proven to be an effective scent-detection technique for various organisms with the benefit of improved target acquisition times over human effort. However, this technology has not been extensively tested on frogs. We investigated the use of scent-detection dogs on amphibians and report on the benefits and limitations of this technique. In an *ex-situ* environment we consistently achieved more than 95% accuracy in amphibian scent detection in various tests including scent dilution, scent mixing, and scent burial. Transfer of this technique to natural conditions was met with a number of challenges

that rendered the test less effective and even impractical for application with certain species. Scent tracks left by frogs are very short compared to what dogs encounter with other conventional conservation applications such as tracking of large mammals or tortoises. The technique cannot be applied widely since aquatic or arboreal species cannot be pinpointed. The value of scent-detection dogs for amphibian conservation lies with the illegal trade at customs control. Even higher detection accuracy was achieved for chytrid fungus than for frogs, but significantly more research is required before disease screening can be implemented as a mitigation tool for chytridiomycosis.

**PRODDING THE SLEEPING DRAGON: SOME INSIGHTS INTO THE REPTILE INDUSTRY IN SOUTH AFRICA**

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Reptiles have become increasingly popular as pets over the past decade and the trade in reptiles has grown virtually unhindered internationally. While many pet reptiles are bred in captivity, many are still taken from the wild or born of wild-caught parents. After narcotics, counterfeiting of products and currency, and human

trafficking, wildlife smuggling is the 4th largest global illegal trade. Authorities around the world suspect that 10% of all wildlife smuggled is intercepted but some countries report less than 1%. The current scale of wildlife smuggling is unsustainable, resulting in it often being identified as the second-largest direct threat to many species after habitat destruction. Trade is usually driven by a demand for a rare or protected species that are smuggled to avoid permits or paying of duty fees. There are particular problems associated with the illegal wildlife trade. The demand for rare species undermines a country's efforts to protect its natural resources. Some 80% of the animals die in transit. There is the risk of the introduction of invasive species and this increases the chances of global epidemics of zoonotic diseases. During the collection process, many bycatch or non-target species are killed. Due to the vast size of most of southern Africa's wilderness areas, a limited number of enforcement officers

and the associated reptile species that occur in these areas, southern Africa is considered one of the international hotspots in the reptile trade. In April 2013, an interagency, nation-wide operation, Operation Cold Blood (OCB), was undertaken as the first official attempt to document the range and variety of reptile (and other incidental) species being kept in the pet industry in South Africa. I present the findings of the KwaZulu-Natal part of the operation. It is a summary of selected holdings and is neither comprehensive nor complete. The extensive findings during OCB were both unexpected and unprecedented. In total, 268 different species were documented by the OCB team of which 194 were snakes, 22 lizards, two tortoises, six alligators and crocodiles, one amphibian, six mammals, one insect, and 36 species of tarantulas. 85% of the species documented were exotic and a number of species had high international conservation statuses.



## POSTERS

### THE AMPHIBIANS AND REPTILES OF THE CANGANDALA NATIONAL PARK (MALANJE PROVINCE, ANGOLA)

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Cangandala National Park, situated in Malanje Province (Central Angola), is one of the most important conservation areas in the country, representing one of the largest biomes in Angola – the Miombo Woodlands – and especially due to the presence of the iconic and endemic Giant-Sable *Hippotragus niger variani*. Despite its importance, few data exist regarding Cangandala National Park's herpetological assemblage. In September and October 2015 a herpetological survey of the park was undertaken by a team composed of technicians from the Instituto Nacional da Biodiversidade e Áreas de Conservação (Angola), the California

Academy of Sciences (USA), and the Museu Nacional de História Natural e da Ciência (Portugal), resulting in the finding of 14 species of amphibians and 18 species of reptiles. Of these, eight (three amphibians and five reptiles) represent new records for the province, while three species (one frog, one gecko, and one skink) represent putative new species. We compare these new records with the herpetofauna already known to the province and present future directions for the study and conservation of these animals in the country.

### CRYPTIC DIVERSITY IN TREE FROGS (*LEPTOPELIS*) OF THE ANGOLAN ESCARPMENT – FITTING THE PIECES TOGETHER

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The Angolan escarpment is located between the coastal plain and the central plateau, extends from the north to the south of the country, and receives frequent moisture from coastal winds. Differences in aspect, altitude, and distance from the coast generate gradients in rainfall and temperature along the escarpment that affect the structure and composition of the associated forests and woodlands, that often occur as isolated patches. The escarpment forests occur in two main blocks, north and south of the Kwanza River. These are centres for speciation and contain high endemism for birds and plants in the country. The treefrogs (*Leptopelis*) are habitat specialists, with many species restricted to forested habitats. They are therefore expected to display similar patterns of speciation to birds and plants in the forest blocks. However, Angola has a poorly-known herpetofauna and currently six species of treefrogs are listed for the country (excluding Cabinda), although species delineation for some requires re-evaluation. Two species, *Leptopelis marginatus* (Bocage, 1895) and *Leptopelis jordani* Parker 1936, are endemic to the escarpment, and remain known only from the type specimens. Herpetological surveys of these forest blocks are in progress. An integrated taxonomy approach is being applied, utilizing morphology, genetics, advertisement calls, and

habitat association to assess tree frog speciation. A number of Operational Taxonomic Units (OTUs) have been identified, indicating cryptic diversity in the genus associated with this habitat. Other unexpected herpetological discoveries indicate further potential cryptic diversity in the amphibians and reptiles inhabiting this region. They highlight the urgent need to effectively protect these singular and endangered habitats that are not currently afforded formal national protected status.

### LOVERIDGE'S ANGOLAN GECKOS

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In 1944 Arthur Loveridge described two new geckos from Angola, *Afroedura karroica bogerti* and *Pachydactylus scutatus angolensis*. The descriptions of both species included vague and

confusing type localities and were based on few specimens (one and two, respectively). Since their description little additional material has been reported. Laurent (1964) record four new specimens of *P. angolensis*, and another was found by Ceriaco *et al.* (2016). No new material for *Afroedura bogerti* has been described from Angola since the original description, although a few specimens from the Namibian Kaokoveld have been provisionally referred to the species. We present and map new distribution records for both species (104 *A. bogerti* and 17 *P. angolensis*) based on collections made during expeditions undertaken from 1971-2015 by the authors. Analysis of this material has not previously been discussed, although some was used in publications that elevated both taxa to specific status. The new collections occur from diverse habitats, elevation gradients and geological substrates. Based on early expedition reports, historical accounts from the region, and a review of cartographic material, refinements to the type localities of both species are proposed. Preliminary taxonomic studies indicate that further adjustments are needed to reflect the revealed cryptic diversity.

**ULTRASTRUCTURAL  
COMPARISON OF  
HEPATOZOON IXOXO  
AND HEPATOZOON  
THEILERI (ADELEORINA:  
HEPATOZOIDAE), PARASITIZING  
SOUTH AFRICAN ANURANS**

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To date, only two haemogregarine parasite species have been described from South African anurans: *Hepatozoon ixoxo*, infecting toads of the genus *Sclerophrys* (syn. *Amietophrynus*); and *Hepatozoon theileri*, parasitizing the common river frog, *Amietia delalandii* (syn. *Amietia queketti*). Both species have been characterised using limited morphology, and molecular data from PCR amplified fragments of the 18S rRNA gene. However, no ultrastructural work has been performed thus far. The aim of this study was to add descriptive information on the two

species by studying their ultrastructural morphology. Mature gamont stages, common in the peripheral blood of infected frogs, were examined by transmission electron microscopy. Results indicate that *H. ixoxo* and *H. theileri* share typical apicomplexan characteristics, but differ markedly in their external cellular structure. *Hepatozoon ixoxo* is an encapsulated parasite presenting a prominent cap at the truncate pole, and shows no visible modifications to the host cell membrane. In comparison, *H. theileri* does not present a capsule or cap, and produces marked morphological changes to its host cell. Scanning electron microscopy was performed to further examine the cytopathological effects of *H. theileri*, and results revealed small, knob-like protrusions on the erythrocyte surface, as well as notable distortion of the overall shape of the host cell.

**THE KNYSNA LEAF-  
FOLDING FROG (AFRIXALUS  
KNYSNAE): BIOLOGY AND  
HABITAT UTILIZATION**

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Global amphibian population declines

have been at the forefront of biodiversity studies and focus in recent years since its detection in the early 1980s. Within Western Cape Province, the southern cape region is identified as an ecotone and as such also a biodiversity hotspot. Conservation objectives have mainly focused on the region's vulnerable flora, fynbos, and remaining natural forests. Amphibian conservation has however been neglected in the minds of planning managers and decision-making authorities for the extent of natural conservation areas. MaxEnt distribution analysis using limited occurrence data was conducted to predict localities of probable occurrence. Passive acoustic monitoring methods are being used within these areas to establish *Afrixalus knysnae* distribution. Using GIS data and map overlays, possible habitats were identified where Songmeters<sup>®</sup> have been placed to record mating calls during the breeding season. One Songmeter has been placed at a site with an established population for an extended period, covering 18 months, in order to determine the exact breeding periods within this time and correlate the calling behaviour with microclimatic data obtained from an automated climate logger close to this site. Purpose designed acoustic analysis software, Songscope, Raven and Kaleidoscope will be used to evaluate acoustic data relating to the calling behaviour, the use of frequency partitioning, and temporal

variations during calling bouts and thus evaluating the acoustic niche hypothesis in habitats under pressure. The data will also assist in determining the effect of microclimatic variables that will induce calling activity. A more robust, final ecological niche model for *Afrivalus knysnae*, based on the results will include microclimatic and environmental data linked to the species calling behaviour and distribution.

**EFFECTS OF CLIMATIC AND ENVIRONMENTAL VARIABLES ON THE MOVEMENT OF LEOPARD TORTOISES IN THE KAROO, SOUTH AFRICA**

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Tortoises (Testudinidae) are believed to be one of the most threatened taxa, with 20% of all species currently listed as ‘Critically Endangered’ and 80% listed as at least ‘Vulnerable’. At least 10 tortoise species have gone extinct since 1700 AD and many more continue to decline, mostly due to anthropogenic pressures, including human-mediated changes to their habitats, overexploitation, and persecution. Given the projected global warming changes and the predicted changes to restrictive temperatures and the availability of food and water

resources, it is important to increase the understanding of tortoise ecology for application in management and conservation. Telemetry data has increasingly been used in movement ecology to investigate an animal’s ecological needs. Commercial farms in the semi-arid Karoo of South Africa provide suitable habitats for several tortoise species. GPS telemeters were fitted and programmed to receive bihourly movement data on 10 adult (5 male; 5 female) leopard tortoises (*Stigmochelys pardalis*) to investigate aspects of their spatial ecology. Displacement distances (distances between points) were calculated for all individuals in the study. These data were compared to climatic (temperature, rainfall) and environmental (e.g., proximity to water resources) variables. GLMMs were used to produce models to identify important predictor variables. It was found that rainfall and distance from increased food resources were poor predictor variables. The important predictor variables included land cover, time of day, distance from water resources, and temperature. In addition, our results highlighted the presence of night-time movement in Leopard Tortoises throughout the study period, mostly during the summer months, where night-time temperatures were warm and sometimes more favourable than day-time temperatures.

**SPECIES BOUNDARIES IN AFRICAN GREEN AND BUSH SNAKES (*PHILOTHAMNUS: SERPENTES*)**

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Green and Bush snakes of the genus *Philothamnus* currently comprise 20 species and four subspecies. The genus has been subject to previous taxonomic revisions based on traditional morphological characters, that in some instances, were found to overlap between species. Only a single molecular assessment for this genus was previously conducted but was focused on species inhabiting

islands in the Gulf of Guinea and few mainland species were represented. We investigated phylogenetic affinities within *Philothamnus* with more inclusive genetic assessment and wider geographical sampling, with the aim of detecting and validating putative species that could contribute to future taxonomic revision of *Philothamnus*. Species relationships were examined within a phylogenetic context and sampling included 124 samples from 14 of the 24 currently recognized species and subspecies. Phylogenies were constructed in Bayesian and Likelihood frameworks using three mitochondrial markers (16S, cytb, and ND4) and two nuclear markers (c-mos and RAG-1). To determine putative taxonomic units, a Bayesian General Mixed Yule-Coalescent Model analysis was conducted. In addition, Species Identifier, a barcoding approach – was used to further clarify species level relationships by comparing frequency distributions between intra- and interspecific sequence divergence. Phylogenetic results suggest that several species within *Philothamnus* require taxonomic revision. There is strong support for raising subspecies of *P. natalensis* (*P. n. natalensis* and *P. n. occidentalis*) to full species. Differences between *P. n. natalensis* and *P. n. occidentalis* are also supported by morphological and ecological differentiation. *Philothamnus semivariiegatus* is paraphyletic and



comprise four evolutionary units; central Africa, southeastern Africa, northeastern South Africa and central-to northern South Africa. Similarly, *P. carinatus* contains two cryptic lineages in central Africa and West Africa. Taxonomic revision for *sensu lato P. semivariiegatus* and *sensu lato P. carinatus* requires morphological and /ecological corroboration. *P. girardi* Bocage, 1893 and *P. dorsalis* (Bocage, 1866) formed a monophyletic clade with low genetic divergence, and the former should be synonymized with the latter. In addition, there was no genetic support for subspecies within *P. nitidus* and *Philothamnus nitidus loveridgei* Laurent 1960 should also be relegated to synonymy. Coalescent based species delimitation methods are robust and show relative accordance with current taxonomy, and are generally supported by the barcoding approach.

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By altering or eliminating delicate ecological relationships, non-indigenous species are considered a major threat to biodiversity, as well as a driver of environmental change. Global climate change affects ecosystems and ecological communities, leading to changes in the phenology, geographic ranges, or population abundance of several species. Thus, predicting the impacts of global climate change on the current and future distribution of invasive species is an important subject in macroecological studies. The African clawed frog (*Xenopus laevis*), native to South Africa, possesses a strong invasion potential and populations have become established in numerous countries across four continents. The global invasion potential of *X. laevis* was assessed using correlative species distribution models (SDMs). SDMs were computed based on a comprehensive set of occurrence records covering South Africa, North America, South America, and Europe and a set of nine environmental predictors. Models were built using both a maximum entropy

**IMPACTS OF CLIMATE CHANGE ON THE GLOBAL INVASION POTENTIAL OF THE AFRICAN CLAWED FROG XENOPUS LAEVIS**

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model and an ensemble approach integrating eight algorithms. The future occurrence probabilities for *X. laevis* were subsequently computed using bioclimatic variables for 2070 following four different IPCC scenarios. Despite minor differences between the statistical approaches, both SDMs predict the future potential distribution of *X. laevis*, on a global scale, to decrease across all climate change scenarios. On a continental scale, both SDMs predict decreasing potential distributions in the species' native range in South Africa, as well as in the invaded areas in North and South America, and in Australia where the species has not been introduced. In contrast, both SDMs predict the potential range size to expand in Europe. Our results suggest that all probability classes will be equally affected by climate change. New regional conditions may promote new invasions or the spread of established invasive populations, especially in France and Great Britain.

**DISTRIBUTION AND SPECIES RICHNESS OF AMPHIBIANS IN AWI ZONE AND WOMBERA DISTRICT, NORTHWEST ETHIOPIA**

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This study was conducted to describe the distribution and species richness

of amphibians found in Awi zone and Wombera district, North West Ethiopia. It deals with amphibian species distribution and richness during the period February 15 to March 5, 2016. Visual encounter survey method was used in careful visual estimation and amphibians were recorded in all habitats of the study area. Eleven species were recorded, belonging to five genera in four families under order anura. Alelitu River and wetland had the highest species richness which accounts for seven species and Mengeha (Ambiki) wetland followed by six species from Awi zone. This study reveals that the Awi zone and Wombera district are rich in amphibian species and endemism. Further studies are needed on the abundance and population structure across seasonal variation and habitat use for better conservation strategies in Awi zone and Wombera district, in particular Alelitu wetland and river near to the town Debrezeit (town of Wombera district).



## GENETIC STRUCTURING OF THE SPOTTED GRASS SNAKE *PSAMMOPHYLAX RHOMBEATUS* (LAMPROPHIIDAE)

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The spotted grass snake *Psammodaphylax r. rhombeatus* is a southern African endemic snake that occurs along the African escarpment. It is absent in the arid interior of the country. Ecologically it is an important species, as it preys upon a variety of vertebrates, and biologically it is an interesting species as it falls between being ovoviviparous and viviparous, laying its eggs partially incubated. We hypothesized that the species is polyphyletic, as the species historically consisted of two southern subspecies (*P. r. rhombeatus* Linnaeus, 1758 and *P. r. trilineata* Boettger, 1883), with corresponding pattern differences (spotted and striped, respectively). Phylogenetic analyses were conducted using mitochondrial markers (16S) on individuals sampled across the southern range of the subspecies *P. r. rhombeatus*. The species was genetically structured across the range, and clades were found to the north and south of their

range. Further work is needed in order to understand the taxonomic level of the clades, and whether the subspecies need to be raised to species level.

## SNAKE DIVERSITY IN THE GRAHAMSTOWN AREA, EASTERN CAPE PROVINCE

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Grahamstown is situated in a very interesting region of the Eastern Cape, as four of the vegetation biomes of South Africa converge in this area. This hybrid zone of climatic and environmental conditions, and the fact that rainfall falls throughout the year, with relatively mild winter temperatures, makes this region a particularly interesting habitat zone for snakes. In addition, much of the region is undeveloped, providing habitat and prey items for snakes. Being ectothermic, snakes are particularly active during warmer times of the year, and their reproduction is often seasonal, coinciding with the warming temperatures of spring. In the Grahamstown area, however, many snake species are active throughout the year. An understanding of the diversity of snake species in the region will provide information about the environmental factors that are at play in the adaptability of snakes to particular

habitats. Sampling of snake species was conducted throughout the year from 2014 to 2016, with ad hoc collection of snakes occurring on average every two weeks. Of the 31 species historically recorded for the Grahamstown area (including *Bitis albanica*, *Bitis atropos* and *Python natalensis*), twenty three were recorded. A diversity index was estimated for the region, and statistical analysis was done of the diversity in Grahamstown relative to other regions in South Africa.

## TERRITORIAL ESTABLISHMENT AND GENERAL BEHAVIOUR OF *AMIETIA DELALANDII*

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Frogs in general, play an important ecological role. It is therefore important to study the activity patterns of frogs, to contribute to their conservation, especially since they belong to the most threatened vertebrate class. This study focused on the interpretation of the territorial and general behaviour of *Amietia delalandii*, and was conducted at the North-West University Botanical

Gardens and at Oudrift Riverside Lodge in Potchefstroom, South Africa. Songmeters were used to measure the active spectrum of nocturnal activity of this species, individual identification keys of back patterns were drawn for each specimen that was observed, and environmental variables were noted. The territorial establishment was assessed by plotting the position of each specimen that was found in the study area on a gridded site map, together with the time and date that they were observed. We found that *A. delalandii* is most active from 20:00 to 23:00. No territorial behaviour was observed for female frogs, where they only occur as migrating individuals between the territories of male frogs. Male frogs were found to choose a preference area in a home range area, moving around in the preference area, and ultimately choosing a territory in the preference site. Preference sites were found to be between well-sheltered plants for both sexes, and that males call from river banks in lotic water systems, but from both river banks, and from inside the water in lentic systems. Breeding was found to take place in both lentic and lotic systems. Minimum and maximum atmospheric temperatures, together with nocturnal water temperatures were compared with the number of frogs that was found for each observational session. From this, a linear relation was found, showing an

increase in the number of frogs with an increase in temperature. Frog activity was also compared with the moon phase, although no relation was found between these two factors.

**CRYPTIC BREVICEPS SPECIES IN NORTHERN ZULULAND: WHAT DO ADVERTISEMENT CALL DATA SHOW?**

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Advertisement call anomalies suggest the presence of at least two cryptic *Breviceps* species in northern Zululand. An analysis of advertisement call data of 16 *Breviceps adpersus* populations from Mutare in the north to Grahamstown in the south is re-examined and new call data from Hluhluwe and Mpophomeni (W of Tembe Elephant Park) is presented. These populations are indistinguishable morphologically from *B. adpersus*. Tissue samples are being collected for molecular analysis.

**MICROORNAMENTATION: ECOLOGICAL ADAPTATION OR PHYLOGENETIC SIGNAL?**

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Microornamentation is present on the scales of various species of southern African snakes. Of these, morphometric similarities are found amongst closely related species. Using scanning electron microscopy and a morphometric characterisation technique previously developed we examined a broad range of species for meaningful similarities. Seven members of Elapidae show dorsal-scale trabeculae with minor species-specific variation. Our results indicate that closely related species show morphometrically similar microornamentation, even where it serves no obvious ecological adaptation. Price (1982) reasons that microornamentation is taxonomically significant as he found no obvious ecological or habitat related variation. If microornamentation is strictly a phylogenetic signal, similar patterns will emerge at the species level. Two members of *Viperidae* show leaf-like protruberances with a similar ecophysiology. The leaf-like

microornamentation may improve the camouflage ability of the vipers. Further, we found morphometrically similar microornamentation on the ventralia of two closely related arboreal species *Dispholidus typus* and *Thelotornis capensis*. The microornamentation may serve similar ecological roles in increasing traction to assist the snake in climbing a tree.

**ONE STEP CLOSER TO RESOLVING THE PACHYDACTYLUS WEBERI SPECIES COMPLEX**

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*Pachydactylus* is the most species rich gekkonid genus in Sub-Saharan Africa with 54 species currently recognised. The north-western xeric regions of southern Africa form the centre of diversity for this genus. Within *Pachydactylus*, the rupicolous species of the *P. serval* and *P. weberi* species complexes have historically proven

to be taxonomically problematic. A detailed morphological and molecular study of these complexes has since been completed and resulted in the recognition of 22 species. Of these, the recently described *Pachydactylus goodi* is listed as Vulnerable due to a restricted range and habitat deterioration through mining activities. Recent field work in the Richtersveld National Park recovered a new population of *P. goodi*, which would extend the species range considerably and have implications for its Threatened status, but this species has not been investigated in a phylogenetic framework. With new material it was possible to investigate the phylogenetic relationships of *P. goodi* populations as well as identify its overall placement within *Pachydactylus*. A maximum likelihood phylogeny was therefore constructed using multiple gene regions (*c-mos*, 12S, 16S, ND2 and *cyt-b*) including all new material plus all *Pachydactylus* species (from GenBank). The resulting phylogeny indicated that the populations of *P. goodi* are paraphyletic with respect to *P. atorquatus*. Furthermore, to corroborate these results, the inter- and intraspecific branch-length differentiation compared to other *Pachydactylus* species were used to investigate divergences between *P. atorquatus* and *P. goodi*. This genetic differentiation between *P. atorquatus* and the two *P. goodi* populations is within the limits of intraspecific divergence for the *Pachydactylus* genus.

Morphology of the newly recorded population was compared with the original species descriptions of *P. goodi* and *P. atorquatus*, and no obvious differences were found. Therefore, on the basis of both genetic and morphological similarities, *P. atorquatus* and *P. goodi* should be considered as a single species with colour-polymorphic populations.

### KAROO BIODIVERSITY SURVEY PROVIDES INSIGHT INTO TAXONOMIC ISSUES WITHIN THE CORDYLIDAE

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The Karoo is the most poorly sampled geographic region in South Africa in terms of its biodiversity. To improve knowledge of Karoo biodiversity and to gain a better baseline of distributional data, field surveys for flora and fauna, including reptiles, are being carried out in the 'BioGaps' project. In 2016, we carried out comprehensive reptile surveys in four target areas. Data collection included specimen identification and DNA sampling for barcoding, to provide insights on field identifications, taxonomic issues and potentially cryptic taxa. Initial DNA barcoding using the ND2 marker suggested that at least two

species of reptiles, *Cordylus cloetei* and *Pseudocordylus microlepidotus* (both of which have some taxonomic uncertainty) are in need of a closer examination regarding their species status. We therefore sequenced two additional markers (16S and PRLR) and carried out a phylogenetic analysis including other species in the genera using Bayesian and likelihood approaches. We also applied a barcoding approach by estimating uncorrected p-distances and examining the 'barcoding gap' where inter and intra specific variation intrinsic to these genera are used to guide species delimitation. Our analyses show that the taxonomic status of the *C. cloetei* as a valid species is in doubt. *Cordylus cordylus* forms a monophyletic clade with congeners in the *C. minor* complex (*C. minor*, *C. aridus*, *C. cloetei*), but the barcoding analysis clearly shows that divergence between these species is intra, not inter-specific (1.8-4.2%) which falls far below the intraspecific barcoding gap of 7.25% for this genus. The *P. microlepidotus* complex, which consists of three sub-species (*P. m. microlepidotus*, *P. m. namaquensis* and *P. m. fasciatus*) was examined using the same methods and markers. The phylogenetic analysis showed that only *P. m. microlepidotus* is monophyletic, and is sister to a clade containing both *P. m. namaquensis* and *P. m. fasciatus*. The barcoding approach shows that sequence divergence between these three sub-species is within the range of

intra-specific divergence (0.4%-4.2%), which is lower than the intra-specific barcode gap of 5.07% for this genus. Sequence divergence between *P. m. microlepidotus* with both *P. m. fasciatus* and *P. m. namaquensis* however, approached values close to the barcode gap (3.7-4.9%). These results indicate that *P. m. microlepidotus* is moderately divergent from the other sub-species, although it is not distinctive at the species level. In contrast, *P. m. namaquensis* and *P. m. fasciatus* are paraphyletic and their sub-species status is not supported by genetic analysis.

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Reference formatting is similar to African Journal of Herpetology.

References should be listed in the following format:

ALEXANDER, G.J. 2007. Thermal biology of the Southern African Python (*Python natalensis*): does temperature limit its distribution? Pp. 50-75. In HENDERSON, R.W., & POWELL, R. (Eds.). Biology of the Boas and Pythons. Eagle Mountain Publishing, Utah.

BRANCH, W.R. 1998. Field guide to the snakes and other reptiles of southern Africa. Third edition. Struik Publishers. Cape Town.

COTTONE, A.M. 2007. Ecological investigations of the Psammophiidae (Squamata: Serpentes). Unpubl. MSc thesis. Villanova University, Pennsylvania.

FROST, D.R. 2010. Amphibian Species of the World: an Online Reference. Version 5.4 (8 April, 2010). <http://research.amnh.org/vz/herpetology/amphibia/> (accessed 27 April 2010).

LAMB, T., BISWAS, S. & BAUER, A. 2010. A phylogenetic reassessment of African fossorial skinks in the subfamily Acontinae (Squamata: Scincidae): evidence for parallelism and polyphyly. *Zootaxa* 2657: 33-46.

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