THE HERPETOLOGICAL BULLETIN

The Herpetological Bulletin is produced quarterly and publishes, in English, a range of articles concerned with herpetology. These include society news, full-length papers, new methodologies, natural history notes, book reviews, letters from readers and other items of general herpetological interest. Emphasis is placed on natural history, conservation, captive breeding and husbandry, veterinary and behavioural aspects. Articles reporting the results of experimental research, descriptions of new taxa, or taxonomic revisions should be submitted to The Herpetological Journal (see inside back cover for Editor's address).

Guidelines for Contributing Authors:

1. See the BHS website for a free download of the Bulletin showing Bulletin style. A template is available from the BHS website **www.thebhs.org** or on request from the Editor.

2. Contributions should be submitted by email or as text files on CD or DVD in Windows® format using standard word-processing software.

3. Articles should be arranged in the following general order:

   Title
   Name(s) of authors(s)
   Address(es) of author(s) (please indicate corresponding author)
   Abstract (required for all full research articles - should not exceed 10% of total word length)
   Text acknowledgements
   References
   Appendices
   Footnotes should not be included.

4. Text contributions should be plain formatted with no additional spaces or tabs. It is requested that the *References* section is formatted following the Bulletin house style (refer to this issue as a guide to style and format). Particular attention should be given to the format of citations within the text and to references.

5. High resolution scanned images (TIFF or JPEG files) are the preferred format for illustrations, although good quality slides, colour and monochrome prints are also acceptable. All illustrations should be entirely relevant to the text and numbered sequentially with Arabic numerals. Images should be separate from the text file and in full resolution. Figure captions should be included within the text file, not embedded within images.

6. Authors will be informed promptly of receipt of their manuscript. Acknowledgement of receipt does not indicate acceptance for publication. All contributions are liable to assessment for suitability and ethical issues and all articles are subject to peer-review. The Editor reserves the right to shorten or amend a manuscript, although substantial alterations will not be made without permission of the primary author.

7. Authors will be supplied with a portable document file (pdf) of their published article and a complimentary copy of the full printed issue. Slides, artwork, and other original material will be returned following publication.

8. The Editor is keen to ensure that the Bulletin is open to as wide a range of contributors as possible. Therefore, if an author has concerns about compliance with submission guidelines or the suitability of a manuscript, or would like help in preparing it, please contact the Editor to discuss.

9. The significance and importance of some articles may be such that the Editor will offer a year's free subscription to the Society.

The views expressed by contributors to the Bulletin are not necessarily those of the Editor or the British Herpetological Society. All manuscript submissions and correspondence arising from the Bulletin should be sent to the Receiving Editors, **herpbulletin@thebhs.org.**

Front Cover: northern viper (*Vipera berus*). See article on page 16.
Photograph credit: Jason Steel.

Environmental enrichment with simple puzzle feeders increases feeding time in fly river turtles (*Carettochelys insculpta*)

ZOE BRYANT[*] & GRANT KOTHER

Zoological Society of London, London Zoo, Herpetology Department, Regents Park, Outer Circle, NW1 4RY, United Kingdom.
[*]Corresponding author email: zoe.bryant@zsl.org

ABSTRACT - Traditionally, enrichment has been associated mainly with mammalian and avian subjects in captivity, to promote natural behaviours, but developments are continually being made in its application to lower vertebrates. Here we outline the use of puzzle feeders for enriching captive Fly River turtles (*Carettochelys insculpta*) in order to prolong feeding activity. This method is applicable to other species of aquatic turtles, as feeding time was significantly increased by 35 minutes.

INTRODUCTION

'**E**nrichment' is a concept, which describes how the environments of captive animals can be changed in order to benefit them. It is a process that may increase behavioural responses and improve or enhance animal care within the context of behavioural biology and natural history (Young, 2009). Environmental changes are made with the goal of increasing the animal's behavioural choices and drawing out their species-appropriate behaviours, thus enhancing animal welfare (AZA, 2012)). Providing physical and mental stimulation in this way is extremely important for any captive animal, as it creates an unpredictability that enhances the animals' world and welfare.

Many perceive enrichment to only benefit mammals, and to a lesser degree birds, but in the herpetology department at ZSL London Zoo a number of novel enrichment regimes are implemented for a diverse number of reptile species, which seem to benefit them greatly by either encouraging activity during usual periods of inactivity, or extending feeding time and by enhancing their environment. Both our on and off-show animal housing facilitates the creation of microhabitats where temperature, photo-period, humidity, substrate, structure, group dynamics, aesthetics, water quality and even prey selection are tailored to meet species specific requirements to ensure the animals' appropriate care and welfare. Simple improvements made to any one of these elements can be considered enrichment. The addition of various substrates to create new tactile sensations and odours, changing enclosure furnishings or the layout requires the animal to re-establish pathways, territories and retreats; all of these modifications can impact on the animals' natural behaviours and curiosity.

Food is another significant stimulus for both reptiles and amphibians. As with most animals the way food is presented directly affects the amount of time an animal is stimulated both mentally and physically. Scatter feeds, although useful, are not always successful as a large portion of reptiles and amphibians are housed in more confined enclosures so prey items are easily found and consumed. Puzzle feeders, which are containers which have to be manipulated in order for the animal to reach the desired food items held inside, are an excellent tool for prolonging feeding events and can provide stimulation for the target animal in various ways. The main benefit to puzzle feeding is that it extends the period of time an animal spends searching for food, and natural foraging behaviours can be encouraged. Although publications on reptile enrichments are far outnumbered by that of primates and big cats for example, some interesting reptile enrichment ideas have been documented (Heindl et al. 2004; Cipreste, 2007). Enriching reptiles is still a relatively new concept, and there is still much to discover and learn.

Fly river turtles (*Carettochelys insculpta*), are maintained at ZSL London Zoo. They are naturally curious, and explore their environment using their prominent nose, which is equipped with sensory receptors which help the turtle to search for and locate food in turbid water or sand (Barone, 2004). They are omnivores, but the majority of their natural diet consists of aquatic plant matter such as algae, *Vallisneria spp*. and *Najas tenuifolia* (Cogger 1970; Schodde et al. 1972; Legler 1982; Georges and Kennett 1989) and fruit, predominantly the wild fig from *Ficus racemosa*, that falls from surrounding trees, into the water of the freshwater rivers, swamps, lagoons, lakes and estuaries that they inhabit in the southern lowlands of Indonesian Papua and Papua New Guinea, and Northern Australia (Georges et al, 2008)

Figure 1: *C. insculpta* investigating the kong enrichment device

MATERIALS AND METHODS

In the Herpetology department, three individuals are maintained, in a tank measuring 250 cm x 96 x 70 cm. The water is at a depth of 70 cm. Sand and gravel is used as substrate, together with various bogwood furnishings, added to create visual barriers as well as providing secluded areas in which the animals can rest or sleep. They are fed 3-4 times a week on a varied diet consisting of nishikoi pellets, pak choy, chicory, pear, fig *F. carica*, and aquatic plants *Valliseneria*. Food is provided for these animals in way that promotes natural feeding behaviour, by placing their food onto the surface of the water. The lighter foods naturally float, and the turtles swim up to the surface of the water to feed, and the heavier fruits sink to the bottom, allowing the animals to seek them out using their acute sense of smell. As successful as this is, due to the smaller surface area of their exhibit compared with their natural environment, feeding time is short as all food can be located easily. The use of a feeding device to prolong feeding activity was therefore deemed appropriate. A plastic feeding device called 'the Cat Feeding Exercise Ball'© by SlimCat was trialled first, this device floated on the water's surface making it challenging for the animals to grasp the device. The animals had to nudge it effectively to release the food. This was a success. A red Kong Ball© roughly 6.5 cm in diameter was also trialled. The Kong Ball was filled with small pieces of fig *F. carica*, so that when the Kong was moved around by the turtles the small pieces would fall from the Kong and travel up to the surface of the water. The Kong was chosen for evaluation as it was heavy enough to sink to the bottom of the tank and is made from tough, versatile rubber, the fly river turtles could bite it safely without them damaging their mouths. Fig was smeared over the outside of the device so that if the initial bright colour of the Kong did not first draw their attention then the smell of the fig would attract them.

Turtles have good colour vision. Williams (2010) found that chelonians appeared to have three photopigments which have peak responses in the purple, green and orange parts of the spectrum. Most mammals see with just two photopigments but chelonians are thought to have evolved their sight in this way due to having a predominantly fruit based diet (Williams, 2010). Identifying red and orange coloured fruit from a green background is very important to enable them to distinguish their food (Williams, 2010). The red colouration of the Kong is therefore significant.

RESULTS

Once the red Kong was placed into the water, all three turtles showed an initial response, biting and nudging the Kong around their exhibit. The more dominant, larger individual spent the most time biting and swimming around with the device, whilst the smaller turtle, although not showing as much interest, would swim around, picking up all the fig that the larger animal had dislodged. The animals spent around 40 minutes interacting with this enrichment, whereas it would normally take the animals around 5-6 minutes to locate and consume the fig just placed in the water. The device was placed in the exhibit 5 times throughout the course of a two

week period, and 40 minutes was the average time the animals spent interacting with it. Feeding time was extended and we achieved what we had set out to do in enriching these animals.

Figure 2: *C. insculpta* eating pear pieces from inside the kong enrichment device

DISCUSSION

Although we deemed this enrichment to be a success, in the future it would be worth investing in two more Kongs so that each animal will have one to engage their attention, and to prevent any aggression between the turtles, as this species can be both aggressive and territorial (Georges and Rose 1993, Dorrian 1994, Bargeron 1997). Other frugivorous and herbivorous turtle species may benefit from this enrichment device, as other fruits can be used and chopped into pieces in order to fit into the device, and it is quick and easy to provide. The use of puzzle feeders for turtle species can be recommended for use by institutions, in order to prolong feeding events.

ACKNOWLEDGEMENTS

REFERENCES

Association of Zoos & Aquariums https://www.aza.org/enrichment/ [accessed July 2012]

Barone, S. (2004). The Pig-nosed Turtle, (*Carettochelys insculpta*) Underwater Glider. *Reptilia Magazine* 33: 56-60.

Bargeron, M. (1997). *Carettochelys insculpta*, Pig-nosed Turtle. *The Tortuga Gazette* 33: 1-2.

Cipreste, C. (2007). Ideas for reptile enrichment. *The Shape of Enrichment* 16: 8-9

Cogger, H.G. (1970). First record of the pitted-shelled turtle, (*Carettochelys insculpta*), from Australia. *Search* 1: 41.

Dorrian, C. (1994). Captive Management of the Pig-nosed Turtle, *Carettochelys insculpta*. *Herpetofauna* 24: 15-18.

Georges, A. & Kennett, R. (1989). Dry-season distribution

and ecology of *Carettochelys insculpta* (Chelonia: Carettochelydidae). *Australian Wildlife Research* 16: 323-335.

Georges, A. & Rose, M. (1993). Conservation biology of the pig-nosed turtle, *Carettochelys insculpta*. *Chelonian Conservation and Biology* 1: 323-335

Georges, A., Doody, J.S., Eisemberg, C. & Alacs, E.A. (2008). *Carettochelys insculpta* Ramsay 1886 - Pig-Nosed turtle, Fly River Turtle. *Chelonian Research Monographs* 5: 009.1-0.009.17

Heindl, S., Tabone, G. & Chepko-Sade, D. (2004). Herpetological challenges can bring interesting rewards. *The Shape of Enrichment* 13: 5-6

Legler, J.M. (1982). The ecology of freshwater turtles in the Alligator Rivers region. Open File Record 66, September 1982. Office of the Supervising Scientist, Darwin.

Schodde, R. Mason, I., & Wolfe, T.O. (1972). Further records of the pitted-shelled turtle (*Carettochelys insculpta*) from Australia. *Transactions of the Royal Society of South Australia* 96: 115-117.

Williams, D. (2010). The chelonian eye in health and disease. *Testudo* 7: 84-89.

Young, R. J. (2009). *Environmental Enrichment For Captive Animals*, Blackwell publishing, Oxford, 2.

Captive husbandry and management of the Rio Fuerte beaded lizard *Heloderma exasperatum*

ADAM RADOVANOVIC

Birmingham Wildlife Conservation Park, Pershore Road, Edgbaston B5 7RL, UK
Email: rad_backinblack@hotmail.co.uk

ABSTRACT - Eight eggs from a pair of Rio Fuerte beaded lizards, *Heloderma exasperatum* were laid under the substrate in a large zoological exhibit and four hatchlings emerged in March 2013 after an unknown incubation period. The nest was excavated and a further two fertile eggs, one with a partially hatched dead lizard and one partially formed foetus in addition to two infertile eggs were found.

INTRODUCTION

The Rio Fuerte beaded lizard, *Heloderma exasperatum* was one of four subspecies of *H. horridum* until recent taxonomic elevations (see Reiserer et al, 2013). *H. exasperatum* occurs primarily in the Sierra Madre and is the northernmost species of beaded lizard (Beck, 2005). Habitat includes subtropical dry forest and occasionally specimens have been located in pine-oak forest in Alamos, Sonora (Reiserer et al, 2013). According to the IUCN Red List (06/08/13) the conservation status of *H. horridum* is LC (least concern). Reiserer et al (2013) suggests that due to habitat threats and a fragmented distribution, the IUCN will likely elevate the conservation status to VU (vulnerable) or a higher threat category. In this paper, we describe the successful captive breeding of *H. exasperatum* without using conventional reptilian incubation techniques.

MATERIALS & METHODS

One male and one female *H. exasperatum* (born 01/09) were kept in a large enclosure measuring 3 x 1.5 x 1.5m (L x W x H). Specimens were introduced together in the exhibit during May 2011. The male weighed 1200 g and the female weighed 950 g. Specimens continued to grow and in May 2012, the male weighed 1500 g and the female weighed 1200 g. Specimens were sexed using morphological characteristics. Males have a larger head, longer neck, longer body and have a large bulge at the base of the tail. These characteristics may be difficult to see in obese specimens (Pers. obs). A 2 KW fan heater was positioned in the corner of the exhibit and attached to a thermostat to allow a constant ambient air temperature. Four 60 W spot bulbs were recessed into the ceiling to add light and extra ambient heat. A basking area was provided for both specimens by using 160 W ZooMed Powersun bulbs, which also contain a high output of UVB and were positioned 30 cm from the substrate. Additional light was provided by using three Aracadia T5 UVB tubes.

Diurnal temperatures in the enclosure ranged from 35-40°C under the basking areas and 21-25°C in other areas on the enclosure. Noctural temperatures were between 17-20°C. A photoperiod of 14-16 hours in the summer and 10-12 hours in the winter was implemented. The enclosure was furnished with large rocks and driftwood with branches to facilitate climbing. Bird sand mixed with Sphagnum moss blocks (these expand when added to water) was used as a substrate and depths varied from 10-60cm. Potted live plants were installed including some fern species, *Asplenium bulbiferum* and mother-in-law's tongue, *Sanseveria trifoliate* (Fig. 1). Both specimens were fed together with no need for separation. Two weaned rats were given to both specimens every four-six weeks. Two raw eggs were fed every six-eight weeks. These were cracked and the contents whisked up in a bowl and left in the enclosure. The enclosure was sprayed once daily with 2 litres of water to increase humidity, hydrate plants and ensure the substrate remained moist. Specimens would drink daily from the water jets. Good ventilation and heat prevented the enclosure from becoming too wet.

Figure 1. Enclosure for 1.1 *H. exasperatum*.

Figure 2. H4 and adult female together.

Figure 3. Contents of the nest; four empty hatched eggs, one partially hatched and dead, one partially formed and dead and two infertile.

RESULTS

On 09/03/13, a hatchling (H1) *H. exasperatum* was observed basking on a rock under a UVB Powersun bulb. Both adult specimens were present in the enclosure and did not show interest in the hatchling. The hatchling was removed and found to weigh 17 g. Subsequently three more hatchlings appeared and were removed from the enclosure and weighed; On 14/03/13, hatchling (H2, weighed 24 g) was observed moving around in a fern; on 17/03/13, hatchling (H3, weighed 27 g) was observed basking on the same rock as the first specimen; On 19/03/13 the final hatchling (H4, weighed 25 g) was observed moving around the enclosure. This neonate still had the umbilical cord attached. The adult specimens were active at the time, and the female was observed moving slowly towards the hatchling with rapid tongue flicking. Once the female's tongue touched the hatchling, it quickly moved away. The female slowly followed the scent of the hatchling with rapid tongue flicking. No aggression or feeding response was observed (Fig. 2).

Hatchlings were housed in Hagen tanks measuring 35 x 20 x 16cm (L x W x H). Due to the highly venomous nature of Helodermatid lizards, the hatchling enclosures were secured in a vivarium and locked and during enclosure maintenance, hatchlings were moved to a secure container. Two small snake hooks were used to support the body. Hatchling *H. exasperatum* move quickly and employ a sideways "head swipe" making them difficult to work with in close proximity. Paper towel was used as a substrate and a small hide and water bowl was added. Paper towel was sprayed daily to allow for extra humidity. This process had a positive effect on H4 and the umbilical cord detached after four days leaving a clean wound that healed after a further five days. Owens, (2006) expressed success using this method with hatchling *H. charlesbogerti*. Hatchlings were also sprayed and observed drinking from the spray bottle. Hatchlings were often observed fully submerged in their water bowls. This behaviour was more commonly seen when temperatures exceeded 29°C. Enclosures were heated using a spot bulb connected to a thermostat and ambient temperatures were between 25-27°C with a basking temperature of 30°C.

Hatchling *H. exasperatum* were offered one pink mouse each, two weeks after the last hatchling emerged. H3 and H4 fed immediately. H2 was coaxed into feeding by gently tapping the pink mouse on the specimens head with forceps. This caused a defensive reaction and the pink mouse was gently pushed into the specimens gaping mouth. Only H1 refused to feed. This specimen was offered a pink mouse coated with egg yolk a week later and was accepted. H1 regurgitated its first two meals due to the pink mice being too large. Smaller pink mice were sourced preventing further regurgitation. Nine days after the last hatchling emerged in the enclosure, the nest was excavated. Eight eggs were located deep under the substrate (approx 30-35cm) and had been wedged under the crevice of a large rock. The substrate was of a damp consistency and when squeezed remained adhered together. There was also a high concentration of sphagnum moss in the nest chamber. Four eggs successfully hatched. One egg contained a dead hatchling that was found with over 50% of its body out of the egg. The egg was cut open to reveal the specimen had absorbed all yolk stores and separated from the umbilical cord. This specimen weighed 24 g. Three eggs were cut open to reveal one partially developed dead foetus and two were infertile (Fig. 3).

A digital min/max hygro-thermometer was used to ascertain the temperature and humidity of the incubating eggs. The probe was placed in the nest chamber and the area was returned to its original state. Temperature and humidity was recorded over a three-month period. The research showed that temperatures varied from 21.7-21.9°C during the first two weeks. From mid-April and May, the temperature incrementally increased in the nest chamber by 0.1°C over a 24-48 hour period. Occasionally, the temperature would remain constant for three-four days, with five days being the longest period recorded. The maximum temperature recorded was 28.8°C. Humidity was consistent throughout the study and was recorded between 87-94% RH. The higher RH recordings were observed when the temperature was above 26°C.

DISCUSSION

Although *H. exasperatum* has been previously bred in captivity (Draeby & Barte, 2006; Reisinger, 2006; Eidenmuller & Reisinger, 2011) the present paper would appear to be the first describing *H. exasperatum* eggs hatching in an enclosure/exhibit without using conventional incubation methods. The results therefore indicate that the husbandry methods used for the adults and the overall captive environment were sufficient for this breeding success to occur. Unfortunately, data on dates/times of copulation and oviposition are unknown but a subsequent clutch of eggs was laid on 04/08/13. The female was observed digging in all areas of the enclosure where the substrate was >20cm and a clutch of 10 eggs were deposited in the same nest site as the clutch described in this paper. The eggs were candled after two weeks and all were fertile but were not incubated due to zoo management protocols. The clutch of eggs were clumped together under a rock crevice and due to the nature of the incubation, eggs closest to the rock may have benefited from the extra warmth and hatched out sooner. An inquisitive interest between H4 and adult female *H. exasperatum* was observed but neither aggression nor antagonistic behaviour was recorded. *Heloderma spp* are more active during the rainy season (Draeby & Barten, 2006) therefore spraying the enclosure with warm water is a good enrichment as it increases activity levels. Specimens foraged and basked frequently during increased simulated rainfall.

Heloderma spp are prone to obesity in captivity due to their ferocious appetite (Draeby & Barte, 2006), large energy storage capacities and a low metabolic rate (Beck, 2005). In light of this, it is recommended that *Heloderma spp* should be fed sporadically throughout the year with a slight increase for gravid/post oviposition females. Spraying the enclosure daily with warm water was beneficial in maintaining high humidity within the nest chamber. Using sphagnum moss mixed in with a sand substrate absorbed excess water and possibly preventing it from flooding the nest chamber. Temperature in the nest chamber during egg collection was 21.7°C and during the three-month study a maximum temperature of 28.8°C was recorded. The slow incremental increase in temperature that occurred in the nest chamber may have allowed the growing foetuses to adapt to these changes. However, Eidenmuller & Reisinger (2011) mention that *Heloderma* eggs are not as sensitive to temperature fluctuations as other reptile eggs. A rapid change in temperature from the lowest to highest values recorded may have had an adverse effect on the foetuses (Eidenmuller & Reisinger, 2011).

There were a large number of rocks in the enclosure, the interior walls were all concrete themed and the substrate mainly consisted of sand. Due to the high heat conducting ability of these elements and substances, it may have caused a slow release of heat that was advantageous to the incubating eggs when temperatures dropped during the night. A long winter cooling (brumation) has often been cited as an essential mechanism for the entire *Heloderma* genus to produce fertile eggs (Reisinger, 2006; Seward, 2006; Eidenmuller & Reisinger, 2011). Although night temperatures in the main enclosure were recorded as low as 17°C, day temperatures were maintained above 25°C with basking temperatures rarely dropping below 30°C. The breeding pair were fed all year round with no instances of specimens failing to feed when offered food. Although hibernation has been effective in breeding *H. exasperatum* (Reisinger, 2006; Eidenmuller & Reisinger, 2011) this study suggests it is not essential. For example, Eidenmuller & Reisinger (2011) express the need for a six to seven week hibernation at 15-17°C to produce fertile eggs. Air temperatures in this study dropped to as low as 17°C during nocturnal hours and it is possible that this reduction in night temperature coupled with a changing photoperiod may have been necessary to produce fertile eggs. There is a lack of published data regarding the reproductive and incubation parameters of *H. exasperatum* and further studies are needed to enhance future ex-situ management and conservation of this species.

ACKNOWLEDGMENTS

REFERENCES

Beck, D.D. (2005). *Biology of Gila Monsters and Beaded Lizards*. Berkeley: University of California Press California, USA.

Draeby, K. & Barten, S. (2006). *Husbandry Guidelines, Beaded Lizard* (Heloderma horridum) European Association of Zoos & Aquaria (EAZA).

Eidenmuller, B. & Reisinger, M. (2011). *Beaded Lizards & Gila Monsters*. *Captive Care & Husbandry*. Frankfurt am Main: Edition Chimaira.

IUCN Red List of Threatened Species. www.iucnredlist.org accessed on 06/08/2013.

Owens, T.C. (2006). Ex-situ: Notes on reproduction and captive husbandry of the Guatemalan beaded lizard (*Heloderma horridum charlesbogerti*). *Iguana*: 212-215.

Reiserer, R.S, Schuett, G.W & Beck, D.D. (2013). Taxonomic reassessment and conservation status of the beaded lizard, *Heloderma horridum* (Squamata: Helodermatidae) *Amphibian & Reptile Conservation* 7: 74–96.

Reisinger, M. (2006). Successful long-term keeping and breeding of the Rio Fuerte beaded lizard, *Heloderma horridum exasperatum*. *Reptilia* 47: 25-33.

Seward, M. (2006). *Heloderma suspectum*, Gila Monster Reproduction. *Reptilia* 47: 19-24.

Variation and zoogeography of the turtle *Chrysemys picta* in Virginia, USA

CARL H. ERNST[1*], JOHN M. ORR[2], ARNDT F. LAEMMERZAHL[3] & TERRY R. CREQUE[2]

[1]Division of Amphibians and Reptiles, mrc 162, Smithsonian Institution, P.O. Box 37012,
Washington, D.C. 20013-7012, USA
[2]Department of Environmental Policy and Public Policy, George Mason University, Fairfax, VA 22030, USA
[3]Biology Program, George Mason University, Fairfax, VA 22030, USA
[*]Corresponding author email: chernst@frontiernet.net

ABSTRACT - During research to determine the subspecific status of the painted turtles, *Chrysemys picta*, and their distribution in Virginia, USA, 1082 turtles from 12 watersheds and 68 counties and municipalities were examined. Watersheds studied included the eastern flowing Shenandoah/Potomac (**A**), Rappahanock/Rapidan (**B**), York (**C**), and James (**D**); the southward flowing Dismal Swamp (**E**), Chowan (**F**), Roanoke (**G**), and Pee Dee (**H**); the small waterways of the Delmarva Eastern Shore (**I**) flowing west into the Chesapeake Bay or east into the Atlantic Ocean; the New River (**J**) that flows northward from North Carolina through western Virginia; and the Tennessee (**K**) and Big Sandy (**L**) watersheds that flow west into the Ohio River, and thence to the Mississippi River.

Two subspecies of painted turtles occur in the Commonwealth, *C. picta picta* [P] and *C. p. marginata* [M]. The 75% Rule of Amadon (1949) was applied to determine if populations of pure P & M exist in Virginia. This revealed that most individuals in the Commonwealth are intergrade (hybrid) MxP. The frequencies of occurrence of P, M, & MxP in these watersheds show that P is predominately a Coastal Plain resident, with a 75% occurrence and a 22% Piedmont occurrence in the Shenandoah/Potomac; 74% Coastal Plain and 36% in the Piedmont of the Rappahannock/Rapidan; and 34% in the Coastal Plain and 64% in the Piedmont of the James. M is essentially restricted to the Piedmont and Headwaters of these watersheds, with only 11% occurring in the Coastal Plain of A. MxP is found in all three physiographic regions of A-D, but in the greatest numbers in the Highlands. This is also true in the Piedmont of the southflowing rivers F-H. Turtles from the western flowing K & L are predominately MxP with lesser numbers of M. The possible origins of these taxa in Virginia's waterways is discussed and compared with the hypothesis of the zoogeographical distribution of North Americas *C. picta* of Bleakney (1958), and the results and conclusions of Ultsch et al. (2001) who considered P to not exist in pure form because of intergradations (hybridization) with M along its south-north distribution.

INTRODUCTION

The painted turtle, *Chrysemys picta*, is the only North American freshwater turtle whose natural range extends from the Atlantic to the Pacific coasts (Ernst & Lovich, 2009). Such a great distribution has led to phenotypic color pattern and morphological variation, resulting in four subspecies being described (Ernst, 1971).

Serious study of variation in *C. picta* was begun by Bishop & Schmidt (1931) and Hartweg (1934); and since has led to a number of regional studies showing intergradation (hybridization) between the four subspecies (Ernst & Lovich, 2009). Such studies have been reported from the Mid-Atlantic states of Pennsylvania (Ernst & Ernst, 1971) and Maryland (Groves, 1983) to the north, the Gulf states to the south (Ernst, 1967), and Kentucky and Tennessee to the west of Virginia (Ernst, 1970; Johnson, 1954).

C. picta has been in Virginia at least since the Late Quaternary (Holman & McDonald, 1986); and two possible subspecies occur in the Commonwealth (Figs. 2-3); the eastern painted turtle, *Chrysemys picta picta* (P), and the midland painted turtle, *Chrysemys picta marginata* (M). P has a maximum straight line carapace length (SCLmax) of 19.0 cm, its vertebral and pleural carapace scutes <30% disaligned,

light (yellow, orange, red or a blending of these colours) borders along the carapacial seams (>2.5mm bordering the pleural seams), a narrow (>1.5 mm) continuous mid-dorsal carapace stripe, and an unmarked (Fig. 2) yellow or only lightly dark spotted plastron (Bishop & Schmidt, 1931). M has a SCLmax of 19.5 cm, alternate vertebral and pleural carapace seams (>30% disalignment), narrow (<2.5mm), dark (black, olive or none) bordered carapacial seams, an absent or poorly developed (discontinuous), narrow (<1.5mm) mid-dorsal carapace stripe, and a plastron marked (Figs. 3-4) with a variable dark central figure (Bishop & Schmidt, 1931). Intergrades (MxP) have a majority of these characters intermediate between P and M. To accurately determine the status of individual turtles, "all" of the above characters must be considered; not only the percentage of seam disalignment and the plastron pattern.

Mitchell (1994) reported that "considerable variation exists throughout Virginia [*C. picta*] populations in the two characters that distinguish *C. p. picta*...from *C. p. marginata*... the alignment of the seams on the pleural and vertebral scutes, and the presence of the marginata type of figure on the plastron... However, only in the upper James River drainage in Bath and Highland counties could Virginia populations be considered intergrades between the two subspecies...

Intergrades may also occur in extreme northern Virginia (C. H. Ernst, pers. comm.)." Although Mitchell (1994) has reported that some turtles seem to be intergrades between eastern P and the more western M, only P has been documented from Virginia (Mitchell & Reay, 1999; Tobey, 1985). In spite of these conclusions, no formal study of intergradation between P and M in Virginia has been reported until now. Herein are the results of an extensive study to determine the variation, taxonomic status, and zoogeography of Virginia's painted turtles.

While the concept of subspecies is controversial, there is utility in its application for zoogeographical and conservation studies (Haig et al., 2006). However, standards on which a subspecies is determined have been vague and variously used. The only quantitative metric that we have found is the 75% Rule of Amadon (1949; as discussed by Patten & Unitt, 2002) that 75% of the individuals in the population in question must be distinguishable from all those from the most proximate populations to be considered a unique subspecies. In this case the Virginia painted turtles versus the populations of P and M in adjacent states; our analysis of the subspecific status of painted turtle populations in the major Virginia watersheds is based on this principle.

METHODS

All turtles were sexed by the characters listed in Ernst (1971). Scute terminology is that of Ernst & Lovich (2009). The SCLmax and greatest nonmedial plastron length (PL) of each turtle were recorded. All measurements were made with metric dial calipers accurate to 0.1 mm.

The methods of measurement introduced by Hartman (1958) were used to compare the degree of disalignment of the carapace scutes. When the seams between the central vertebral scutes and lateral pleural scutes lie in the same transverse line they were considered to be 0% disaligned; if the seams alternate exactly they were considered 100% disaligned. The base point for measuring is the inner end of the seam separating the second and third pleural scutes. The imaginary line from the base point forward and parallel to the longitudinal axis of the carapace, to the point opposite the inner end of the seam between the second and third pleurals was measured, and was denoted as 1a on the left side and 2a on the right side. The part of this same imaginary line ending at the base point between the second and third vertebrals was measured and denoted 1b on the left side and 2b on the right side (See Fig. 2 of Hartman, 1958.). The average percent disalignment was then calculated as 1b/1a + 2b/2a. P exhibits none or very low disalignment, normally <30%; while M has disalignment >30%.

The light border of the posterior seam of the second pleural was measured at its widest point and its colour noted. Red, orange or yellow borders were considered characters of P; black, olive, or no border pigmentation were considered those of M (Ernst & Ernst, 1971). The greatest width of the mid-dorsal stripe (CDS) on the carapace was measured on the second vertebral scute. M usually has a discontinuous mid-dorsal stripe while that of P is normally uninterrupted. Completeness of the CDS was calculated as a percentage of the greatest width of the broadest foreleg stripe (FLS), CDS/FLS (P >70%, M <50, MxP 51-69%). The extent of plastron pigmentation as described above was illustrated in Bishop & Schmidt (1931).

All data were statistically analyzed using SAS package 8.2; levels of significance were set a priori at $\alpha = 0.05$. To compare possible intergrades (hybrids), Fisher's discriminant analysis was run on combined data using the following nonsexually dimorphic variables: pleural scute disalignment, seam width, central stripe width, and the width of the widest foreleg stripe. Normality was checked visually using probability plots. To analyze the data, first, a training data set was created using data from known pure taxa from Kentucky, Maryland, North Carolina, Pennsylvania, and Virginia (Ernst, 1970; Ernst & Ernst, 1971; Ernst et al., 2006; Groves, 1983; Ultsch et al., 2001).

Study Areas. C. picta (N=1082) from 12 river watersheds (Fig. 1) and 68 counties and municipalities in Virginia were examined. The western Appalachian Mountains divide its river drainages; those flowing east or south eventually enter the Atlantic Ocean; those flowing west enter the Gulf of Mexico (Jenkins & Burkhead, 1994).
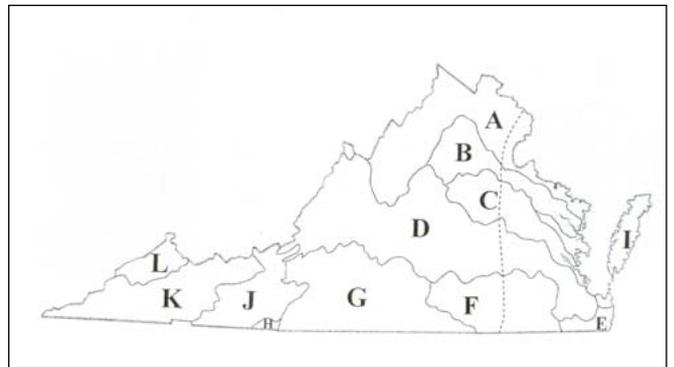

Figure 1. Virginia watersheds from which specimens of *C. picta* were studied: A, Shenandoah/Potomac; B, Rappahanock/Rapidan; C, York; D, James; E, Dismal Swamp; F, Chowan; G, Roanoke; H, Pee Dee; I, Delmarva Eastern Shore; J, New; K, Tennessee; and L, Big Sandy. Dashed north-south line denotes the Fall Line separating the Coastal Plain from the Piedmont and Western Headwaters.

Several major river watersheds eventually flow eastward toward the Chesapeake Bay and Atlantic Ocean; from north to south these are: The Potomac/Shenandoah Drainage [A] drains about 39% of Virginia with tributaries both west and east of the Blue Ridge Mountains, and eventually crosses the Fall Line (the upstream limit for commercial boating traffic) at Great Falls, Fairfax County, and flows into the Chesapeake Bay. It also receives water from West Virginia, Maryland, and Pennsylvania. Ernst et al. (1997) reported the painted turtles from the vicinity of Fairfax County as intergrade MxP. The Rappahannock/Rapidan Drainage [B] occurs entirely within Virginia. The Rappahannock begins in the Blue Ridge Mountains and flows eastward through the Piedmont of central Virginia to join the mostly south flowing Rapidan River near the Fall Line at Fredericksburg and finally empties into the Chesapeake Bay. The York River [C] results from the jointure of the Mattaponi River and Pamunkey Rivers (formed by the union of the North and South Anna rivers), and is essentially a Coastal Plain drainage entering the Chesapeake Bay between [B] and the James River [D]. The James River watershed [D], with the exception of two streams originating

Figure 2. *C. picta picta*: carapace, Roger W. Barbour; plastron, Richard D. Bartlett.

Figure 3. *C. picta marginata*: carapace and plastron, Roger W. Barbour.

in West Virginia, flows east entirely through Virginia, draining almost 25% of the Commonwealth, and finally enters the Chesapeake Bay. It crosses the Fall Line east of the Richmond Basin. Although Mitchell (1994) reported that only painted turtles from Bath and Highland counties in the headwaters of this watershed are MxP, Schwab (1989) described a turtle from Prince George County near its mouth that was clearly a MxP.

Several other drainages flow southward into North Carolina and finally empty into the Atlantic Ocean: The Dismal Swamp watershed [E] generally flows south in the Coastal Plain from extreme southeastern Virginia into North Carolina and empties into the Albemarle Sound. Pague & Mitchell (1991) reported P present at Back Bay northeast of the Great Dismal Swamp. Southeastern Virginia's Chowan River [F] is made up of the Nottaway and Meherrin rivers from the Piedmont above the fall line and the Blackwater River of the Coastal Plain. It enters northeastern North Carolina and finally flows into the Albemarle Sound. The Roanoke River watershed [G] occurs above the Fall Line in southcentral Virginia, flows southeastward draining about 16% of Virginia into North Carolina, and eventually reaches the Albemarle Sound west of the Chowan River (which is sometimes considered part of the Roanoke system). The Pee Dee watershed [H] is essentially a North and South Carolina system with only a small portion in Virginia. It arises as the Ararat River in the Blue Ridge Mountains and flows southeastward into the Yadkin River that joins the Pee Dee River in southern North Carolina which

finally meets the Atlantic Ocean in South Carolina.

The southern Delmarva Eastern Shore watershed [I] is composed of short Coastal Plain waterways in Accomack and Northampton counties that flow either west into the Chesapeake Bay or east into the Atlantic Ocean. P has been reported from Assateague and Chincoteague islands (Lee, 1972; Mitchell & Anderson, 1994; where they were apparently introduced [W.A. Dunson, pers. comm., in Mitchell & Anderson, 1994].

The major Virginia watersheds flowing westward to the Gulf of Mexico via the Ohio and Mississippi rivers are as follows. The New River system [J] arises in North Carolina, flows northward through southwestern Virginia's southern Blue Ridge Highlands and more northern Valley and Ridge physiographic provinces, crosses much of West Virginia, and finally enters the Ohio River drainage. Unfortunately, the only specimen from the New River examined was a DOR individual from Floyd County consisting of shell pieces with no identifiable taxonomic characters (Virginia Museum of Natural History [VMNH] 150006). Seidel (1981 [1982]), during a study of the species of Pseudemys in the river, reported the painted turtles there to be intergrade MxP. The Clinch and Holston rivers originate in southwestern Virginia and flowing westward, form the headwaters of the Tennessee River system [K], a major tributary of the Ohio River. The Big Sandy River watershed [L] begins in the Appalachian Plateau of southwestern Virginia and forms the border between Kentucky and West Virginia while flowing northward to the Ohio River.

Watershed (N)	Plastron Pattern (%)	Carapace Seam Disalignment (%)	Subspecific Character Carapace Dorsal Stripe Colour (%)	Width (mm)	Condition (%)	Width (mm)	CDS/FLS (%)
A (199)	P 104 (52.3) M 57 (28.6) MxP 38 (19.1)	23.4 (4.7-62.2)	Y 121 (60.8) R 2 (1.0) RY 69 (34.7) OR 3 (1.5) Ol 2 (1.0) Or 1(0.5) OlY 1 (0.5)	2.81 (0.1-9.8)	Cont. 131 (65.8) Disc. 68(34.2)	1.0 (0.4-34.2)	70.8 (22.2-131.8)
B (28)	P 21 (75.0) M 3 (10.7) MxP4 (14.3)	18.7 (1.2-55.6)	Y 25 (89.3) RY 3 (10.7)	2.98 (0.5-4.6)	Cont. 23 (82.1) Disc. 5 (17.9)	1.2 (0-4)	52.3 (0-100)
C (16)	P 9 (56.3) M 3 (18.8) MxP 4 (25.0)	20.2 (8.3-53.5)	Y 15 (93.8) RY 1 (6.2)	3.27 (2.1-5.0)	Cont. 11 (68.8) Disc. 5 (31.3)	0.9 (0.6-4.7)	58.6 (20-100)
D (494)	P 229 (46.4) M 18 (3.6) MxP 247 (50.0)	22.3 (2.0-26.9)	Y 444 (899) RY 44 (8.9) Or 3 (0.6) OrY 2 (0.4) OR 1 (0.2)	2.80 (0.1-6.9)	Cont 356 (72.1) Disc. 138 (27.9)	0.9 (0-2)	61.2 (0-180)
E (73)	P 42 (57.5) M 10 (13.7) MxP 21 (28.8)	20.9 (5-50)	Y 54 (79.0) RY 12 (16.4) Or 3 (4.1) OrY 4 (5.5)	2.36 (0.2-4.5)	Cont. 57 (78.1) Disc. 16 (21.9)	0.7 (0-1.2)	58.9 (0-120)
F (70)	P 43 (61.4) M 8 (11.4) MxP 19 (27.1)	18.7 (5.0-48.8)	Y 59 (84.3) OR 5 (7.1) R 2 (3.0) RY 2 (3.0) Ol 2 (3.0)	2.01 (0.2-4.5)	Cont. 56 (80.0) Disc. 14 (20.0)	0.7 (0.3-1.6)	59.1 (0-109.1)
G (69)	P 29 (42.0) M 22 (31.9) MxP 18 (26.1)	26.1 (7.8-63.9)	Y 57 (82.6) Or 4 (5.8) OrY 4 (5.8) R 2 (3.0) RY 2 (3.0)	2.10 (0.1-3.9)	Cont. 55 (79.7) Disc. 14 (20.3)	8.4 (0.4-1.2)	69.5 (36.4-122.2)
H (7)	P 4 (57.1) M 2 (28.6) MxP 1 (14.3)	13.2 (3.4-34.5)	Y 5 (71.4) RY 2 (28.5)	1.5 (0.7-2.7)	Cont. 5 (71.4) Disc. 2 (18.5)	0.5 (0.4-0.7)	55.0 (33.3-100.0)
I (110)	P 61 (55.3) M 10 (9.1) MxP 40 (36.3)	26.3 (0.8-67.5)	Y 60 (54.5) R 2 (1.8) RY 41 (37.3) Ol 7 (6.4)	2.2 (0.1-4.8)	Cont. 84 (76.4) Disc. 26 (23.6)	0.8 (0-4)	58.7 (0-175)
J (1*)	-	-	-	-	-	-	-
K (6)	P 1 (16.7) M 1 (16.7) MxP 4 (66.7)	26.3 (10.9-34.0)	Y 6 (100)	1.0 (0.6-2.3)	Cont. 5 (83.3) Disc. 1 (16.7)	0.6 (0.3-1.1)	27.9 (0-65)
L (9)	P 5 (55.6) M 3 (33.3) MxP 1 (11.1)	22.0 (10.5-36.5)	Y 9 (100)	2.5 (0.8-3.7)	Cont. 5 (55.6) Disc. (44.4)	0.9 (0.6-1.1)	64.7 (42.1-91.7)

Table 1. Phenotypic characters by watersheds for Virginia *C. picta* (P = *picta*, M = *marginata*, MxP = *marginata* x *picta* intergrades. Watersheds are described in the text; see Figure 1 for locations. *See text for explanation: CDS = carapace dorsal stripe, FLS = Foreleg stripe. Colours: Y=yellow, R=red, O=orange, Ol=olive.

Taxon Frequency			
Watershed (N)	*picta*	*marginata*	*marginata* x *picta*
A (199)	72 (36.2)	28 (14.1%)	99 (49.7%)
B (28)	14 (50%)	1 (3.6%)	13 (46.4%)
C (16)	5 (31.3%)	0 (-)	11 (68.8%)
D (494)	229 (46.4%)	18 (3.6%)	247 (50.0%)
E (73)	26 (35.6%)	6 (8.2%)	41 (56.2%)
F (70)	43 (61.4%)	8 (11.4%)	19 (27.1%)
G (69)	15 (14.5%)	8 (11.6%)	46 (66.7%)
H (7)	1 (14.3%)	0 (-)	6 (85.7%)
I (110)	51 (46.4%)	8 (7.3%)	51 (46.4%)
J (1*)	-	-	-
K (6)	0 (-)	1 (20.0%)	5 (80.0%)
L (9)	0	1 (11.1%)	8 (88.9%)
Total (N) 1082	**455 (42.2%)**	**79 (7.3%)**	**545 (50.5%)**

Table 2. Taxonomic subspecific status of *C. picta* (N) examined per Virginia Watershed (see text for explanations; and Figure 1 for locations); *VMNH 150006, Floyd County, DOR specimen consisting of shell pieces with no reliable data, see text.

Watershed (N)	% *picta* (N)	% *marginata* (N)	% *marginata* x *picta* (N)
Potomac/Shenandoah (199)			
Coastal Plain	75.0% (54)	10.7% (3)	13.1% (13)
Piedmont	22.2% (16)	32.1% (9)	17.2% (17)
Highlands	2.8% (2)	57.1% (16)	69.7% (69)
Total (199)	36.2% (72)	14.1% (28)	49.7% (99)
Rappahannock/Rapidan (28)			
Coastal Plain	64.3% (9)	- (0)	7.7% (1)
Piedmont	35.6% (5)	- (0)	42.6% (6)
Headwaters	(0)	100.0% (1)	46.2% (6)
Total (28)	50.0% (14)	3.6% (1)	46.4% (13)
James (494)			
Coastal Plain	34.5% (79)	- (0)	17.4% (43)
Piedmont	65.1% (149)	72.2% (13)	72.5% (179)
Headwaters	0.4% (1)	27.7% (5)	10.1% (25)
Total (494)	46.4% (229)	3.6% (18)	50.0% (247)

Table 3. Distribution of the subspecific taxa in the three major East to West watersheds of Virginia (see text for descriptions). N = numbers of individuals.
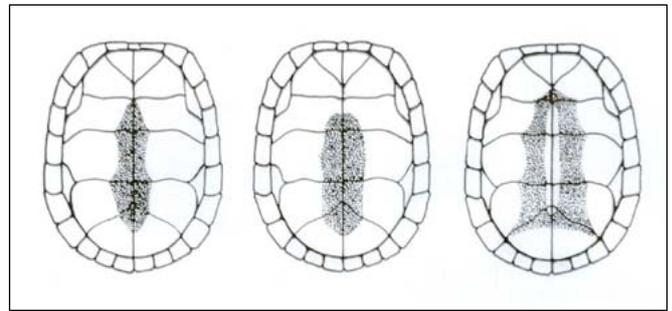
Figure 4. Variations in the plastron pattern of *C. picta marginata* (from Bishop & Schmidt 1931).

RESULTS

Each of the 1082 *C. picta* was examined visually to determine its plastron pattern, carapace seam colour, and the condition of its carapace dorsal stripe (CDS); and measured to determine the percentage of disalignment and width of its carapace seams, and the widths of its carapace dorsal stripe (CDS) and widest foreleg stripe (FLS) to determine its CDS/FLS. These characters (see above) were then used to assign each turtle to a subspecific taxon (P, M, MxP). The tabulated results are presented in Tables 1-3.

Tables 1 & 2 show the subspecific diagnostic characters and the taxon frequencies of each watershed. It is clear from the data in these two tables that only watershed A reaches 70% frequency of P, and that P and M overall amounted to less than 50% and 10% of the 1082 Virginia painted turtles examined. The only exceptions were the Rappahannock/Rapidan with 50% P, and the Chowan with 61.4% P. Although the painted turtles of Virginia have been referred to as P, they are clearly not predominately that subspecies. Instead they form an intergrade (hybrid) swarm of P, M, and MxP, with the great majority of the turtles being MxP (Table 2).

DISCUSSION

Our zoogeographic hypothesis of the distributional origins of Virginia's painted turtles is based on Bleakney (1958), who proposed a theory as to the centers of origin of the four subspecies of *C. picta* and how they subsequently migrated into their present geographical ranges after the Wisconsinian glacial period. He proposed that at the end of the last North American glacial period *C. picta* was divided into three separate populations that represented separate incipient species: *C. picta* in the southeastern Atlantic coastal region, *C. dorsalis* in the lower Mississippi River Valley, and *C. bellii* in the Rio Grande and Pecos river watersheds of New Mexico. He thought that these three populations extended their ranges northward with the final retreat of the glaciers: *C. dorsalis* moved up the Mississippi River and met *C. bellii* in the region of St. Louis "near the Missouri-Mississippi-Ohio [rivers] junctures." There, Bleakney hypothesized the two hybridized and produced the species *C. marginata*. Marginata then migrated up the Mississippi and Ohio river watersheds eventually reaching the northeastern United States and adjacent Canada where they met and interbred with *C. picta*, which had migrated up the Atlantic Coast, and also

met with and interbred with *C. bellii* in the area of Wisconsin and Michigan. Because the four "species" of painted turtles had not evolved reproductive isolation to prevent genetic exchange by the time their ranges met, broad zones of intergradation (hybridization) were established (Ernst & Lovich, 2009). However, Ernst et al. (2006) have proposed that the center of origin of *C. marginata*, based on the existing fossil record, was more likely the Tennessee River Valley, from which it spread north and east. Our discussion of the possible zoogeography of the modern subspecies of *C. picta* in Virginia are only concerned with the subspecies M and P.

Painted turtles possibly reached Virginia after the Wisconsinin Ice Age by four ways: directly up or downstream along major existing waterways, stream capture, overland migration between nearby separate drainages, or by translocation by Native Americans who used them for food or in their ceremonies (Adler, 1968; Lovich et al., 2014). Unfortunately, there is no way of determining the role of humans in the introduction and distribution of painted turtles in Virginia. Thus, our research centered on the species current distribution in the 12 watersheds of the Commonwealth.

Genes from M had three possible directions of entry into Virginia's waterways; from what is now northwestern North Carolina; from now Tennessee, Kentucky, and West Virginia to the west; or from present Maryland and Pennsylvania to the north.

The identity of the recent painted turtle colonies in northwestern North Carolina has not been established with certainty. Palmer & Braswell (1995) reported that more specimens are needed from the mountains and Piedmont of western North Carolina to establish the range of M there, and consequently referred to all North Carolina populations only as *C. picta*. As M is known from Tennessee adjacent to North Carolina (Ernst, 1970; Johnson, 1954), it is probable that at least some of the populations in western North Carolina are of this subspecies and could have moved north into southern Virginia. The Virginia drainages possibly affected by migration from western North Carolina are the Powell, Clinch, and Holston of the Tennessee River drainage. It is also possible that an opposite migration from Virginia southward may have established M at some North Carolina localities.

M occurs in the mountains of eastern Tennessee (Ernst, 1970; Gentry, 1956; Johnson 1954); and it or MxP are also known from Laurel, Mason, Bath, and Rowan counties in eastern Kentucky (Ernst, 1970). In Kentucky, Clover Fork and Poor Fork, headwaters of the Cumberland River, and Russell Fork, a headwater of the Big Sandy River, are close to Virginia, and are potential migration routes into the Commonwealth. Green & Pauley (1987) reported P from Mercer and Monroe counties, and M from Greenbrier and Summers counties in southeastern West Virginia; indicating that intergradation between the two subspecies occurs in West Virginia. The potential introduction of genes of M from eastern Tennessee, Kentucky and West Virginia exists at least for Virginia's Powell, Clinch, Holston, New, James, and Potomac/Shenandoah watersheds; and Hoffman (1949) reported MxP from Virginia's James River watershed in Monroe County.

To the North, M may have entered Virginia from Maryland to the Potomac River via the Youghiogheny River of the Ohio River watershed west of the Atlantic-Ohio Divide in Pennsylvania, and possibly from West Virginia by stream capture or overland migration (Ernst & Ernst 1971, Groves 1983). It could also have reached the Potomac by moving southward along its tributaries from Adams and Franklin counties, Pennsylvania. Once M reached Virginia, it could have easily migrated southward up the Shenandoah River's branches into westcentral Virginia. Also, the Susquehanna River watershed could have provided M or MxP a more eastern avenue of entry into Virginia via the Chesapeake Bay. The major Virginia watersheds affected by such northern entry paths would be the Potomac/Shenandoah, Rappahannock/Rapidan, York, James Rivers, and those of the Delmarva Eastern Shore.

P would have moved north into Virginia from North Carolina; either up the New River Valley, or upstream in the Pee Dee, Dan, Roanoke, Meherrin, Chowan, or Dismal Swamp drainages, where it eventually met M from the North. P probably reached the Virginia Eastern Shore by migration north along the Chesapeake Bay.

Table 3 shows the physiographic distribution of P, M, and MxP in the three major west-east flowing watersheds (Potomac/Shenandoah[A], Rappahannock/Rapidan[B], and James[D]: the eastern Coastal Plain below the fall line), the central Piedmont above the fall line, and the western Headwaters. Except in the James River, P is found predominately on the Coastal Plain and M on the central and western regions. MxP is found predominately west of the fall line but is also present on the Coastal Plain. This supports the hypotheses of P's northward movement into these three watersheds, and also those of the York [C] and Delmarva/Eastern Shore [I] (Table 2); and the eastern and southward movements of M into Virginia. The taxon frequencies shown in Table 2 of the southward flowing Dismal Swamp [E], Chowan [F], and Roanoke [G], and the north flowing Pee Dee [H] river support a northward flow of P's genes into Virginia from North Carolina.

Although examination of only 15 turtles from the western flowing Tennessee (6) and Big Sandy (9) watersheds revealed no P and only M and MxP, it indicates a western invasion of M.

Our overall results support both Bleakney's (1958) hypothesis of the northward movement of P and the eastward and southward movement of M. They also possibly support the statement by Ultsch et al. (2001) that "pure picta [P] do not exist; there is marginata [M] [genetic] influence throughout picta's range, particularly at the extremes." However, Ultsch et al. (2001) used slightly different subspecific characters and statistical ranges, and had relatively small sample sizes from their various P sites (with the exception of Groton, New London, Connecticut). The major difference between the two studies is that Ultsch et al. (2001) did not apply the 75% subspecific standard (Amadon, 1949). If they had, their results and conclusions may have been different.

Their other confusing conclusion is that P is a genetic intergrade (hybrid) with M, and is thus MxP. They accepted Bleakney's (1958) explanation that M was formed as a result of hybridization between the then *C. bellii* and *C. dorsalis* (see above). This would result in the evolution of an intergrade (hybrid) from a previous intergrade (hybrid) *C. bellii* and *C. dorsalis*. In our opinion, this is a highly unlikely mode of speciation.

ACKNOWLEDGEMENTS

REFERENCES

Adler, K. (1968). Turtles from archeological sites in the Great Lakes Region. *The Michigan Archaeologist* 14:147-163.

Amadon, D. (1949). The seventy-five per cent [sic] rule for subspecies. *The Condor* 51:250-258.

Bishop, S.C. & Schmidt, F.J.W. (1931). The painted turtles of the genus Chrysemys. *Field Museum of Natural History*: *Zoolological Series* 18:123-139.

Bleakney, S. (1958). Postglacial dispersal of the turtle, *Chrysemys picta*. *Herpetologica* 14:101-104.

Ernst, C.H. (1967). Intergradation between the painted turtles *Chrysemys picta picta* and *Chrysemys picta dorsalis*. *Copeia* 1967:131-136.

Ernst, C.H. (1970). The status of the painted turtle *Chrysemys picta* in Tennessee and Kentucky. *Journal of Herpetology* 4:39-45.

Ernst, C.H. (1971). *Chrysemys picta*. *Catalogue of American Amphibians and Reptiles* 106:1-4.

Ernst, C.H., Belfit, S.C., Sekscienski, S.W. & Laemmerzahl, A.F. (1997). The amphibians and reptiles of Ft. Belvoir and northern Virginia. *Bulletin of the Maryland Herpetological Society* 33:1-62.

Ernst, C.H. & Ernst, E.M. (1971). The taxonomic status and zoogeography of the painted turtle, *Chrysemys picta*, in *Pennsylvania*. *Herpetologica* 27:390-396.

Ernst, C.H., Laemmerzahl, A.F. & Creque, T.R. (2006). A review of morphological and pattern variation in the painted turtle, *Chrysemys picta*, in Missouri, USA, with an alternate hypothesis of the origin of *Chrysemys picta marginata*. *Herpetological Bulletin* 95:6-15.

Ernst, C.H. & Lovich, J.E. (2009). *Turtles of the United States and Canada*. Baltimore, MD., The Johns Hopkins University Press.

Gentry, G. (1956). An annotated checklist of the amphibians and reptiles of Tennessee. *Journal of the Tennessee Academy of Science* 31:12-23.

Green, N.B. & Pauley, T.K. (1987). *Amphibians and Reptiles in West Virginia*. Pittsburgh, PA., University of Pittsburgh Press.

Groves, J.D. (1983). Taxonomic status and zoogeography of the painted turtle, *Chrysemys picta* (Testudines: Emydidae), in Maryland. *American Midland Naturalist* 109:274-279.

Haig, S.M., Beever, E.A., Chambers, S.M., Draheim, H.M., Dugger, B.D., Dunham, S., Elliott-Smith, E., Fontaine, J.B, Kesler, D.C., Knaus, B.J., Lopes, I.F., Loschl, P., Mullins, T.D. & Sheffield. L.M. (2006). Taxonomic considerations in listing subspecies under the U.S. Endangered Species Act. *Conservation Biology* 20:1584-1594.

Hartman, W.H. (1958). Intergradation between two subspecies of painted turtles, genus *Chrysemys*. *Copeia* 1958:261-265.

Hartweg, N.E. (1934). A study of genetic variation in the genus *Chrysemys*. Unpublished Ph.D. dissertation, University of Michigan, Ann Arbor.

Hoffman, R.L. (1949). The turtles of Virginia. *Virginia Wildlife* 10:16-19.

Holman, J.A. & McDonald, J.N. (1986). A Late Quaternary herpetofauna from Saltville, Virginia. *Brimleyana* 12:85-100.

Jenkins, R.E. & Burkhead, N.M. (1994). *Freshwater Fishes of Virginia*. Bethesda, MD., American Fisheries Society.

Johnson, R.M. (1954). The painted turtle, *Chrysemys picta*, in Eastern Tennessee. *Copeia* 1954:298-299.

Lee, D.S. (1972). List of the amphibians and reptiles of Assateague Island. *Bulletin of the Maryland Herpetological Society* 8:90-95.

Lovich, J.E., La Rue, C.T., Drost, C.A. & Arundel, T.R. (2014). Traditional cultural use as a tool for inferring biogeography and provenance: A case study involving painted turtles (*Chrysemys picta*) and Hopi Native American culture in Arizona. *Copeia* 2014:215-220.

Mitchell, J.C. (1994). *The Reptiles of Virginia*. Washington, D.C., Smithsonian Books.

Mitchell, J.C. & Anderson, J.M. (1994). Amphibians and Reptiles of Assateague and Chincoteague Islands. *Virginia Museum of Natural History Special Publication* 2:1-120.

Mitchell, J.C. & Reay, K.K. (1999). Atlas of Amphibians and Reptiles in Virginia. Richmond, Virginia Department of Game and Inland Fisheries. Spl. Publ. 1:1-122.

Pague, C.A. & Mitchell, J.C. (1991). In *The amphibians and reptiles of Back Bay, Virginia*, pp. 159-166. Marshall, H.G. & Norman, M.D. (Eds.). Norfolk, VA. Old Dominion University. Palmer, W.H. & Braswell, A.L. (1995). *Reptiles of North Carolina*. Chapel Hill, University of North Carolina Press.

Patten, M.A. & Unitt, P. (2002). Diagnosability versus mean differences of sage sparrow subspecies. *The Auk* 119:26-35.

Schwab, D. (1989). *Chrysemys picta picta* (Eastern Painted Turtle): Prince George County, VA. *Catesbeiana* 9:34.

Seidel, M.E. (1981[1982]). A taxonomic analysis of pseudemyd turtles (Testudines: Emydidae) from the New River, and phenetic relationships in the subgenus *Pseudemys*. *Brimleyana* 6:24-44.

Tobey, F.J. (1985). *Virginia's Amphibians and Reptiles: A Distributional Survey*. Purcellville, Virginia Herpetological Society.

Ultsch, G.R., Ward, G.M., LeBerte, C.M, Kuhajdam B.R. & Stewart, E.R. (2001). Intergradation and origins of subspecies of the turtle *Chrysemys picta*: Morphological comparisons. *Canadian Journal of Zoology* 79:485-498.

Head-scale instability and the apparent heritability of a head scale anomaly in the northern viper (*Vipera berus*)

RICK HODGES* & CLIFFORD SEABROOK

Kent Reptile and Amphibian Group, c/o KMBRC, Brogdale Farm, Brogdale Rd, Faversham, Kent, ME13 8XZ, UK
*Corresponding author email: info@kentarg.org

....

INTRODUCTION

The northern viper or adder (*Vipera berus*) is increasingly the subject of conservation projects. The data collected by such projects can be subject to much deeper analysis if they are collected from known individuals. Individual recognition can be achieved by marking adders (scale clipping, paint spots, etc.) but this involves varying degrees of disturbance. This disturbance can be avoided if the adder's natural markings are exploited, in particular, the number and arrangement of head-scales (Benson, 1999) provide a natural 'fingerprint' and head and neck markings (Sheldon & Bradley, 1989) are distinctive. Other unusual features such as healed injuries or scale anomalies can facilitate quick and easy recognition. Since the advent of digital photography and easy access to computers, the cataloguing and retrieval of images showing head-scale patterns and other features have become relatively easy. In addition, 'photo-id' image analysis software is available to aid comparison between 'unknown' adder photos and images in a project archive (see http://www.conservationresearch.co.uk/adders/adders.htm).

Individual recognition by the use of head-scale patterns relies on the assumption that such patterns are stable during the life time of the individual. In general, it is believed that reptile scales and scale hinges are differentiated during embryonic development and that any post-natal alterations to the size, shape and distribution of scales are a result of injury (Maderson, 1965). If there are natural injuries and abrasions to scales then the healed scales are never regular and there is no restoration of their geometric pattern (Maderson et al., 1978).

Within the frame of the Kent Reptile and Amphibian Group's 'Adders in Decline Project', there have been detailed investigations of adder populations on the North Downs since 2004. From the start these involved individual adder recognition from photographs of head-scales and neck markings. The project archive to date holds head-scale pattern records for 594 individuals, of which 78% have been observed more than once and of the 172 adults, 34 were known from when they were immature. Two interesting observations on head-scales came to light in 2014 and are documented here.

OBSERVATIONS

Scale instability

Until recently the only changes in head-scale patterns detected between successive observations had been those resulting from obvious injury (or possibly disease). In 2014, observation of a sub-adult male (SM44) indicated that scale numbers may increase by sub-division of scales (technically termed 'polymerisation'). SM44 was born in 2012 and from then until the end of 2014 has been seen on 15 occasions. It is an unusual specimen as towards the end of 2014 it adopted a silver-grey colouring, unlike the fawn colour of its peers, suggesting the onset of sexual maturity despite being only at the end of its second full year of life. Sexual maturity would normally be expected during the third full year of life (Prestt, 1971). However, close to the time of hibernation it returned to a more normal fawn colouration. On the 30th August, SM44 had only three paraocular scales on the left hand side (Fig. 1a). By the 15th September the second scale in the row appeared to be partially sub-divided (Fig. 1b). By the 16th October the second scale was completely divided into two smooth-edged scales of normal appearance, i.e. no appearance of injury, so that the number of scales in the row increased from three to four (Fig. 1c).

This is not the first occasion that head-scale instability has been reported. Observations on the meadow viper (*V. ursinii macrops*) in Montenegro over a period of four years revealed considerable changes in head-scale patterns; 12 out of 23 specimens (52.2%) that were seen more than once had quite distinct changes (Tomovi et al., 2008) and these occurred in adult males and females as well as immatures. The observations were very detailed but no explanation was offered as to why the scale patterns had changed. A more recently published study, on the head-scales of a different sub-species (*V. ursinii rakosiensis*) in Hungary (Üveges et al., 2012), appears to contradict these findings as observations from 2004 to 2012 gave no evidence of any post-natal instability of head-scales. Since this is a little known phenomenon it would appear to occur under unusual circumstances.

To date, our observations on the North Downs populations of adders suggests that although new head-scales can be created quickly (<2 months) this occurs rarely. It is therefore unlikely to result in any significant inaccuracy in our biological investigations, especially when other indicators such as neck markings are also taken into account in individual recognition. Nevertheless scale instability remains an interesting and unexplained phenomenon.

Inherited scale anomaly

A female adder (F1), known as an adult since 2006 and seen on
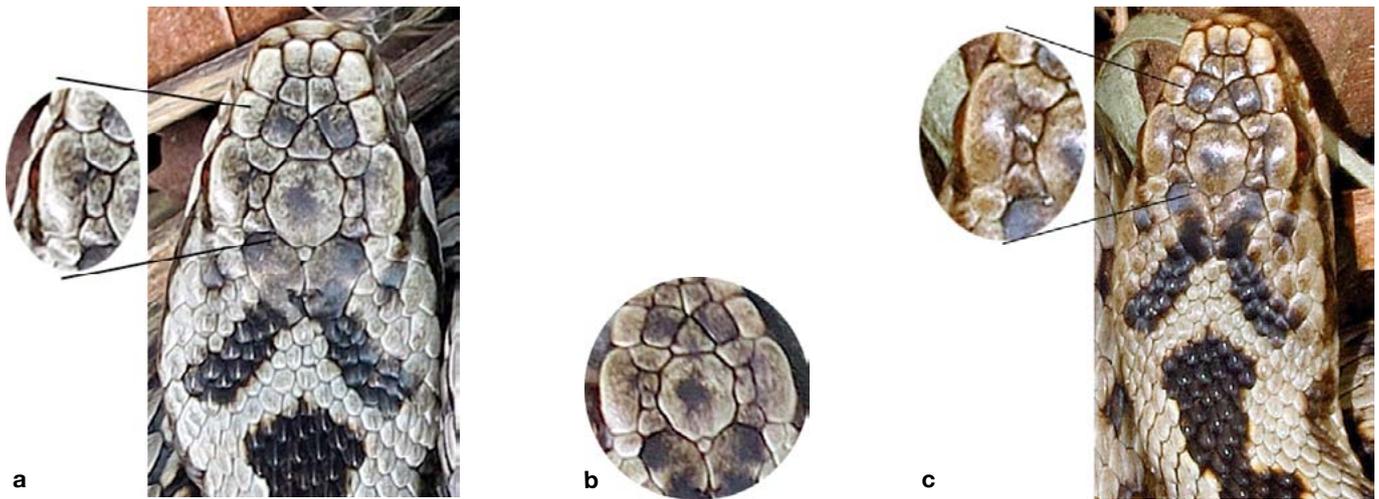
Figure 1. A change in the number of paraocular scales on the left hand side of sub-adult male (SM44) *V. berus* in the period 30th August to 16th October 2014, **a.** 30/8/14 - SM44 showing 3 paraocular scales, **b**. 15/9/14 - SM44 with 2nd paraocular scale partially subdivided, **c**. 16/10/14 , SM44 with four smoothly edged paraocular scales.

61 occasions, is very unusual in having a slit-like fold into the anterior portion of her frontal scale (Fig. 2a). She gave birth in August 2014 and four of the young that were found displayed the same character to some degree; the example shown in Fig. 2b is the most pronounced, i.e. in the others the slit was shorter. As a large mature female she would most likely have given birth to more than four young; these were not observed (or perhaps not recognised as her young) and so it remains

Figure 2. Scale anomaly, a slit in the anterior portion of the frontal scale (indicated by arrows) found in both a female adder and some of her brood, **a**. Adult female (F1) showing a slit in the anterior portion of the frontal scale, **b**. Neonate from the brood of female F1 showing a similar slit

unknown whether any others also displayed the same anomaly The scale anomaly would appear to have been inherited from the mother. Until 2014, the anomaly was unique to F1, which is surprising since from 2006 to the present she may have produced as many as five litters; biennial reproduction is normal for female adders (Prestt, 1971). Her offspring are likely to have been included in the observations of our monitoring programme but prior to 2014 none showed the frontal slit. This suggests that the anomaly may be a genetically recessive trait and may have been expressed only as a result of mating with one of her own male offspring; something that may not have happened in

previous years. Female adders often engage in multiple mating and broods may be sired by several males (Ursenbacher et al., 2009), this is likely to be the case with F1 as she was observed to mate with at least two males in April 2014. Consequently, not all offspring would necessarily show the anomaly.

The presence of this scale marker may help to assign maternity and location of birth in adders found in later years if, from the size of an individual, it is possible to estimate its year of birth as being 2014.

REFERENCES

Benson, P.A. (1999). Identifying individual adders, *Vipera berus*, within an isolated colony in East Yorkshire. *The Herpetological Bulletin* 67: 21-27.

Maderson, P.F.A. (1965). The embryonic development of the squamate integument. *Acta Zoologica* 46: 275-295.

Maderson, P.F.A., Baranowitz, S. & Roth, S.I. (1978). A histological study of the long term response to trauma of the squamate integument. *Journal of Morphology* 157: 121-135.

Prestt, I. (1971). An ecological study of the viper *Vipera berus* in Britain. *Journal of Zoology*, *London* 164: 373-418.

Sheldon, S. & Bradley, C. (1989). Identification of individual adders (*Vipera berus*) by their head markings. *The Herpetological Journal* 1: 392 – 395.

Tomović, L., Carretero, M.A., Ajtić, R. & Crnobrnja-Isailović, J. (2008). Evidence for post-natal instability of head scalation in the meadow viper (*Vipera ursinii*) - patterns and taxanomic implications. *Amphibia-Reptilia* 29: 61-70.

Ursenbacher, S., Erny, C. & Fumagalli, L. (2009). Male reproductive success and multiple paternity in the wild, low-density populations of the adder (*Vipera berus*). *Journal of Heredity* 100: 365-370.

Üveges, B., Halpern, B., Péchy, T., Posta, J. & Komlósi, I. (2012). Characteristics and heritability analysis of the head-scales of the Hungarian meadow viper (*Vipera ursinii rakosiensis*, Méhely 1893). *Amphibia-Reptilia* 33: 393-400.

World's largest olive ridley turtles *Lepidochelys olivacea* nesting grounds: Gahirmatha rookery now uncertain for arribada in future, East-Coast of India

SATYARANJAN BEHERA[1,*], BASUDEV TRIPATHY[2] & BINOD CHANDRA CHOUDHURY[3]

[1,3]Odisha Biodiversity Board, Nayapalli, Bhubaneswar, India
[2]Zoological Survey of India, New Alipore, Kolkata - 700 053, India
[3]Wildlife Institute of India, PO Box 18, Chandrabani, Dehradun - 248 001, India
[*]Corresponding author: behera.satyaranjan@gmail.com

ABSTRACT - The nesting season of olive ridley marine turtles *Lepidochelys olivacea* is confined to between November and May at the Gahirmatha rookery of Odisha state, India. Historically nesting has occurred all along the Gahirmatha rookery, however in recent times the nesting has been confined to isolated areas of coast. The Gahirmatha rookery on the Odisha Coast of India is the largest known mass nesting rookery for olive ridley sea turtles in the World. The recent nesting decline at Gahirmatha is likely due to the unavailability of available nesting areas on the beach. The long-term conservation of this species at Gahirmatha is now under serious concern among managers, scientists and conservationists.

INTRODUCTION

Of the seven species of sea turtle found in the Indo-Pacific region (*Caretta caretta*, *Chelonia mydas*, *Eretmochelys imbricata*, *Lepidochelys kempii*, *L. olivacea*, *Natator depressus*, *Dermochelys coriacea*), five are found in India. Of these, four are reported to occur in the coastal waters of Odisha (Fig. 1). These are the Leatherback (*D. coriacea*), green turtle (*C. mydas*), hawksbill (*E. imbricata*) and the olive ridley turtle (*L. olivacea*). The latter is the most common and is known to nest en-masse along the Odisha coast (Dash & Kar, 1990); Pandav, 2000). This species is known to form enormous congregations along the Odisha coast during the breeding season (November to April) with nesting taking place along suitable nesting beaches at Gahirmatha, Rushikulya and Devi rookeries. Gahirmatha is known to be the largest Olive ridleys rookery in the World (Bustard, 1976; Dash & Kar, 1990). Estimates of annual turtle nesting in Gahirmatha have ranged from between 100,000 to 800,000 in different years (Patnaik et al., 2001; Tripathy, 2002). Although multiple mass nesting events have been reported at Gahirmatha there are also records of failure (Dash & Kar, 1990; Patnaik & Kar, 2000; Shanker et al., 2004). At Gahirmatha, the recent trend on mass nesting has occurred either in alternative years or apparently absent in some consecutive years (Pandav & Choudhury, 2000; Draft Final Report WII, 2011). For instance, the failure of mass nesting in 1997 and 1998 at Gahirmatha is a cause for concern due to drastic changes of nesting beach profile (Pandav & Choudhury, 2000; Shanker et al., 2004) since nesting has been a continuous event since its discovery in 1974 until 1982. Historically, mass nesting has taken place along the 10 km of mainland coast in the Bhitarkanika Wildlife Sanctuary. However, from 1989 nesting became restricted to a 4 km long isolated sand bar projecting into the Bay of Bengal. A super cyclone in 1999 fragmented the 4 km nesting beach into two islets viz Nasi-I & Nasi-II. There was an absence of nesting at Nasi-I and Nasi-II during 1997, 1998, 2002 (Shanker et al., 2004) and 2008 (Draft Final Report WII, 2011), the highest incidences of failure in the documented history at this rookery. The Defence Research and Development Organisation have reported that mass nesting now takes place along a section just 900 m long beach of the Wheeler Island, which is located at the tip of the sand bar. In this paper we describe recent nesting activity at the Gahirmatha rookery on the east coast of India.

METHODS

The field work was carried out between 2009 and 2012 season at the < 1km (900 m) south beach of Wheeler Island (Fig. 1). Beach profiling was carried out on a fortnightly basis from November to April following standard procedures as suggested by Cooper et al., (2000). Every 100m, a permanent landmark was fixed (a). These points were marked with a handheld GPS (Garmin 72, Garmin Inc.) for subsequent monitoring. Beach width was measured perpendicular from the High Tide Line (HTL) to the permanent land-mark. The formula for calculating the available nesting beach was first by finding the width of the beach (l) from a ± b, where b is the width of beach from the permanent landmark (a) (Tripathy & Rajasekhar, 2009). Finally, area available for nesting was calculated as average beach width (l) x total length of the beach.

RESULTS AND DISCUSSION

The effective nesting area above highest high tide at Nasi-I and Nasi-II was 22.4 and 29.6 ha during 2001 (Prusty & Dash, 2006). However in the 2009 and 2010 breeding seasons, the effective nesting areas of the current nesting beach (South beach; 900 m) was restricted to only 6.9 ha, which is newly formed at the southern end of Wheeler Island. During the 2011 and 2012 breeding years the effective nesting area was drastically reduced to 5.7 ha and 5.9 ha respectively. This is a
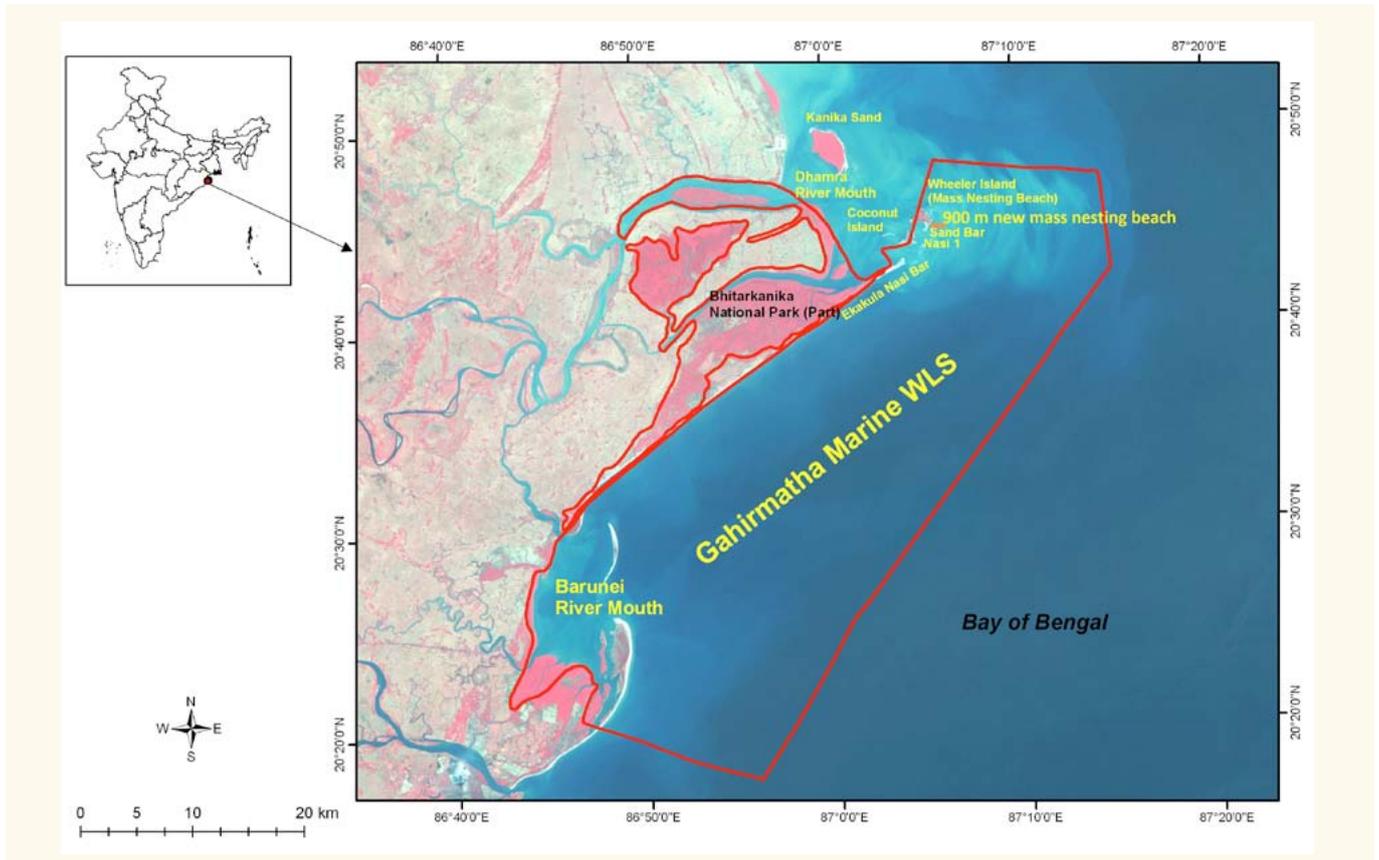
Figure 1. The newly formed mass nesting beach near the southern part of Wheeler Island at Gahirmatha rookery, Odisha coast, India.

huge loss of beach within a four year period. A study conducted by Prusty & Dash (2006) to assess the factors leading to the non-occurrence of mass nesting at Gahirmatha, indicates that the nesting beaches are eroding at a faster annual rate. During the 2009 and 2010 nesting season, mass nesting took place in new-formed extended sand spit < 1 km (900 m) south beach adjacent to the southern end of the Wheeler Island (Fig. 1).

Historically, nesting takes place within an interval of 45 to 50 days. However, in the last decade, the second nesting failed to take place and the exact reason for non-occurrence is not known. However, in 2010 Gahirmatha two nesting periods occurred within a period of 14 days. The estimated number of nesting females was 363,000 (Satyaranjan unpublished data.). Significant shrinkage of beach due to erosion and inundation exposes the majority of nests laid during the mass nesting. A mean of 57 % and 22 % of nesting beach has been lost at Gahirmatha within the incubation period during 2009 and 2010 nesting seasons, which has resulted in hatching success of 20.4 and 64 % respectively. Erosion of nesting beaches can result in partial or total loss of suitable nesting habitat and are influenced by dynamic coastal processes, including sea level rise (National Research Council, 1990). At Gahirmatha, the hatching success is largely governed either by erosion or predation (Dash & Kar, 1990; Pandav, 2000).

A larger portion of sand spit (South beach) where mass nesting took place at Gahirmatha was inundated by tidal waves during the month of March 2009 and 2010, which is likely to have adversely affected the incubation success of the nests. Nests deposited on shifting beaches are more

susceptible to damage due to erosion. Almost 40-60% of the nests of leatherbacks laid on shifting beaches are reported to have been lost because of beach erosion (Whitmore & Dutton, 1985). As a result, there has been a substantial loss of nesting habitat at Gahirmatha rookery (Draft Final Report WII, 2011). Earlier researchers (Dash & Kar, 1990; Choudhury et al., 2003; Mortimer, 1981; Cornelius & Robinson, 1986) have suggested that heavy loss of the post ovipositional eggs of Olive ridley could occur as a result of beach erosion at mass nesting sites. Erosion of the Gahirmatha beach after the 1970's was due to the planting of *Casuarina equisetifolia* along the coast. However, the mass nesting in recent years is affected not only by the presence of *C. equisetifolia* but to other factors including nearby coastal industrial developments (B.C. Choudhury, personal observation). Due to the constraint of nesting beach availability on the South beach of Wheeler Island, turtles may be shifting the mass-nesting to other nearby beaches. This is largely because of beach exchange, which is part of a complex phenomenon that *L. olivacea* use to colonise new areas or move to another beach altogether (Valverde et al., 1998; Tripathy & Pandav, 2008). Although mass nesting was absent or occurred in alternative years, the frequency of sporadic nests laid during the breeding season (November-May) showed a monthly peak in March (Fig. 2) when the nesting beaches are more vulnerable to erosion due to seasonal changes of sea currents (Prusty et al., 2007; Behera et al., 2013).

Over the years the mass nesting beach at Gahirmatha has been severely fragmented and reduced, possibly because of the changes in coastal geomorphology, the topography
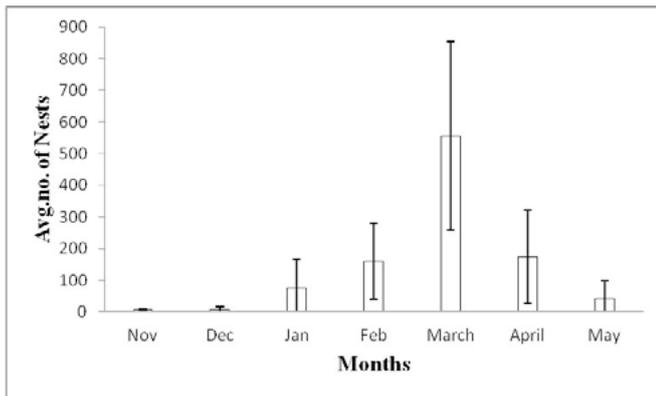
Figure 2. Annual nesting pattern of non-arribada *L. olivacea* at Gahirmatha beach, from 2007-2008 to 2009-2010. A total of 3046 nests were counted, averaging 145 (S.D. 193.3) nests per month.

of the land and seascape (Draft Final Report WII, 2011; Prusty et al., 2007). Mass nesting did not take place in 2014 during the turtle breeding season at the Gahirmatha rookery [Anonymous, 2014]. Therefore, the fate of this rookery is uncertain. Mass nesting at beaches on other sections of the Odisha coast may also be threatened unless fishing activities and predators of these regions are regulated. Additional research is now needed to determine potential or possible alternative nesting sites in and around the Gahirmatha turtle rookery so that conservation measures can be implemented to safeguard these potential valuable sites.

AKNOWLEDGEMENTS

REFERENCES

Behera, S., Tripathy, B., Sivakumar, K. & Choudhury, B.C. (2013). A Case Study on Olive Ridley (*Lepidochelys olivacea*) Solitary Nests in Gahirmatha Rookery, Odisha, India. *Testudo* 7: 49-60.

Bustard, H.R. (1976). World's largest sea turtle rookery. *Tiger Paper* 3: 25.

Choudhury, B.C., Tripathy, B. & Andrews, H. (2003). *Sea Turtle Conservation: Eco (turtle) friendly Coastal Development, A GOI-UNDP Sea Turtle Project Manual*. Centre for Herpetology/Madras Crocodile Bank Trust, Mammalapuram, Tamil Nadu, India, 46 pp.

Cooper, N.J., Leggett, D.J. & Lowe, J.P. (2000). Beach-Profile Measurement, Theory and Analysis: Practical Guidance and Applied Case Studies. *Water & Environment Journal* 14: 79-88.

Cornelius, S.E. & Robinson, D. (1986). Post nesting movements of female olive ridley turtles tagged in Costa Rica. *Vida Silvestre Neotropical* 1: 12-23.

Dash, M.C. & Kar, C.S. (1990). *The Turtle Paradise - Gahirmatha*. Interprint, New Delhi, 295 pp.

Draft Final Report, WII. (2011). Determining the Offshore Distribution and Migration Pattern of Olive Ridley Sea Turtles (*Lepidochelys olivacea*) along the east coast of India. *Wildlife Institute of India*, Dehradun, 224 pp.

Mortimer, J.A. (1981). Reproductive ecology of the green turtle, *Chelonia mydas* at Ascension Island. PhD Thesis, University of Florida, Gainesville.

National Research Council, (1990). *Decline of Sea Turtles: Cause and Prevention*. National Academy Press, Washington DC, 280 pp.

Pandav, B. (2000). Conservation and Management of olive ridley sea turtle (*Lepidochelys olivacea*) along the Odisha Coast. PhD Thesis, Utkal University, Odisha.

Pandav, B. & Choudhury, B.C. (2000). *Conservation and management of Olive Ridley Sea Turtle (Lepidochelys olivacea) in Orissa*. Final report. Dehradun: Wildlife Institute of India, 77 pp.

Patnaik, S.K. & Kar, C.S. (2000). Status and conservation of sea turtles in Orissa, India. In: *Sea turtles of the Indo-Pacific: Research, Conservation and Management*, pp13-24. Pilcher, N. & Ismail, G. (eds.). London: ASEAN Academic Press.

Patnaik, S.K., Kar, C.S. & Kar, S.K. (2001). *A Quarter Century of Sea Turtle Conservation in Odisha*. Wildlife Wing, Forest Department, Government of Odisha, Bhubaneswar

Prusty, G. & Dash, S. (2006). The Effect of Rookery Geomorpholoy on olive ridley nesting in Gahirmatha, Odisha. In: *Marine Turtles of Indian Subcontinent,* Shanker, K. & Choudhury, B.C. (Eds.). Universities Press, 415 pp.

Prusty, G., Dash, S. & Singh, M.P. (2007). Spatio-temporal analysis of multi-date IRS imageries for turtle habitat dynamics characterisation at Gahirmatha coast, India. *International Journal of Remote Sensing* 28: 871-883.

Shanker, K., Pandav, B. & Choudhury, B.C. (2004). An assessment of the olive ridley turtle (*Lepidochelys olivacea*) nesting population in Odisha, India. *Biological Conservation* 115: 149-160.

Tripathy, B. (2002). Is Gahirmatha the world's largest sea turtle rookery? *Current Science* 83: 1299.

Tripathy, B. & Pandav, B. (2008). Beach fidelity and inter-nesting movements of olive ridley turtles (*Lepidochelys olivacea*) at Rushikulya, India. *Herpetological Conservation and Biology* 3: 40-45.

Tripathy, B. & Rajasekhar, P.S. (2009). Natural and anthropogenic threats to olive ridley sea turtles (*Lepidochelys olivacea)* at the Rushikulya rookery of Orissa coast, India. *Indian Journal of Marine Science* 38: 439-443.

Valverde, R.A., Cornelius, S.E. & Mo, C.L. (1998). Decline of the olive ridley sea turtle (*Lepidochelys olivacea*) nesting assemblage at Nancite beach, Santa Rosa National Park, Costa Rica. *Chelonian Conservation and Biology* 3: 58-63.

Whitmore, C.P. & Dutton, P.H. (1985). Infertility, embryonic mortality and nest-site selection in leatherback and green sea turtles in Suriname. *Biological Conservation* 34: 251-272.

Use of a subterranean habitat by the Mediterranean stripe-necked terrapin (*Mauremys leprosa*)

ARLO HINCKLEY[1*], DAVID HERRERO[2] & ANDREA GARCÍA DE CASTRO VIDAL[3]

[1]Cl Pere Roma Rector, nº20. 07141 Marratxí, Islas Baleares, Spain
[2]Cl. Embajadores, 161, 3ºC. 28045, Madrid, Spain
[3]Cl. Morcuera, 16, 2ºB. 28231 Las Rozas, Madrid, Spain
*Corresponding author email: arlohinckley@hotmail.com

Use of caves by turtles is an uncommon but reported behaviour. According to the literature, some turtles are known to use caves sporadically to hide from predators (Acuña-Mesen, 1994) or as temporary refuges during the dry season. (Tuberville et al., 2005). But until now, caves have never been reported as thermoregulatory refuges. The Mediterranean stripe-necked terrapin (*Mauremys leprosa*) occurs in a wide variety of habitats from fast flowing mountain streams to ponds and drainage ditches and it is highly tolerant of a wide range of water conditions; acid, alkaline and brackish water. It hibernates from November to February in Central Spain (Salvador & Pleguezuelos, 2002).

During January 2014, two individuals of *M. leprosa* were seen in the abandoned iron mine at Valmayor (38º 24' 23.55''N 4º 10' 01.50'' W, 684 m altitude). The mine is 424 m long, 2.5 m high, 2m wide and filled with polluted black water (1 m maximum depth) that pours into the Valmayor river. This mine has been worked since the Roman period and the water contains a mixture of bat guano and leachates.

Figure 1. One of the two *M. leprosa* found inside the tunnel. (David Herrero)

The two individuals were found approximately 50m from the cave entrance. Both were females of 121 mm and 115 mm carapace length that were active and seemed to have a good body condition with no visible abnormalities. Air temperature

inside the cave was 20 ºC and 3 ºC on the outside. The air temperature in the tunnel is constant all year round (De Paz personal communication) while outside air temperatures can drop to -5 ºC. The warm temperature of the tunnel presumably allows any resident terrapin to remain active throughout the whole year but is lower than normal activity body temperatures recorded for *M. leprosa* (e.g. Meek, 1983). It remains to be seen whether terrapins overwintering in this environment are able to feed to maintain their raised metabolic rates.
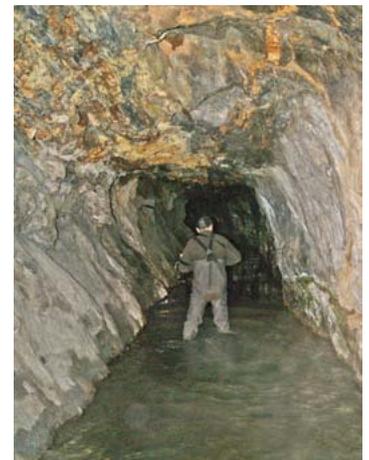
Figure 2. Tunnel where the *M. leprosa* were found. (David Herrero)

ACKNOWLEDGEMENTS

REFERENCES

Acuña-Mesen, R.A (1994). Morphometric variation and ecologic characteristics of the habitat of the *Kinosternon scorpioides* turtle in Costa Rica (Chelonia, Kinosternidae). *Revista Brasileira de Biologia* 54:537-547.

Meek, R. (1983). Body temperatures of a desert population of the stripe- necked terrapin, *Mauremys caspica*. *British Journal of Herpetology* 6: 335 -337

Salvador, A. & Pleguezuelos, J.M. (2002). *Reptiles Españoles. Identificación, Historia Natural y Distribución*. Canseco editores. 491 pp

Tuberville, T., Buhlmann, K., Bjorkland, R., & Boother, D. (2005). Ecology of the Jamaican Slider Turtle (*Trachemys terrapen*), with implications for conservation and management. *Chelonian Conservation and Biology* 4: 908-915

*Physalaemus nattereri (*Cuyaba dwarf frog*)*: Parasitism

PRISCILLA G. GAMBALE[1*], FABRÍCIO HIROIUKI ODA[1], IAGO CARVALHO[2],
TAINÃ CARDOSO[2], ÉVERTON K. K. FERNANDES[3] & ROGÉRIO PEREIRA BASTOS[2]

[1]Programa de Pós-Graduação em Ecologia de Ambientes Aquáticos Continentais, Universidade Estadual de
Maringá, Nupélia - Núcleo de Pesquisas em Limnologia, Ictiologia e Aqüicultura - Maringá, PR, Brazil.
[2]Laboratório de Herpetologia, Instituto de Ciências Biológicas, Universidade Federal de Goiás, Brazil.
[3]Universidade Federal de Goiás (UFG), Instituto de Patologia Tropical e Saúde Pública. Goiânia, GO, Brazil
*Corresponding author email: priscillagambale@gmail.com

The genus *Amblyomma* Koch, 1844 is currently represented by 30 valid tick species in Brazil, and at least seven are known from the Brazilian Savanna (Szabó et al., 2007), parasitising amphibians, reptiles, birds, and mammals (Dantas-Torres et al., 2009). Among these tick species, *A. dissimile* Koch, 1844 and *A. rotundatum* Koch, 1844 are the most commonly found in Amphibia and Reptilia groups (Onofrio et al., 2006; Guglielmone & Nava, 2010). *A. rotundatum* is a neotropical tick with a wide distribution that has been reported from Argentina to Mexico (Luz & Faccini, 2013). It is also established in the United States of America where it was accidentally introduced, in South Florida, parasitising *Rhinella marina* (Oliver et al., 1993). In Brazil, this tick species was reported from Amazonas to Rio Grande do Sul (Luz & Faccini, 2013), parasitising species of *Rhinella* anuran group. Parasitism by *A. rotundatum* is common on species of bufonids, and some cases have been reported from other anurans, for example *Discoglossus pictus*, *Pipa pipa*, *Pelophylax esculentus* and *Spea bombrifons* (Guglielmone & Nava, 2010). Awareness of new cases may help to understand parasite-host relationships. Here we report the parasitism of an adult female *Physalaemus nattereri* by a nymph of *A. rotundatum* in Cerrado, the Brazilian Savanna.

On December 20, 2013, we captured 17 individuals of *P. nattereri* in a temporary pond (16º35'54.8"S 48º52'43.7"W) in a pasture area in the municipality of Bonfinópolis, Goiás, central Brazil. Visual assessment of the frogs revealed that one specimen (female, SVL = 47.87 mm, weight = 11.47 g) was parasitised by a nymph *A. rotundatum*, which was found in the upper ventral region on the left thigh (Fig. 1). The female frog was found in amplexus with a co-specific male. The tick was removed from the body of the host using anatomical forceps and was fixed in 70% ethanol. It was identified following a dichotomic key (Martins et al., 2010) at the Instituto de Patologia Tropical e Saúde Pública (IPTSP), Universidade Federal de Goiás (UFG). This voucher specimen is deposited in the zoological collection of the Universidade Federal de Goiás, Goiânia, Brazil (ZUFG 8493). Guglielmone & Nava (2010) listed records of parasitism of *A. rotundatum* on 13 anuran hosts: *Anaxyrus terrestris*, *D. pictus*, *P. esculentus*, *Peltophryne peltocephala*, *P. pipa*, *Rhinella arenarum*, *R. crucifer*, *R. granulosa*, *R. icterica*, *R. marina*, *R. schneideri*, *Rhinella* sp., *S. bombifrons*. In

Figure 1. Nymph of *A. rotundatum* tick (white arrow) on adult female *P. nattereri*.

Brazil, the records are restricted to species of bufonids: *R. granulosa*, *R. icterica*, *R. jimi*, *R. marina*, *R. schneideri*, *Rhinella* sp. (see revision Luz & Faccini, 2013). Therefore, our report appears to be the first record of *A. rotundatum* parasitising *P. nattereri*, a leptodactylidae frog. The relationships between ectoparasites and anuran hosts are still unclear (Antonucci et al., 2011; Luz & Faccini, 2013). Although, this report concerns only a single observation it represents a new case, at a Cerrado Savanna, of a tick parasitising anuran species belonging to the *Physalaemus* group. This presents possibilities for study of parasite-host interactions involving anuran fauna in Cerrado.

ACKNOWLEDGEMENTS

REFERENCES

Antonucci, A.M., Oda, F.H., Signorelli, L., Santana, N.F. & Mendes, M.C. (2011). Parasitismo de *Amblyomma rotundatum* (Koch, 1844) (Acari: Ixodidae) em *Rhinella schneideri* (Werner, 1894) (Anura: Bufonidae) no estado do Paraná, Brasil. *Natureza on line* 9: 103-105.

Dantas-Torres, F., Onofrio, V.C. & Barros-Battesti, D.M. (2009). The ticks (Acari: Ixodida: Argasidae, Ixodidae) of Brazil. *Systematic & Applied Acarology* 14: 30-49.

Guglielmone, A.A. & Nava, S. (2010). Hosts of *Amblyomma dissimile* Koch, 1844 and *Amblyomma rotundatum* Koch, 1844 (Acari: Ixodidae). *Zootaxa* 2541: 27-49.

Luz, H.B. & Faccini, J.L.H. (2013). Parasitismo por carrapatos em anuros no Brasil. Revisão. *Veterinária e Zootecnia (Edição Comemorativa)* 20: 100-111.

Martins, T.F, Onofrio, V.C., Barros-Battesti, D.M. & Labruna, M.B. (2010). Nymphs of the genus *Amblyomma* (Acari: Ixodidae) of Brazil: descriptions, redescriptions, and identification key. *Ticks and Tick-borne Diseases* 1: 75-99.

Oliver, J.H., Hayes, M.P., Keirans, J.E & Lavender, D.R. (1993). Establishment of the foreign parthenogenetic tick *Amblyomma rotundatum* (Acari: Ixodidae) in Florida. *Journal of Parasitology* 79: 786-90.

Onofrio, V.C., Labruna, M.B., Pinter, A., Giacomin, F.G. & Barros-Battesti, D.M. (2006). Comentários e chaves para as espécies do gênero *Amblyomma*. In: *Carrapatos de importância médico-veterinária da Região Neotropical: um guia ilustrado para a identificação de espécies*, pp.53-113. Barros-Battesti, D.M., Arzua, M. & Bechara, G.H. (Eds.). São Paulo: Vox/ICTTD-3/Butantan.

Szabó, M.P.J., Olegário, M.M.M & Santos, A.L.Q. (2007). Tick fauna from two locations in the Brazilian savannah. *Experimental and Applied Acarology* 43: 73-84.

A note on behaviour of the peninsular rock agama (*Psammophilus dorsalis*) at Yellampet, in Telangana, India

GOLUSU BABU RAO[1*], BUDDI LAXMI NARAYANA[2] & KUMMARI SWAMY[3]

[1]Care Earth Trust, H.no-3, 6th Street, Thillaiganga Nagar, Chennai, Tamil Nadu, India-600 061
[2]All India Network Project on Agricultural Ornithology, ANGR Agricultural University, Rajendra Nagar, Hyderabad, Telangana, India-500 030
[3]A.V.C College, Mannampandal, Mayiladuthurai, Tamil Nadu, India-609 305
*Corresponding author email: rao.3in@gmail.com

The Peninsular rock agama (*Psammophilus dorsalis*) is, as its name suggests, an agamid lizard associated with rocky terrain in hilly areas of Southern India (Das, 2002; Daniel, 2002). It is a sexually dimorphic species; males are large and unique with bright red and black breeding colour on the head and dorsal surface of the body, females are smaller than males and are dull grey in colour without any contrasting markings. Perch height also differs between sexes; males prefer to perch at greater heights than females, which may vary during breeding season (Radder et al., 2005). It is very rare to see this species associating with water with only one previous reported observation. This concerned a lizard observed entering water at Hampi, Karantaka by Veeranagoudar et al., (2010). These authors concluded that entering water was a way of reducing body temperature since the difference between the body temperature of the lizard in water was almost 4°C lower than when it was out of water. In this paper we describe a second instance of this behaviour in *P. dorsalis* in a rock pool and suggest another possibility for the behaviour. The observation was made during a faunal survey at Yellampet village Gunti Thanda (18.426794° N, 78.511673° E, 527 m asl.) Machareddy Mandal, Nizamabad district, Telangana state, situated in the central Deccan landscape, on 9th October 2012, at 0900hr. A female *P. dorsalis* was sighted in a small water pool between the rocks, which was formed by rain water from the previous months. Habitat of this area consisted of rocky boulders and scrub jungle. Maximum temperatures in this area may reach 40°C during the summer months with minimum winter temperatures around 18-23°C. The lizard was observed in water for more than 50 minutes and the activity recorded using a NIKON COOL PIX P100 camera. The lizard was seen to move into water and make rhythmic circular movements including placing the ventral surface of its abdomen in the water while simultaneously splashing water on to the belly using its fore limbs (Fig. 1a). Frequently the two hind limbs were stretched and plunged into the water many times (Fig. 1b) and the forelimbs and hind limbs were also rubbed against the abdominal region (Fig. 1c & 1d). The snout was wiped on the ground similar to that described by Veeranagoudar et al., (2010). The lizard was also observed to shuttle between the pool and dry area. When in water, respiration was very fast as observed by abdomen movement, again as noted by Veeranagoudar et al., (2010). No observations of drinking (orally) were made during the 50 minute period. Veeranagoudar et al., (2010) concluded

Figure 1. Behaviour of *P. dorsalis* in a shallow rock puddle. See the text for details.

that this behaviour involved thermoregulation and was a way of reducing body temperature, indicating that this is particularly important for gravid females. For instance, another agamid, *Calotes versicolor* resists prolonged embryonic growth by lowering body temperature when environmental conditions are less than favourable (Shanbhag et al., 2003). However, given the lack of good evidence for thermoregulatory behaviour (2 body temperature measurements; Veeranagoudar et al., 2010) consideration must also be given to other possibilities for the behaviour, for example water uptake. In certain agamid and iguanid lizards that live in arid regions water uptake is by means of transporting water across the skin (Sherbrooke, 1993, Withers, 1993). This includes the Australian agamid *Moloch horridus* that transports water to the mouth from damp sand by rapid actions of the ventral body surface in the sand (Sherbrooke, 1993; Withers, 1993; Wade et al, 2007). Further studies are therefore needed to determine if the behaviour of *P. dorsalis* involves water uptake rather than thermoregulation as indicated by Veeranagoudar et al., (2010) or both.

ACKNOWLEDGEMENTS

REFERENCES

Das, I. (2002). *Snakes and other Reptiles of India*. New Holland, London, UK.

Daniel, J.C. (2002). *The Book of Indian Reptiles and Amphibians*. Oxford University Press, Mumbai, India.

Radder, R.S., Saidapur, S.K. & Shanbhag, B.A. (2005). Population density, microhabitat use and activity pattern of the Indian rock lizard, *Psammophilus dorsalis* (Agamidae). *Current Science* 89: 560-566.

Shanbhag, B.A., Saidapur,S.K. & Radder, R. S. (2003). Lowering body temperature induces embryonic diapause during prolonged egg retention in the lizard, *Calotes versicolor*. *Naturwissenschaften* 90: 33–35.

Sherbrooke, W.C. (1993). Rain-drinking behaviours of the Australian thorny devil (Sauria: Agamidae). *Journal of Herpetology* 27: 270–275.

Veeranagoudar, D.K., Shanbhag, B.A. & Saidapur, S.K. (2010). A novel thermoregulatory behaviour in a gravid rock lizard, *Psammophilus dorsalis*. *Herpetology Notes* 3: 101-103.

Withers, P. (1993). Cutaneous water acquisition by the thorny devil (*Moloch horridus*; Agamidae). *Journal of Herpetology* 27: 265–270.

Wade, C.S., Andrew, J.S., Rocky, D.N. & Lin, S. (2007). Functional morphology of scale hinges used to transport water: convergent drinking adaptations in desert lizards (*Moloch horridus* and *Phrynosoma cornutum*). *Zoomorphology* 126: 89–102.

Field observations, morphometrics and a new locality for *Tylototriton uyenoi* in Chiang Mai Province, Thailand.

CHRISTOPHER J. MICHAELS

Harrison Institute, Bowerwood House, St. Botolph's Road, Sevenoaks, Kent, TN13 3AQ, UK
Corresponding author email: c.j.michaels44@gmail.com

The newt genus *Tylototriton* is distributed across southern and southeast Asia (Rafaelli, 2013; Sparreboom, 2014). Several new species have recently been described (see Nishikawa et al., 2013; Rafaelli, 2013), including *Tylototriton uyenoi* Nishikawa et al. (2013), which has a fragmented highland range in northern Thailand (Pomchote et al., 2008; Nishikawa et al., 2013). At Chiang Dao Wildlife Sanctuary (19.367° N 98.833°E; 1200m a.s.l.; 10/07/2007) newts were collected at night in a pond among bamboo scrub at the forest edge, and during the day under wads of cut grass, both in the vicinity of Khun Huay Mae Kok Guard Station. The pond was shallow and sparsely vegetated with a deep substrate of reddish silt. Water quality, which may be useful for captive husbandry and habitat identification, was measured in this pool using a Tetra Test 5 in 1 (Tetra) dip test kit. At Doi Inthanon National Park (approximately 19.385°N 98.841°E; above 1000m a.s.l.; 15/07/2007) an adult female was collected at night in disturbed pine and grassy scrub near to a campsite.

Newts were restrained and the following characters were measured, using callipers: snout-to-vent length (SVL), from the tip of the snout to the posterior margin of the cloaca; tail length (TL), from the posterior margin of the cloaca to the tip of the tail; axilla-groin distance (AGD), from the posterior margin of the shoulder joint to the anterior margin of the hip joint; maximum head width (MXHW), the width of the head at its widest point; head length (HL), from the snout tip to the line of the posterior margin of paratoids; interocular distance (IOD), between the medial margins of the eyes. Data for all sixteen animals (twelve males, three females and one juvenile) are presented in Table 1. Figure 1 show animals from Chiang Dao and from Doi Inthanon. A single larva was also found in the pond at Chiang Dao. Water quality in this pond was pH: 6.4; GH : 3°d; KH: 3°d; NO2- : 0mg/l; NO3-: 0 mg/l. These animals were similar in size to those reported by Pomchote et al. (2008) and Nishikawa et al. (2013) and in appearance to those pictured by Gerlach (2012). Like the former two authors, females (n=3; mean SVL = 79.59 mm (75.04 – 84.41 mm) were found to be larger than males (n=12; mean SVL = 75.74 mm (71.03 – 83.26 mm) and females (n=3; TL:SVL = 0.89 (0.85 – 0.93)) had proportionately shorter tails than males (n=11, TL:SVL=0.98 (0.87-1.14)). Aquatic males (n=9) also had longer tails on average than terrestrial males (n=2) (TL:SVL = 0.99 (0.91-1.14) and 0.95 (0.87-1.03), respectively). These figures exclude the juvenile

Figure 1. A. Adult male *T. uyenoi*, terrestrial phase. **B**. Juvenile *T. uyenoi*. **C**. Adult female *T. uyenoi*, the single animal from Doi Inthanon. **D**. Adult male *T. uyenoi*. **E**. Aquatic phase *T. uyenoi* males in collecting container.

and, for comparisons of tails, an adult male with a damaged tail tip. The juvenile (Fig. 1B), collected at Chiang Dao, was more brightly coloured, had more rugose skin and a considerably shorter tail (TL:SVL = 0.49; Table 1) than adults. Pomchote et al. (2008), Gerlach (2012) and Nishikawa et al. (2013) report *T. uyenoi* in similar habitat, and breeding from May to July, which concurs with my observations. However, the larva reported herein was found earlier than dates reported for larval presence by Pomchote et al. (2008) and Nishikawa et al. (2013) (from August), but the observation is consistent with Gerlach (2012) who found well developed larvae in mid-July. The newts collected from Chiang Dao represent a new locality for this species. Chiang Dao is within the cluster of mountains reported as hosting *T. uyenoi* (Pomchote et al., 2008; Gerlach, 2012; Nishikawa et al. (2013) and so its presence here is unsurprising.

Locality	Sex	Age	SVL	TL	AGD	MXHW	HL	IOD
Chiang Dao, terrestrial	-	J	40.66	19.75	19.97	8.76	9.48	3.69
	F	A	75.04	63.55	38.55	17.63	21.72	7
	F	A	79.32	73.93	42.33	18.08	22.47	7.57
	M	A	71.79	62.54	36.62	14.91	18.42	6.39
	M	A	71.89	74	35.22	15.27	16.71	6.91
Chiang Dao, aquatic	M	A	83.26	84.74	39.31	17.95	19.76	7.91
	M	A	77.32	75.07	32.36	16.32	20.33	7.5
	M	A	75.35	85.64	36.66	16.9	21.1	8.38
	M	A	81.08	73.08*	36.73	17.04	21.31	7.9
	M	A	76.36	71.76	37.59	17.46	21.06	7.62
	M	A	77.78	73.2	37.13	17.2	21.35	7.94
	M	A	71.77	69.81	36.19	16.6	20.08	7.57
	M	A	74.4	78.31	37.8	16.67	21.69	8.2
	M	A	76.9	71.44	37.85	17.34	21.65	8.08
	M	A	71.03	64.95	33.36	15.4	19.64	7.5
Doi Inthanon, terrestrial	F	A	84.41	74	46.17	18.82	21.92	8.82

Table 1. Morphometric measurements from *T. uyenoi* newts collected at Doi Inthanon and Chiang Dao National Parks, Chiang Mai, Thailand. All measurements are in millimetres. See the text for definitions of measurements. * indicates a damaged tail tip.

REFERENCES

Gerlach, U. (2012). Im Habitat das Birma-Krokodilmolches *Tylototriton verrucosus* in Thailand. *Amphibia* 11: 13-15.

Nishikawa, K., Khonsue, W., Pomchote, P. & Matsui, M. (2013). Two new species of *Tylototriton* from Thailand (Amphibia: Urodela: Salamandridae). *Zootaxa* 3737: 261-279.

Pomchote, P., Pariyanonth, P. & Khonsue, W. (2008). Two distinctive color patterns of the Himalayan newt *Tylototriton verrucosus* (Urodela: Salamandridae) found in Thailand and its implication on geographic segregation. *Natural History* 8: 35-43.

Rafaelli, J. (2013) Les Urodeles du Monde. *Plumelec*, Edition 2013. France.

Sparreboom, M. (2014). *Salamanders of the Old World*. KNV, Zeist, The Netherlands.

The Dice Snake, *Natrix tesselata*: Biology, Distribution and Conservation of a Palaearctic Species

Konrad Mebert, Editor

....

Occasionally we are sent a book which seems sufficiently important, and likely to be of interest to a wide variety of Bulletin readers, that we consider it appropriate to ask more than one person to review it, so that a wider range of views from the herpetological spectrum is represented. This volume is one of them.   Roger Meek, Roger Avery, Editors.
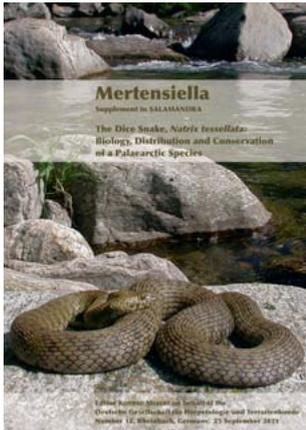
From time to time the journal *Salamandra*, published by Deutsche Gesellschaft für Herpetologie und Terrarienkunde, has supplements which are produced as *Mertensiella*. This book is volume 18. It is devoted entirely to one species, the Dice Snake. It's a large volume, with 469 pages, a lot of good quality illustrations, an attached DVD, more than 130 authors, 47 major articles and 10 "Photo Notes" (which are equivalent to Short Notes in this *Bulletin*). Even as little as a generation ago, a herpetologist would have been astonished that such a thing was possible: it's an indication of how rapidly the study of reptiles and amphibians has grown.

Dice snakes have a wide geographical distribution, from Switzerland to China, and are clearly an adaptable and successful species (although they are vulnerable at the edges of their range, especially in north-west Europe). The emphasis in this volume, as the title suggests, is on distribution, ecology and conservation, and almost the whole of the species' range is covered: most of the papers relate to Europe, but there are also contributions about these snakes in Russia, Caucasia, Turkey, Jordan, Egypt, Iran and China. Forty-four of the papers are in English, three are in German. Inevitably the scope of individual articles is varied, but all seem to me to be very worthwhile and I wish that I had space to mention them all.

The first paper "sets the scene": a masterly review of the contribution of molecular studies to the phylogenetic history of the species by Daniela Guicking & Ulrich Joger. *Natrix tesselata* probably appeared in south-west Asia in the Miocene, and radiated at about the time of the Miocene-Pliocene boundary. In spite of its current widespread geographical distribution, the species has relatively low geographic differentiation. My hypothetical herpetologist of a generation ago would have been amazed at just how much information about the history of a species and the details of its evolution can be provided by studies of mitochondrial DNA (on which most of the argument is based) and similar molecular techniques.

Two further papers are fairly general in scope: on geographical variation in morphological characters by Konrad Mebert, and on head morphology and diet by Jonathan Brecko et al. From this point onwards, the order of articles becomes broadly geographical. Four papers investigate the ecological relationships between Dice Snakes and their closest relatives *N. natrix* and *N. maura*. A careful study in Italy (Stefano Scali, "Ecological comparisons of the dice snake...and the viperine snake... in northern Italy") shows that the species rarely occur in exactly the same habitats, but that where they do, diet, the detailed aquatic habitat used for hunting and details of the diel cycle of activity are more important than thermal niches - body temperatures are identical. Similarly, in Croatia, dice snakes and grass snakes (*N. natrix*) occupy slightly different aquatic habitats and have slightly different - but overlapping - diets (Bilanja Janev Hutinec & Konrad Mebert, "Ecological partitioning between dice snakes... and grass snakes...in southern Croatia"). Both of these papers, and several others, emphasize that dice snakes feed exclusively on fish.

There are two papers which attempt a more holistic approach: "Dietary, thermal and reproductive ecology of *N. tesselata* in Central Italy: a synthesis", by Massimo Capula et al, and "Parasitism in the Dice Snake...a literature review" by Andrei Mihalca (as someone who was a professional parasitologist, I can say that this is one of the most comprehensive - and interestingly-written - accounts of the parasites of a reptile species that I have seen. More work is clearly needed in this area of research, for example I am sure that the overall list of ectoparasites will eventually come to more than the one species of mite mentioned here).

The ten "Photo Notes", based around one or more photographs, should also be mentioned. Three of them particularly intrigued me: "Mating aggregations of *N. tesselata*" by Konrad Mebert & Thomas Ott, "Luring a dice snake by wave action in the water - a predatory response to a moving aquatic prey?" by Konrad Mebert & Benny Trapp and "Terrestrial dice snakes: how far from water a semiaquatic snake ventures out?" by Konrad Mebert. My review copy was an electronic one, so I couldn't watch the film on the DVD, but I have no doubt that it achieves the same high standards as the book.

If you have any kind of scientific interest in snakes, you should read this volume. Even better, have a copy on your shelves. It will act as a useful source of reference, and may well provide inspiration, for some while to come.

It will be apparent from the tone of these comments that I have a high opinion of this nicely-produced book. It must have represented a huge amount of labour by Konrad Mebert, the editor. Actually, "must have represented" is the wrong verb. I know it did, because he says so in the six-page preface. I don't blame him. The preface tells more of the rationale, genesis and editorial problems of this book than is usual. I thought that this was a most refreshing and instructive break with convention.

ROGER AVERY

7 Bishops Avenue, Bishopsteignton, Devon TQ14 9RE, UK
Email: roger.avery1@btinternet.com

The dice snake (*Natrix tessellata*) is a truly palearctic snake naturally occurring across three continents; Europe, Asia and a small part of Africa. Across its epic range, the snake inhabits freshwater channels, rivers, lakes, swamps, brackish lagoons, and even sea water and offshore islands. It has successfully colonized mountain streams up to 2800m, desert oasis and isolated semi-arid areas.

The book is a huge compendium on a single species. Konrad Mebert assembled the leading experts to submit their latest research experience as a series of papers for the Deutsche Gesellschaft für Herpetologie und Terrarienkunde (DGHT). Together more than 120 authors and researchers contributed 57 articles and a DVD, from over 25 countries. Mebert himself confesses in the introduction that the experience of collating the work was somewhat draining! One sympathises, communicating and editing in several languages is a daunting thought for anyone, let alone in scientific glossary.

The books' topics and research are all current, useful and applied. They include aspects about conservation projects, national distributions, new populations, range expansions, population dynamics, ecology, genetics, morphology, radio-telemetry, interspecific competition, inbreeding, hybridization, fossils, parasites, behaviour, hunting, predation and diet - a snake fanatic's dream symposia. To comment on all the chapters would take considerable time, as has reading through the whole book, so instead I am hand picking some of the fascinating snippets that may entice readers to dip into this project.

The phylogeography chapter explains the distribution and origin of mitochondrial clades and identifies the origin of dice snakes to be from SW Asia. I found it particularly interesting too that the morphology of dice snakes varies clinally from west to east. Snakes are known to be gape limited predators and as such dice snake populations with thinner heads seem to prefer a more piscivorous diet and those with a broader heads feed more prevalently on amphibians. The population chapter was also very interesting and presented findings about isolated populations of dice snakes from Germany.

Consultant ecologists might find the chapter on reintroductions especially useful as it demonstrates the importance of extending watercourses and subsequent re-colonisation by dice snakes across habitat that had been improved for them. Radiotelemetry and spatial study work has also been treated in one chapter. It showed that dice snakes exhibited fairly regular patterns in their diurnal activity. I found that the chapter on radiotelemetry was very open and honest about the successes and difficulties of using the techniques applied. I think that many readers investigating uses of radiotelemetry would benefit from reviewing the work.

Captive breeding has also been explored for the species and a full praise of the successes and limitation of potentially breeding for re-release is discussed including details on disease and mortality of hatchlings. Reading through many of the chapters I was amazed at the sheer breadth of research that had been collated and summarised. Purchasers of this text may be disappointed by occasional grammar and typographical errors but these are few and far between. I was unconcerned by this as the volume of work covered is so interestingly diverse. As far as a monograph for a single species is concerned this work is highly substantial and would make a good model for other workers considering a compendium for other well documented species. I would recommend this text for those interested in understanding natricine snakes as much of the ecology may be relevant to similar species.

TODD LEWIS

4 Worgret Road, Wareham, Dorset, BH20 4PJ.
Email: ecolewis@gmail.com.

Animal Cannibalism: The Dark Side of Evolution

David Soulsby 2013

Publisher: 5m Enterprises, Sheffield. 585 p. ISBN: 9780955501166
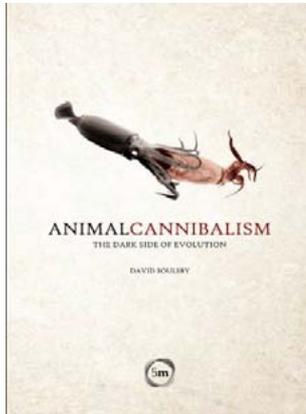
With a title like Animal Cannibalism; The Dark side of Evolution, who can resist sitting down and reading this book with some fava beans and a nice Chianti? However, this book is no 'light bedtime reading' and should be considered more of a reference book to turn to when investigating inter and intra specific relationships between organisms. The culmination of over twenty-five years' worth of personal observations and research into the subject; who would of thought that a 'chance' observation of a simple cannibalism event between armoured bush crickets in southern Zimbabwe would result in such a comprehensive account of cannibalism in vertebrates and invertebrates.

Animal Cannibalism is a hugely informative and comprehensive desk resource that has exquisite attention to editorial detail. With 410 pages of content; including 21 colour plates and 95 pages of references, the book incorporates an authoritative evaluation of papers, notes, thesis, documentaries and personal accounts enthusiastically collected by the author throughout his quest. Being sensibly split down into two parts; invertebrates and vertebrates, the book makes for easy interrogation or in my case flipping straight to Chapters 6 and 7; amphibians and reptiles (respectively). There are however nine chapters in total encompassing micro-organisms and lower vertebrate groups such as jellyfishes and anemones (Chapter 1), arthropods (Chapter 2) and molluscs and echinoderms (Chapter 3), to vertebrates; Fishes (Chapter 5), Birds (Chapter 8) and mammals (Chapter 9), with an interesting chapter on Cannibalism in palaeontology (Chapter 4) to set the scene.

Each chapter summarises which five aspects to cannibalistic behaviours; (1) killing of victims; (2) gaining food resources from victims; (3) size-dependent interactions; (4) density-dependent interactions, and (5) inter-specific competition are expressed amongst that group. The effects of the cannibalistic act; (1) regulation of population size or density; (2) modification of population size or sexual structure; (3) creation of cyclical or chaotic population fluctuations; (4) population stabilization, depending upon other interactions, and (5) population bistability are also estimated. Additionally the book goes further in highlighting any important cost of cannibalism in the transmission of harmful pathogens or toxins.

None of the content will come as much of a surprise to any herpetologist or ecologist who actively reads around the subject, as many of the accounts relate to incidents of cannibalism which are readily recorded. In the case of reptiles and amphibians, these predominantly comprise; eating of sloughed skin, kin, smaller individuals and incidental occurrences where; two snakes feeding on the same prey item, when snouts meet, the larger snake will go on to swallow the other along with the prey item. There are tables present at the end of each chapter which also provide additional useful examples of observed or reported cannibalistic behaviour and reference to the literature where the observation was cited; broken down by species.

An interesting casual read and potentially invaluable desk reference for researchers; reducing the amount of time undertaking background searches, this book provides a relevance to herpetologist and a wider audience alike. Its price [at £25.00] makes it an affordable book to have on the bookshelf, although caters specifically for a particular niche.

STUART GRAHAM

Sevens Road, Rawnsley, Cannock, Staffordshire.
Email: stuartgrahamuk@hotmail.co.uk

Cold Blood: Adventures with Reptiles and Amphibians

Richard Kerridge 2014

Publisher: Chatto & Windus. 304 p ISBN: 9780701187958
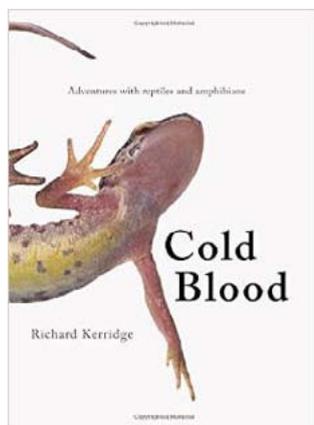
When Cold Blood: Adventures with Reptiles and Amphibians arrived, I did not have any background information such as listening to Radio 4 where this book was read on air. Therefore I was expecting a species specific book with detailed information on the native herpetofauna of the United Kingdom. However, the book turned out to be 80 percent biography 20 percent species information. This review does not cover the complexity of this book and anyone interested should be swift in their purchase and delve into Richard Kerridge's life and adventures.

Richard Kerridge begins with Chapter 1 'Palmate Newt', where he relives some of his old family holidays in Dartmoor and his first real experience with the palmate newt or 'Golden newt' as he referred to it at the time. I have to admit, the start of this chapter was difficult to read, it did not inspire me with the urge to read on, but it is well written nevertheless. I was interested to read the historical background of the palmate newt's first discovery to the modern day usage of the *Lissotriton helveticus* scientific name. The author also provides a useful description of amphibian anatomy and physiology in an easy to digest fashion. The author gives an opinion on the capturing wild species and provides information on reptile and amphibian protection within the UK indicating the rather obvious need to protect our declining species populations. Chapter 2, 'Common Toad' has a better beginning than Chapter 1, presenting useful and subtle information about the common toad through a short pleasing tale of his adult life. I particularly liked the section on anthropomorphic projection, where the author explains how human culture associates certain feelings with animals and the general misinterpretations of the common toad both in the present and in the past. The author then provides an easy to digest physical description of the colour variation of male and female toads, followed by details of their reproduction. Chapter 3, 'Common Frog, Marsh Frog, Edible Frog, Pool Frog, Smooth Newt, Slow Worm and Great Crested Newt'. The author once again starts this chapter with a quick insight into his youthful adventures, but also describes the common frog, marsh frog, edible frog and pool frog providing information on their habitats and their behaviour, for example, comparing the common frog to the other three green frogs. Information is also provided on the hybridisation of the pool and marsh frog to produce the edible frog. This gives the reader a good indication on possible identification between the common frog and its counterparts.

I did enjoy the author's enthusiasm for nature that shines through on each page. Controversially, he indicates he would love to have more amphibians and reptiles in this country, whether they are native or not. However, he also makes clear alien species can impact negatively on ecosystems. I feel that he could have gone into a little more depth with the great crested newt section, however he does emphasise the protection of this rare species. I can relate to his strong feelings on the downsides to this protection, which minimises exposure to this species and may hinder peoples perception of it.

Chapter 4 'Common Lizard, Slow Worm and Sand Lizard', begins with morphological description and habitat specifications for the common lizard, which is the most detailed of any species in the book. The author then discusses the sand lizard and describes the major differences between dune and heath sand lizards. On Page 165 there is a useful description of general lizard behaviour including basking and breathing mechanisms. At the conclusion of this chapter there is the story off the campaign to re-establish sand lizard population with the north west led by Chris Davis, who was spurred on by the efforts of Keith Corbett. Davis used captured specimens for a breeding program and released their hatchlings into suitable locations where the species had a great chance of survival. It brings hope of having these beautiful animals around Britain to show to my children. The opening paragraphs to chapter 5 'Grass Snake, Smooth Snake, Adder', encapsulates the unique movements of snakes in a fluid and rhythmic way, which is emphasised by the authors travels in Italy with the Western Whip Snake, *Coluber vividiflavus,* (now of course *Hierophis viridiflavus*) and his more recent visits to view captive snakes in museums. I think he puts together a very good argument that we only get real excitement from wild specimens due to their unpredictability and their free movement, while captive animals do not exhibit their true and thrilling nature. The morphological characters of all three species, including length and general colouration, are described including their eating habits (prey species), their historical significance and their old British names. Moving on, the author gives a snippet on the general teeth morphology and eating mechanisms of snakes but I would have liked to have seen some annotated diagrams to go with it. I felt that the section starting on page 230 on the physiological aspects, concepts on human evolution, prehistoric behavioural interaction and religious provenance that snakes may have induced was extremely interesting. For myself, this may possibly be the most interesting part of the book since I was not aware of much of this. Chapter 6 'Natterjack toad, Aesculapian Snake', begins with the explanation of very limited distribution of the natterjack toad in Britain, and its specialised habitat in sandy

landscapes. This is followed its life cycle the need to breed in ponds with no competitors like the common frog and toad, so their young will grow appropriately. He further explains their preferred habitat type and their general morphological appearance. The author then discusses the possible origins of the natterjack's name and the common names such as the 'Running toad' originating from its scuttling movements. The author briefly describes the presence of the Aesculapian Snake in the UK and also the theories on their original occurrence and their invasive status in the UK. The book is concluded with a brief but insightful section for further reading, which provides a good grounding for any reader to expand their interests in UK herpetofauna.

Cold Blood: Adventures with Reptiles and Amphibians emphasises Richard Kerridge's passion for wildlife, but links it with his turbulent but exciting life. It is a delight to read from the first page until the last, however, it has some bad language and situations in the story line that would only be intended for the older reader. I am still confused with the book as a whole, and I would not be able to place it on a specific shelf in a book store. I am not sure what sort of reader the book would appeal to; there is good detail on each species but it lacks any annotated pictures/diagrams alongside, therefore a novice may find it hard to follow completely without further reading being involved. The book is more of a novel with species information provided along the way. A herpetologist may find the information interesting but would have to sift through the life story of the author to get to it.

STEVEN PIGGOTT

1 Mere Drive, Clifton, Manchester, M27 8SD
Email: stevepiggott@hotmail.co.uk

Commemorative Symposium on Reptiles and Amphibians

Saturday 24th January 2015, 1.00pm - 6.00pm.

at

Birkbeck College, 43 Gordon Square, London WC1H 0PD

ADMISSION FREE

A half-day Symposium on the health, welfare and pathology of reptiles and amphibians will be held at Birkbeck College, University of London, on Saturday 24th January 2015.

The meeting is organised in conjunction with the British Herpetological Society (BHS) supported by the British Chelonia Group (BCG) and the British Veterinary Zoological Society (BVZS).

The Symposium marks the 120th anniversary of the birth of Dr Edward Elkan, pioneer of lower vertebrate pathology. His research and writings on diseases and pathology contributed much to the health and welfare of reptiles and amphibians and influenced a generation of veterinary surgeons, zoologists and herpetologists. The Symposium will mark the end of the series of Elkan Memorial Lectures instigated after Edward Elkan's death in 1983. However, his Reference Collection of Lower Vertebrate Pathology, part of which will be on display at the Symposium (see below), remains available for study by scientists and students - a long-term legacy of this great man.

Provisional Programme

- 13.00   Arrival and Registration.
- 13.30   Welcome by the President of the British Herpetological Society, Professor Richard Griffiths First session – Margaret E Cooper (Chairman)
- 13.40   Background to the Symposium: "The Elkan Legacy" – John E Cooper
- 13.50   Presentation: "Edward Elkan and amphibian-reptilian trematodes" – Peer Zwart
- 14.10   Presentation: "Edward Elkan and the Xenopus pregnancy test"- Jesse Olszynko-Gryn
- 14.30   Presentation: "'The chameleon and the microscope - a lesson in
- 14.31   Comparative pathology" – David L Williams
- 14.50   Brief statements about their work by the British Chelonia Group (BCG) and the British Veterinary Zoological Society (BVZS)
- 15.00   Tea and coffee break. Literature and specimens from Edward Elkan's Collection, as well as other material, will be on display.
- 15.45   First session. Short Presentations about the health and diseases of reptiles and amphibians and advances in herpetological medicine, introduced by Martin P C Lawton (Chairman)
- 16.00   "Living with amphibians: A hobbyist and veterinary surgeon's perspective" – Mark Naguib
- 16.20   "Diagnosis and treatment of chytridiomycosis in Cameroon caecilians" – Matthew Rendle
- 16.40   "Reptiles and amphibians; the challenges of modern "exotic animal" veterinary practice" - Faye Bethell
- 17.15   General Discussion.
- 17.30   Closing Remarks. Professors Richard Griffiths and John Cooper
- 18.00   Departure

Those hoping to be present at the Symposium are asked to send an email message to the Co-ordinators of the Edward Elkan Memorial Lectures: Professor John E Cooper, FRCVS and Mrs Margaret E Cooper, LLB, at: ngagi2@gmail.com

Photo: Wikimedia Commons/Charlesjsharp
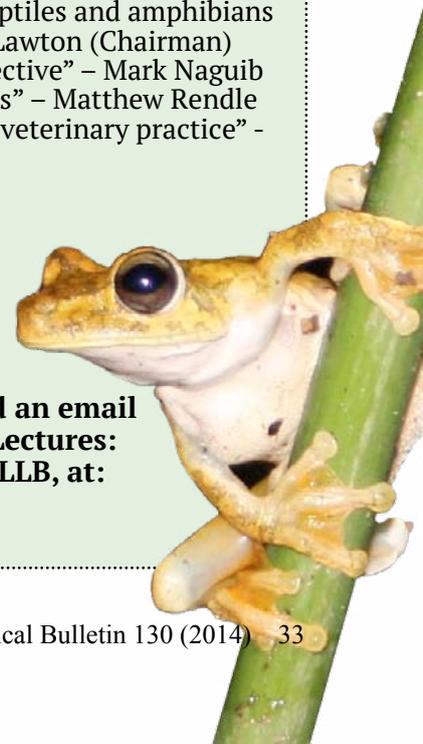
BRITISH CHELONIA GROUP
2015 SPRING SYMPOSIUM

SATURDAY 14th MARCH 2015
10.30am – 17.30pm

THEME: CHELONIA AND MAN

An opportunity to hear about projects from people directly
involved in chelonian conservation, husbandry and veterinary practice,
as well as meeting other enthusiasts

The Open University, The Berrill Theatre, Walton Hall, Milton Keynes MK7 6AA

SPEAKERS (in alphabetical order)

- John Chitty MRCVS : Diagnostic testing – what can we do and why?
- Ian Dunn: CEO Galapagos Conservation Trust on their work with tortoises
- David Perpignan MRCVS : Medical management of sea turtles
- Dr Peter Richardson : Marine turtle conservation in the Turks and Caicos Islands
- Professor Ian Swingland OBE : Conservation of terrestrial chelonia in situ and ex situ

Non-members welcome ~ Ample parking on campus ~ £30 including lunch

CPD 5 hours ~ CPD participants half price

For further information and directions visit: www.britishcheloniagroup.org.uk

Or contact: Symposium Organiser, British Chelonia Group, P.O. Box 16216, Tamworth B77 9LA

Email: symposium.bcg@ntlworld.com

THE HERPETOLOGICAL BULLETIN

Contents: Issue 130, Winter 2014