The Herpetological Bulletin

Issue 135, Spring 2016

Published by the British Herpetological Society

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: Common lizards *Zootoca vivipara* basking on a fence post in August at Loch Lomond, Scotland. See Research Articles on pages 4 and 11. Photograph by Chris McInerny.

Printed by: Bruce Clark (Printers), Units 7-8, Marybank Lane, Dundee, DD2 3DY. ISSN 1473-0928.

REVIEW ARTICLE

The Herpetological Bulletin 135, 2016: 1-3

Conserving the hip hoppers: Amphibian research at Greater Manchester Universities

ROBERT JEHLE[1*], RACHAEL ANTWIS[1] & RICHARD PREZIOSI[2]

[1]School of Environment and Life Sciences, University of Salford, M5 4WT Salford, UK
[2]Faculty of Life Sciences, University of Manchester, M13 9PT Manchester, UK
[*]Corresponding author Email: r.jehle@salford.ac.uk

Characterising Greater Manchester is not an easy task. As a hotbed of radical ideas, the rise of Greater Manchester during the industrial revolution was followed by a significant economic and population decline. As one of the fastest-growing regions in the United Kingdom of the 21st century, contemporary Greater Manchester is shaped by a conglomerate of different influences. The dynamic history of the area is also reflected in emerging herpetological research activities. Without a pronounced tradition in organismal herpetology, Greater Manchester has recently developed into a national hotspot for academic research on amphibian conservation. Perhaps most importantly, the emerged activities are largely shaped through efforts led by postgraduate students. The present overview summarises these developments.

A main home of amphibian research activities in Greater Manchester is represented by the Manchester Amphibian Research Group (MARG, http://amphibianresearch.org), with a main goal to "advance both ex situ and in situ amphibian conservation through evidence-based research". The first MARG meeting took place at the University of Manchester in 2010, and convened the principal investigators R. Preziosi, C. Klingenberg and C. Walton (University of Manchester), A. Gray (Manchester Museum), E. Harris (Manchester Metropolitan University), and R. Jehle (University of Salford) together with their graduate students. After a series of meetings and presentations at the Universities of Manchester and Salford, MARG continues to be an informal platform for meetings and exchange of contacts among local researchers. The research interests of MARG members span from field survey methods, disease susceptibility, life histories and population genetics to morphometrics and phylogeography. The perhaps most prolific field of MARG, however, is the advancements of modern approaches towards ex-situ conservation strategies for endangered anurans. Since the foundation of MARG in 2010, its members have (co-)authored more than three dozen refereed scientific journal articles related to the conservation of amphibians from all three orders (Table 1), as well as a monographic book on a flagship species of the British amphibian fauna (the great crested newt, Jehle et al. 2011).

Apart from producing scientific outputs, Greater Manchester has also been the home of the Herpetological Journal, the flagship journal of the British Herpetological

Figure 1. Participants of the 2015 Amphibian Conservation Research Symposium in Cambridge. The conference series started in Manchester in 2012.

Table 1. Amphibian conservation-related research outputs (indexed journal articles) produced at Greater Manchester Universities since the first MARG meeting in 2010.

Research area	References
Advances in husbandry and captive breeding to aid in ex-situ conservation	Ogilvy et al. 2012, Antwis et al. 2014abcd, Michaels & Preziosi 2014, Michaels et al. 2014abc, Michaels & Preziosi 2015, Antwis et al. 2015, Bland 2013, Bland 2015, Ogilvy et al. 2011, Ogilvy & Preziosi 2012
In-situ conservation and conservation genetics	Arntzen et al. 2010, Jehle 2010ab, Madden & Jehle 2013, Balacs et al. 2014, O'Brien et al. 2015, Roth & Jehle 2016
Life-histories and sexual selection	Liao et al. 2013, Liao et al. 2014, Liao et al. 2016, Michaels & Preziosi 2013, Rausch et al. 2014, Zeng et al. 2014, Jiang et al. 2015, Ursprung et al. 2011ab, Ursprung et al. 2012
Development of genetic markers	Barratt et al. 2012, Petchey et al. 2014
Caecilian morphometrics	Sherratt et al. 2012, Sherratt et al. 2014

Society (BHS) which received in excess of 700 manuscripts between April 2009 (when the journal editorship moved from the University of Bangor to the University of Salford) and September 2015 (when the journal editorship moved from the University of Salford to the University of Brighton). In both 2013 and 2014, the Herpetological Journal held the highest scientific impact factor (a metrics based on the number of citations per article over a given timeframe) of all quarterly journals devoted to herpetology globally, and is thus well embedded in the main phalanx of research outlets advancing amphibian conservation research (see also e.g. the editorial Perry et. al 2012, which was jointly published with seven journals based at other herpetological societies in North America, South America, Europe and Africa).

A further main hub of amphibian conservation activities and research in Greater Manchester is represented by the vivarium at Manchester Museum, led by A. Gray and his team (A. Bland, M. O'Donnell, and a large number of volunteers). Since its launch, the Frog Blog Manchester initiated by A. Gray (http://frogblogmanchester.com/) has received in the order of 450 000 hits so far - this number is not far off the entire population number of the city of Manchester, and a remarkable figure for a group of vertebrates which is otherwise seen as underrepresented in the perception of the general public. A main flagship project at Manchester Museum is centred around the charismatic Central American lemur leaf frog *Agalychnis lemur* (www.lemurfrog.org, see also Petchey et. al 2015), a species which is close to extinction in the wild and which has, for example, played a prominent role in the BBC 2 documentary Fabulous Frogs presented by Sir David Attenborough in 2014. In March 2015, Manchester Museum also hosted the 68th AGM of the BHS, the first ever held outside London.

A final front of activities stems from the initiation and organisation of a series of scientific meetings devoted to amphibian conservation. The first Amphibian Conservation Research Symposium (ACRS, organised by R. Antwis and C. Michaels, at the time PhD students with R. Preziosi) took place at the University of Manchester in 2012, and kick-started an annual series at other venues across the country (2013: London Natural History Museum, jointly with the British Herpetological Symposium; 2014: Zoological Society of London, 2015: Department of Zoology, University of Cambridge, Figure 1). Remarkably, ACRS has now been adopted by two major global organisations for amphibian conservation (the Amphibian Survival Alliance and the IUCN Amphibian Specialist Group), with a 2016 meeting held at the North-West University, Potchefstroom, South Africa. ACRS will continue to be held in international locations, in addition to the ongoing development of a "Future Leaders of Amphibian Conservation" programme, more information on both can be found at www.amphibians.org/acrs/.

REFERENCES

Antwis, R.E., Garcia, G., Fidgett, A.L. & Preziosi R F. (2014a) Passive integrated transponder (PIT) tagging frogs causes disruption to the cutaneous bacterial community and proliferation of opportunistic fungi. *Applied and Environmental Microbiology* 80: 4779-4784.

Antwis, R.E., Haworth, R.L., Engelmoer, D.J.P., Ogilvy, V., Preziosi R.F. & Fidgett, A.L. (2014b) Ex situ diet influences the bacterial community associated with the skin of red-eyed tree frogs (*Agalychnis callidryas*). PLOS One 9: e85563.

Antwis, R.E., Preziosi R.F. & Fidgett, A.L. (2014c). The effect of different UV and calcium provisioning on health and fitness traits of red-eyed tree frogs (*Agalychnis callidryas*). *Journal of Zoo and Aquarium Research* 2: 69-76.

Antwis, R.E., Purcell R., Walker S.L., Fidgett, A.L. & Preziosi R F. (2014d) Effects of visible implanted elastomer marking on physiological traits of frogs. *Conservation Physiology* 2: cou042.

Antwis, R.E., Preziosi, R.F., Harrison, X.A. & Garner, T.W.J. (2015) Amphibian symbiotic bacteria do not show a universal ability to inhibit growth of the global panzootic lineage of *Batrachochytrium dendrobatidis*. *Applied and Environmental Microbiology* 11: 3706-3711.

Arntzen, J.W., Burke, T. & Jehle, R. (2010) Estimating the propagule size of a cryptogenic crested newt population. *Animal Conservation* 13 (Suppl. 1): 74-81.

Baláž, V., Vörös, J., Civiš, P., Vojar, J., Hettyey, A., Sós, E., Dankovics, R., Jehle, R., Guldager, D., Clare, F., Fisher, M.C., Garner, T.W.J. & Bielby, J. (2014) Taxonomic and geographic selectivity of *Batrachochytrium dendrobatidis* infection in Europe: Assessing risk and directing future monitoring. *Conservation Biology* 28: 213-223.

Barratt, C.D., Horsburgh, G., Gower, D.J., Wilkinson, M., Loader, S.P. & Jehle, R. (2012). Isolation and characterisation of nine polymorphic microsatellites for the caecilian amphibian (Gymnophiona) *Boulengerula uluguruensis*, and cross-species amplification in three congeneric species. *Conservation Genetics Resources* 4: 225-229.

Bland, A. (2013) The husbandry and captive reproduction of the gliding leaf frog *Agalychnis spurrelli* (Boulenger 1913). *Herpetological Bulletin* 124: 9-12.

Bland, A. (2015) A record of reproduction in the red-bellied toad *Melanophryniscus klappenbachi* with notes on the use of a short-term brumation period. *Herpetological Bulletin* 131: 15-18.

Jehle, R. (2010) Predicting the fate of metapopulations is aided by DNA fingerprinting of individuals. *Animal Conservation* 13: 123-124.

Jehle, R. (2010a) Herpetology and conservation genetics. *Animal Conservation* 13 (Suppl. 1): 72-73.

Jehle, R., Thiesmeier, B. & Foster, J. (2011). *The Crested Newt: a Dwindling Pond Dweller*. Laurenti: Germany. ISBN 978-3-933066-44-2. 152pp.

Jiang, A., Zhong, M.J., Xie, M., Lou, S.L., Yang, L.R., Jehle, R. & Liao, W.B. (2015) Seasonality and reproductive lifespan is positively related to brain size in Andrew's toad (*Bufo andrewsi*). *Evolutionary Biology* 42: 339-348.

Liao, W.B., Lou, S.L., Lu, D. & Jehle, R. (2016) Geographic variation in life-history traits: growth season affects age structure, egg size and clutch size in Andrew's toad (*Bufo andrewsi*). *Frontiers in Zoology* 13: 6.

Liao, W.B., Lu, X. & Jehle, R. (2014) Altitudinal variation in maternal investment and trade-offs between egg size and clutch size in the toad *Bufo andrewsi*. *Journal of Zoology* 293: 84-91.

Liao, W.B., Zenf, Y., Quan, C. & Jehle, R. (2013) Sexual size dimorphism in anurans fails to obey Rensch's rule. *Frontiers in Zoology* 10: 10.

Madden, N. & Jehle, R. (2013) Farewell to the bottle trap? An evaluation of aquatic funnel traps for great crested newt (*Triturus cristatus*) surveys. *Herpetological Journal* 23: 241-244.

Michaels, C. J. & Preziosi, R.F. (2013). Basking behaviour and ultraviolet B radiation exposure in a wild population of *Pelophylax lessonae* in Nothern Italy. *Herpetological Bulletin* 124: 1-8.

Michaels, C. J., Downie, J.R & Campbell-Palmer, R. (2014) The importance of enrichment for advancing amphibian welfare and conservation goals: A review of a neglected topic. *Amphibian & Reptile Conservation* 8: e77.

Michaels, C.J., Antwis, R.E. & Preziosi R.F. (2014a) Impacts of UVB provision and dietary calcium content on serum vitamin D3, growth rates, skeletal structure and coloration in captive oriental fire-bellied toads (*Bombina orientalis*). *Journal of Animal Physiology and Animal Nutrition* 99: 391-403.

Michaels, C.J., Antwis, R.E. & Preziosi, R.F. (2014b) Impact of plant cover on fitness and behavioural traits of captive red-eyed tree frogs (*Agalychnis callidryas*). *PLOS One 9*: e95207.

Michaels, C.J., Antwis, R.E., & Preziosi, R.F. (2014c) Manipulation of the calcium content of insectivore diets through supplementary dusting. *Journal of Zoo and Aquarium Research* 2: 77-81.

Michaels, C.J., Gini, B.F. & Preziosi, R.F. (2014c). The importance of natural history and species-specific approaches in amphibian ex-situ conservation. *Herpetological Journal* 24: 135-145.

Michaels, C.J. & Preziosi, R.F. (2015) Fitness effects of shelter provision for captive amphibian tadpoles. *Herpetological Journal* 25: 21-26.

O'Brien, C.D., Hall, J.E., Orchard, D., Barratt, C., Arntzen, J.W. & Jehle, R. (2015) Extending the natural range of a declining species: Genetic evidence that great crested newt (*Triturus cristatus*) populations in the Scottish Highlands are native. *European Journal of Wildlife Research* 61: 27-33.

Ogilvy, V., Fidgett, A.L., & Preziosi, R.F. (2011) Differences in carotenoid accumulation among three feeder-cricket species: implications for carotenoid delivery to captive insectivores. *Zoo Biology* 31: 470-478.

Ogilvy V. & Preziosi R. F. (2012) Can carotenoids mediate the potentially harmful effects of ultraviolet light in *Silurana (Xenopus) tropicalis* larvae? *Journal of Animal Physiology and Animal Nutrition* 96: 693-699.

Ogilvy V., Preziosi, R.F. & Fidgett, A.L. (2012) A brighter future for frogs? The influence of carotenoids on the health, development and reproductive success of the red-eye tree frog. *Animal Conservation* 15: 480-488.

Perry, G., Bertoluci, J., Bury, B., Hansen, R. W., Jehle, R., Measey, J., Moon, B., Muths, E., & Zuffi. M. A. L. (2012). The "Peer" in "Peer Review". *Herpetological Journal* 22: 1.

Petchey, A., Gray, A., Andren, C., Skelton, T., Kubicki, B., Allen, C. & Jehle, R. (2014) Characterisation of 9 polymorphic microsatellite markers for the Critically Endangered lemur leaf frog *Agalychnis lemur*. *Conservation Genetics Resources* 6: 971-973.

Rausch A., Sztatecsny, M., Jehle, R., Ringler, E. & Hödl, W. (2014) Male body size and parental relatedness but not nuptial colouration influence paternity success during scramble competition in *Rana arvalis*. *Behaviour* 151: 1869-1884.

Roth S. & R. Jehle (2016) High genetic diversity of common toad (*Bufo bufo*) populations under strong natural fragmentation on a Northern archipelago. *Ethology & Evolution* 6: 10.1002/ece3.1957

Sherratt, E., Gower, D.J., Klingenberg, C.P. & Wilkinson, M. (2014) Evolution of cranial shape in caecilians (*Amphibia: Gymnophiona*). *Evolutionary Biology* 41: 528-545.

Sherratt, E., Wilkinson, M., Gower, D.J. & Klingenberg C.P. (2012). Evolution of cranial modularity in caecilians. *Integrative and Comparative Biology* 52: E159.

Ursprung, E., Ringler, M., Jehle, R. & Hödl, W. (2011) Toe regeneration in the neotropical frog *Allobates femoralis* (Aromobatidae). *Herpetological Journal* 21: 83-86.

Ursprung, E., Ringler, M., Jehle, R. & Hödl, W. (2012) The female perspective of mating in *A. femoralis*, a territorial frog with paternal care: a spatial and genetic analysis. *PLOS One 7*: e40237.

Ursprung, E., Ringler, M., Jehle, R. & Hödl, W. (2011) Strong male-male competition allows for non-choosy females: high levels of polygynandry in a territorial frog with paternal care. *Molecular Ecology* 21: 1759-1771.

Zeng Y., Lou, S.L., Liao, W.B. & Jehle, R. (2014) Evolution of sperm morphology in anurans: the roles of mating system and spawning location. *BMC Evolutionary Biology* 14: 104.

Accepted: 21 December 2015

RESEARCH ARTICLE The Herpetological Bulletin 135, 2016: 4-6

Observations on felt and corrugated roof sheeting as materials for constructing coverboards to assess slow worm (*Anguis fragilis*) and common lizard (*Zootoca vivipara*) populations

ALEXIA C. M. FISH

Institute of Biological & Environmental Sciences,
University of Aberdeen, Zoology Building, Tillydrone Avenue, Aberdeen, AB24 2TZ, UK
Present address: Waypoint, Southway, Sidmouth, Devon, EX108JL, UK
Email: alexia.fish.10@aberdeen.ac.uk

ABSTRACT - An eight-week study in open areas of Collyweston Great Wood and Eastern Hornstocks NNR utilised 120 coverboards laid in groups of 20 with alternating felt and black corrugated roof sheeting construction materials. Adult slow-worms (*Anguis fragilis*) showed no significant preference for lying beneath coverboards of either material, but juvenile slow-worms were significantly more likely to be found beneath felt and common lizards (*Zootoca vivipara*) were significantly more likely to be found basking on corrugated roof sheeting. Numbers of *A. fragilis* fluctuated significantly week on week, and more slow-worms were found during the afternoon than during mornings. The significance of these results is discussed with particular reference to the importance of considering construction materials, time of sampling and weather conditions when planning surveys of reptiles utilising coverboards.

INTRODUCTION

Laying down pieces of material which animals can use for shelter and sometimes for thermoregulation has become a standard technique for assessing numbers of reptiles and amphibians in many kinds of terrestrial habitats: the population estimates that results are usually relative rather than absolute. The refuges are now usually called coverboards. The technique became widely used from the 1990s; for a discussion of its application to some British species, see Riddell (1996) and Reading (1997) and for recent appraisals see Willson & Gibbons (2009) for amphibians and Dorcas & Willson (2009) for snakes. Coverboards are usually made of felt, corrugated iron, tin or plywood (Halliday and Blouin-Demers, 2015) but other materials have been used from time to time (Adams et al. 1999; Chavel et al. 2012; Beebee et al. 2009; Sewell et al. 2012).

The results reported here arose as incidental to an investigation of the effects on slow-worm (*Anguis fragilis*) and common lizard (*Zootoca vivipara*) numbers of coppicing small-leaved lime woodland (Collyweston Great Wood and Eastern Hornstocks National Nature Reserve on the Northamptonshire-Cambridgeshire border in the UK, further details in Fish (2016). Coverboards were made of felt or black corrugated roofing sheets (CRS): since these were laid out in grids with alternating materials, it was possible to compare the effectiveness of the two.

MATERIALS AND METHODS

The coverboards used in this study were made of felt or of CRS with the trade name "Bitumin". These materials were chosen on the basis of ready availability. All boards measured 50 cm x 50 cm. Initially 100 boards were used, laid out in five areas in grids of 4 x 5 boards with all boards separated by 5 m from edge to edge with felt and CRS alternating in both dimensions. Two weeks after the commencement of the study a further 20 boards were added. All the boards were in relatively open areas of the predominantly wooded nature reserve because no reptiles were found associated with boards in coppiced woodland (Fish, 2016). The open areas consisted mostly of grassland or were dominated by young, low-growing vegetation, such as bracken (*Pteridium aquilinum*), brambles (*Rubus fruticosus*) or stinging nettles (*Urtica dioica*) and had a little or no canopy shading them.

The coverboards were placed in position on 15th June 2013 and finally removed on 5th August. After being put in position, the coverboards were left undisturbed for one week, for the local reptile population to acclimatise to them being there, as well as for them to sink further into the vegetation, as is standard with coverboard studies (Willson and Gibbons, 2009). The sites were sampled on 3-6 days a week for 8 weeks. Each day, alternately, half the boards were sampled in the morning (approximately 8-10 a.m.) and the other half in the afternoon (approximately 2-5 p.m.).

The count data of slow-worms and common lizards under or on the boards contained a considerable number of zeros and so was not normally distributed. As not more than 5 reptiles were recorded in association with a board on any single occasion, it was decided to transform the data to presence-absence data as suggested by Thompson et al. (1998) and Crawley (2005). By having the count data in presence-absence form, it was possible to carry out binomial regressions as general linear models using the statistical programme R (Crawley, 2005). A non-binomial GLM was used for time of day data because this variable is categorical.

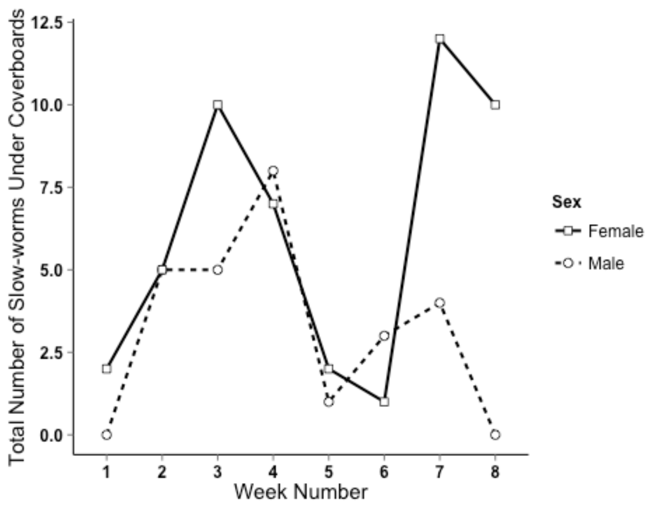


Figure 1. Graph showing the total number of adult *A. fragilis* found between mid-June to mid-August (8 weeks). See text for details.

RESULTS

102 slow-worms were found under cover boards during the 8-week study period: 49 adult females, 26 adult males and 27 juveniles. There was no significant difference in the numbers of adults found beneath felt or CRS coverboards ($p>0.05$) but juveniles showed a significant preference for felt (21 vs 6: z-value using a binomial GLM = 2.27, $p=0.02$). Numbers of adult slow-worms fluctuated significantly from week to week (males: $z=-2.73$, $p=0.01$, females: $z=-2.23$, $p=0.03$, see Fig. 1), though there was no significant relationship found between the total numbers of slow-worms found and weather or daily rainfall. Weekly rainfall was shown to affect the total number of reptiles seen ($z=2.74$ and 2.22, $p=0.03$ respectively), particularly in the case of common lizards ($z=3.97$, $p=0.01$).

More slow-worms were found under cover-boards during the afternoon than during the morning and this appeared to be the trend for all the categories of reptiles, although the differences were significant only for adult female and juvenile slow-worms ($z=2.33$ and 2.22, $p=0.01$ and 0.03 respectively). Unlike slow-worms, common lizards were almost always found on – not underneath - the coverboards. Of the 41 common lizards seen, a significant proportion showed a preference for CRS (31 vs 10: $z=-2.29$, $p=0.02$).

DISCUSSION

There are at least three reasons why coverboards might attract slow-worms. They might act as shelter (Halliday and Blouin-Demers, 2015). They might be used for thermoregulation by contact (this has been called thigmothermy, see Pough & Gans, 1982), utilising heat derived from solar radiation transferred by conduction from the upper to the lower surface, as described in Bustard's classic studies of some Australian geckos living under loose bark and since confirmed for many lizards and snakes (Avery, 1982). They might act as a food source, since many invertebrates were also preferentially found under coverboards in this study. There are few studies on this matter that are specific to slow-worms, though coverboards have been used successfully in the past to survey slow-worms (Stumpel and van der Werf, 2012) and are regularly used by ecological consultancies to estimate slow-worm population sizes. This study is empirical: it does not seek to distinguish between these possibilities – which are, of course, not mutually exclusive. Why juvenile slow-worms should show an apparent preference for felt coverboards is conjectural, but this may have been due to their body size, as it is possible it is easier for them to get close to the warming material of flat felt coverboards than the corrugated CRS coverboards and thus thermoregulate more efficiently. It has been mentioned in the literature before that some adult and juvenile reptiles have been shown to have ontogenetic differences in habitat choice (Heatwole, 1977), which may be the case in terms of artificial refugia here. It is also possible that the juvenile slow-worms were avoiding other reptiles, including adults of their own species, as the others were generally found more often under CRS coverbards. That being said, there were several instances where juvenile and adult slow-worms and even occasionally juvenile slow-worms and common lizards were found utilising the same coverboards.

The probable relationship between common lizards and coverboards is more clear cut. They almost certainly use them as substrates for basking. Although there is much anecdotal evidence for preferential use of different substrates by common lizards (see Beebee & Griffiths, 2000), there has been no systematic study of the relationships between substrate and basking efficiency in this, or indeed in any, lizard species. CRS is probably a more satisfactory substrate for basking than felt: it almost certainly has a higher thermal capacity and a lower thermal conductivity than felt, both factors which would increase its effectiveness in retaining heat and facilitating its transfer to a basking lizard. It is significant in this context that many reptiles, including lacertid lizards, often use bitumen road surfaces preferentially for basking (see Meek, 2014).

The results of this study confirm that, in both planning and interpreting the data of studies of reptile populations using coverboards, a considerable number of factors need to be taken into consideration. The first highlighted here is the material from which the boards are constructed. Felt and CRS are differentially attractive for slow-worms and other lizards, and there is no reason to suppose that many other materials which might be used could also differ in this respect. Recorded numbers of both slow-worms and common lizards were greater during the afternoon than during the morning, so the timing of sampling is an important factor (see also Stumpel, 1985). The recorded numbers of slow-worms varied greatly week on week. Casual observation suggested that the weather was an important factor: slow-worms and common lizards both appeared to be recorded in greater numbers during overcast or wet weather, although sample sizes are too small to test this rigorously. This is clearly an aspect of the interpretation of coverboard data, which needs to be investigated further.

ACKNOWLEDGEMENTS

I would like to thank my honours project supervisor Professor Stephen Redpath and also Dr Eddie Brede at the University of Aberdeen for their invaluable help and suggestions throughout my project. I am very grateful to Sir Maitland Mackie and Dr Chris Gleed-Owen of Amphibian and Reptile Groups of the UK. Without their generous funding, purchase of sufficient equipment for the project would have been impossible. Thanks also to Chris Gardiner, Jimmy and everyone else at Natural England, who were incredibly helpful and gave me the opportunity to carry out this project in Collyweston Great Wood and Eastern Hornstocks NNR in the first place. Many thanks to the Green family for making my stay in the area so enjoyable. Finally, thanks to Dr. Alex Douglas, Dr. Martin Barker and Professor David Robinson at the University of Aberdeen for help with statistical analyses and Dr Roger Avery for help in preparation of the manuscript.

REFERENCES

Avery, R.A. (1982). Field studies of body temperatures and thermoregulation. In: *Biology of the Reptilia 12 Physiology* C. Gans, C. & Pough, F.H. (Eds.) pp. 93-166 London: Academic Press.

Beebee, T.J.C. & Griffiths, R.A. (2000). *Amphibians and Reptiles*. London: Harper Collins.

Crawley, M. J. (2005). Statistics: An Introduction to Using R. Chichester: Wiley.

Dorcas, M. E. & Willson, J. D. (2009). Innovative methods for studies of snake ecology and conservation. In: *Snakes: Ecology and Conservation*. *Mullin*, S. J. & Seigel, R. A. (Eds.) pp 5-37. New York: Cornell University Press.

Fish, A. C. M. (2015). Common lizards (*Zootoca vivipara*) and slow-worms (*Anguis fragilis*) are not found in coppiced Small-Leaved Lime (*Tilia cordata*) areas of a Northamptonshire-Cambridgeshire Nature Reserve. Herpetological Bulletin 134: 26-27

Halliday, W. & Bloin-Demers, G. (2015). Efficacy of coverboards for sampling small northern snakes. *Herpetology Notes* 8: 309-314

Heatwole, H. (1977). Habitat Selection in Reptiles. In: *Biology of the Reptilia 7 Ecology and Behavior*, A. Gans, C. & Tinkle, D. W. (Eds.) pp. 137-155. New York: Academic Press.

Meek, R. (2014). Temporal distributions, habitat associations and behaviour of the green lizard (*Lacerta bilineata*) and wall lizard (*Podarcis muralis*) on roads in a fragmented landscape in Western France. *Acta Herpetologica* 9: 179-186.

Pough, F.H. & Gans, C. (1982). The vocabulary of reptilian thermoregulation. In: *Biology of the Reptilia 12 Physiology* C. Gans, C. & Pough, F.H. (Eds.) pp. 17-23. London: Academic Press.

Reading, C.J. (1997). A proposed standard method for surveying reptiles on dry lowland heath. *Journal of Applied Ecology* 34: 1057-1069.

Riddell, A. (1996). Monitoring slow-worms and common lizards, with special reference to refugia materials, refugia occupancy and individual recognition. In Reptile Survey Methods. English Nature Science Series no. 27, pp. 46-60. Foster, J. & Gent, T. (Eds,) Peterborough, English Nature.

Stumpel, A. H. P. (1985). Biometrical and ecological data from a Netherlands population of *Anguis fragilis* (Reptilia, Sauria, Anguidae). *Amphibia-Reptilia* 6: 181-194.

Stumpel, A. H. P. and van der Werf, B. (2012). Reptile habitat preference in heathland: implications for heathland management. *Herpetological Journal* 22: 181-194

Thompson, W. L., White, G. C. & Gowan, C. (1998). Monitoring vertebrate populations. San Diego: Academic Press.

Willson, J. D & Gibbons, J. W. (2009). Drift fences, coverboards and other traps. In: *Amphibian Ecology and Conservation: A Handbook of Techniques*. Jr., Dodd, C.K. (Ed.), pp. 229-245. Oxford: Oxford University Press.

Accepted: 17 November2015

RESEARCH ARTICLE

The Herpetological Bulletin 135, 2016: 7-10

A method for blood sampling the Galápagos tortoise, *Chelonoidis nigra* using operant conditioning for voluntary blood draws

ZOE BRYANT*, LUKE HARDING, SEBASTIAN GRANT & MATTHEW RENDLE
Zoological Society of London, London Zoo, Regents Park, Outer Circle, NW1 4RY, London, UK

*Corresponding author Email: zoe.bryant@zsl.org

ABSTRACT - Here we outline the methodology of implementing a blood draw training protocol for use with Galápagos tortoises (*Chelonoidis nigra*) using operant conditioning in order to obtain blood samples for routine blood analysis. The procedure is minimally invasive and does not require manual restraint.

INTRODUCTION

The Galápagos tortoise *Chelonoidis nigra* (Quoy & Gaimard, 1824) is the largest living species of tortoise and one of the heaviest living reptiles, with some specimens reaching up to 5 feet in length and weighing up to 400kg (Caccone et al., 1999). Listed on the IUCN Red List as a vulnerable species (IUCN, 2015), *C. nigra* is protected by the Ecuadorian government. This large species grazes on grass and browses on leaves, cacti and native fruit and is an important seed disperser (Blake et al., 2012).

One of the biggest challenges in managing captive chelonians is to reduce the amount of stress for individual specimens surrounding diagnostic and treatment processes. Tortoises, like all animals, can suffer from stress (Fazio et al., 2014), be that psychological or physical, in a number of ways and this may make it difficult to interpret behaviour and can affect diagnostic results.

Tortoises do not often exhibit obvious clinical signs in the early stages of a disease (pers. com, Divers, 2014) and this, combined with their cryptic behaviour, often leads to clinical misinterpretation of health status and wellbeing. Thus routine blood sampling is often necessary for early diagnosis, prognosis, and treatment of disease. Blood analysis is an important mechanism in the diagnosis of health and disease status (Fazio et al., 2014). In addition, blood draws enable keepers to make a quantifiable assessment of an element of a tortoise's husbandry with parameters such as total 25-hydroxyvitamin D_3 (Selleri & Girolamo, 2012) which can inform and evolve husbandry practices, specifically the provision of UVB radiation. It is becoming much more accepted that blood sampling is an essential tool for optimal captive husbandry within modern zoological collections.

At ZSL London Zoo five Galápagos tortoises are maintained in the Land of the Giants exhibit. Historically, blood sampling has not been routine due to the need for manual restraint and the perceived stress that this would have on the animals. In order to obtain routine blood samples from our *C. nigra* we utilised their finch response and through a programme of desensitisation training and operant conditioning successfully obtained blood samples from the optimal site in a minimally invasive and minimally stressful way. This was achieved through a process of active desensitisation (Hellmuth et al., 2012), where a new stimulus is introduced; in this case the keepers used their fingers to tap and apply pressure to the necks of *C. nigra* in order to simulate the pecking of the finches; this elicits a response of the specimen stretching its neck and going into a trance like state which facilitates access to the veins in the neck for blood withdrawal.

Since the early 1990s there has been a dramatic increase in the use of operant conditioning techniques to train exotic animals for husbandry purposes (Fleming & Skurski, 2014). There has been some published success in using both classical and operant conditioning in training Aldabran tortoises (*Aldabrachelys gigantea*) (Weiss & Wilson, 2003) but this technique has not been documented for use in *C. nigra*. Operant conditioning is a form of learning. It relies on a simple premise, which is that actions have consequences and this can be taught by using reinforcement (positive or negative) and can mean that a desired behaviour can be strengthened and is more likely to occur again in the future. In this paper we describe how by using operant conditioning, blood draws can be obtained in Galapagos tortoises. This technique has facilitated the development of a training protocol that can be used for captive *C. nigra*.

MATERIALS AND METHODS

The first step in any training programme should be to develop and implement a plan and shaping document. This document should outline the methods, as well as the desired outcomes and should take into account factors such as enclosure layout or limitations, as well as staffing and species limitations. The most important element of any training programme is consistency (Swaisgood & Stephenson, 2004). The method was developed as follows for the operant conditioning of 2.3 *C. nigra* at ZSL London Zoo.

A focal individual was first conditioned to allow handling and finching to take place. Because the finch response is a natural behaviour, this did not pose too much of a challenge; the animal just needed to associate the finch response with the positive reinforcement of being touched. Early conditioning attempts were hindered by conspecific animals. Non-target specimens would often interact with the animal being trained. We therefore incorporated separation into our protocol. Once the finch response was evoked by the tactile stimulation from the keeper, non-target conspecific animals were separated behind a fence in order to prevent disturbance of the target animal during the training process.

The focal individual was touched and lightly scratched; first on the legs and then the neck to elicit the finch response. When the specimen achieved the finch response, with neck and legs fully extended and an even weight distribution on all four limbs, a second keeper, acting as a stand-in for a member of the veterinary team approached the animal and touched the neck in order to locate the vein; it lies in a groove easily felt when the neck skin is pulled taught. Once the vein had been located, a finger was then pushed onto the neck skin to try to desensitise the animal to the feeling of pressure being placed on this area, in anticipation of when the needle goes in on an actual blood draw event. Other stimuli were trialed to replicate the sensation of needle penetration but finger pressure was the method of choice. Once this process had been repeated four times, the animal was rewarded with a high value food item such as a small piece of carrot, and this concluded the conditioning session.

This conditioning was carried out daily in the afternoon over three consecutive days prior to the first blood draw attempt. Attempting to take blood from a *C. nigra* in the afternoon was considered advantageous as it allowed the animal enough time to bask in the morning which resulted in increased body temperatures by the afternoon and improved engorgement of jugular veins due to peripheral vasodilation, allowing for a blood sample to be obtained more easily (Dessauer, 1970). We elicited the finch response with the target animals at other random times of the day to disassociate it from any possible negative response with the blood draw procedure. The technique used to elicit the finch response on these occasions was kept exactly the same as for the actual blood draw procedures.

On the day of an actual blood draw, a veterinarian or veterinary nurse took the place of the stand-in secondary keeper whilst the first keeper remained ‘finching’ the tortoise from behind. The veterinarian first inserted a butterfly needle into the vein, and left the needle inserted whilst the tortoise would inevitably retract its neck. When the animal was successfully re-finched, a syringe was then attached to the butterfly needle and the blood taken. The animal was then instantly rewarded with food, indicating the end of the procedure.

Figure 1: Veterinary team member palpates the neck of *C. nigra* in order to find the jugular vein, once the animal has been finched.

Figure 2: Veterinary team member inserts the butterfly needle into the jugular vein of *C. nigra* whilst the animal maintains the finch position.

RESULTS AND DISCUSSION

Since the implementation of the training protocol we have now been able to obtain routine blood samples from all of our five *C. nigra* under operant conditioning and we have achieved an 85% success rate of the behaviour learned. The options of blood sampling sites from *C. nigra* are often restricted to dorsal tail vein, the sub-carapacial venous sinus and the jugular veins. The lymphatic system in tortoises is extensive and any lymph contamination of blood samples renders results spurious and misleading. The jugular veins are considered the venipuncture site with the least risk of lymph contamination and therefore the optimal site for blood sampling (Wright, 2009). Examination of a blood sample should be a component of a routine medical work up of any chelonian medical case (MacArthur, Wilkinson & Meyer, 1988) but the procedure of obtaining the blood could cause stress (Fazio et al., 2014). Manual restraint of large chelonians is likely to compromise their welfare, as well as being impractical due to their large size and strength, and should be avoided where possible.

C. nigra exhibit a classic example of a symbiotic relationship with some Galápagos finches, (e.g. *Geospiza fuliginosa*) (Christian, 1980). The ectoparasite-eating finch stimulates a reaction in the tortoise that evokes a change of posture to one with neck fully extended and standing as high as possible and therefore exposing as much skin as possible. This improves feeding access for the finches and facilitates the removal of ectoparasites. This behaviour is maintained in captive populations despite the absence of the finches. During the finch response the tortoises go into a trance-like state, in which they do not react to stimuli such as the presence of food (pers. obs).

The training protocol is now established and working effectively, but during the process there were a number of obstacles to overcome. Many factors can affect the success rate of this process, such as the ability of the veterinary team member to successfully locate the vein. This process was made more difficult by the fact that the vein often moves, making locating it on a first attempt more difficult. Historically, multiple attempts to obtain a blood samples were made. There were concerns that target specimens could become shy of needles and that the skin and vein could be damaged. In order to minimise this, a three strike rule was implemented which meant that only three attempts of needle insertion could be made and if these were unsuccessful after the third try, the session would conclude regardless of the success in obtaining a blood sample. A seven day rest period between blood draws was also implemented, which meant that if a blood draw attempt was unsuccessful, another attempt could not be made until another seven days had elapsed.

Keeper shyness is a term we have given to represent the behaviour of an animal when the presence of a keeper is associated with any negative stimuli and this often leads to a specimen displaying unwillingness to exhibit the desired finching behaviour. On such occasions there was little or no finch response present. Anecdotally, in extreme circumstances this can manifest itself as a sudden physical percussing of the plastron on the floor. This behaviour can be rectified or avoided by making sure that the training is positively reinforced regularly without the negative stimuli being present and by interacting with the tortoises outside the blood draw sessions.

Initially when the de-sensitisation process was attempted, we used many methods to try to prepare the animal for the sensation of the needle being inserted into the vein. These included blunt needles pressed against the skin as well as rubber bands flicked on the neck to try and recreate the sensation for training without the needle actually being used. However, after these methods were trialed, we did not feel anything could replicate the sensation of the pain response once a needle was actually inserted. We changed the methods to applying pressure with a forefinger and focused on the ability of the keeper to move the neck and head of the tortoise to the correct angles which better exposed the neck vein and facilitated blood sampling events.

We now have a method that is effective and allows us to routinely monitor the health status of our *C. nigra* group. Carrying out routine blood screening allows us to gather data to create a detailed profile of tortoise health which can then be correlated to other data such as transcoelomic ultrasound scans to track many aspects of tortoise husbandry, reproduction and the treatment of illness.

ACKNOWLEDGEMENTS

We would like to thank Benjamin Tapley, Iri Gill, Christopher Michaels, and Steve Plested from the Herpetology Section for their continued help and support for this training programme, Nic Masters, Yedra Feltrer, Tai Strike, Heather Macintosh, and Sophie Barnes from the Veterinary Department in obtaining and processing the blood samples, Jim Mackie, and Alison Parbles for their advice and support on the training programme, and Grant Kother for his assistance in first initiating the training programme.

REFERENCES

Blake, S., Wikelski, M., Cabrera, F., Guezou, A., Silva, M., Sadeghayobi, E., Yackulic, C.B. & Jaramillo. P. (2012). Seed dispersal by Galápagos tortoises. *Journal of Biogeography* 39: 1961-1972.

Boyer T.H. & Boyer D.M. (2005). Turtles, tortoises and terrapins. In *Reptile Medicine and Surgery*. Pp 78-99. Divers, S. J., & Mader, D. R. (Eds.) Chicago: Elsevier Health Sciences.

Caccone, A., Gibbs, J.P., Ketmaier, V., Suatoni, E. & Powell, J.R. (1999). Origin and evolutionary relationships of giant Galapagos tortoises. *PNAS* 96: 13223-13228.

Christian, K. A. (1980). Cleaning/Feeding symbiosis between birds and reptiles of the Galapagos Islands: New observations of inter-island variability. *The Auk* 97:887-889.

Dessauer, H. C. (1970). Blood chemistry of reptiles: physio logical and evolutionary aspects. In *Biology of Reptilia*. Vol 3. Pp. 1-72. Gans C. & Parsons T.H. (Eds.). New York: Academic Press.

Fazio, E., Medica, P., Bruschetta, G. & Ferlazzo, A. (2014). Do handling and transport stress influence adrenocortical response in the tortoises (*Testudo hermanni*)? *ISRN Veterinary Science* 2014: 1-3.

Fleming, G.J. & Skurski, M. L. (2014). Conditioning and behavioural training in reptiles. In, *Current Therapy in Reptile Medicine and Surgery*. Pp 128-133. Mader, D.R. & Divers, S.J. (Eds.). Missouri: Elsevier Saunders.

Hellmuth, H., Augustine, L., Watkins, B. & Hope, K (2012). Using Operant Conditioning and Desensitization to Facilitate Veterinary Care with Captive Reptiles. Veterinary Clinics: *Exotic Animal Practice* 15: 425-443

Selleri, P. & Di Girolamo. N. (2012). Plasma 25-hydroxi hydroxyvitamin D3 concentrations in Hermann's tortoises (*Testudo hermanni*) exposed to natural sunlight and two artificial ultraviolet radiation sources. *American Journal of Veterinary Research* 73: 1781-1786.

Swaisgood, R. & Stephenson, D. (2004). Scientific Approaches to Enrichment and Stereotypies in Zoo Animals: What's Been Done and Where Should We Go Next? *Zoo Biology* 24: 499-518.

Tortoise & Freshwater Turtle Specialist Group (1996). *Chelonoidis nigra*. The IUCN Red List of Threatened Species. www.iucnredlist.org. [Accessed 29 July 2015].

Weiss, E. & Wilson, S. (2003). The Use of Classical and Operant Conditioning in Training Aldabra Tortoise (*Geochelone gigantean*) for Venepuncture and Other Husbandry Issues. *Journal of Applied Animal Welfare Science* 6: 33-38.

Wright, K. (2008). Diagnostic Sampling and Other Procedures with Turtles and Tortoises. In *NAVC Conference* 2008. Pp 1801- 1803.

Accepted: 22 November 2015

RESEARCH ARTICLE The Herpetological Bulletin 135, 2016: 11-14

Reptile populations persist following the installation of a hydroelectric scheme at Loch Lomond, Scotland

CHRISTOPHER J. MCINERNY

School of Life Sciences, University of Glasgow, Glasgow G12 8QQ, UK
Email: Chris.McInerny@glasgow.ac.uk

ABSTRACT - The land adjacent to Loch Lomond, Scotland, contains areas that have populations of reptiles, including northern vipers *Vipera berus*, slow-worms *Anguis fragilis* and common lizards *Zootoca vivipara*. At one site, where reptile numbers and breeding activity have been monitored, a hydroelectric scheme was implemented that passed through an area of high reptile density. This paper describes the reptile monitoring before, during and after the development; and an environmental management plan put in place to mitigate the effect of the installation on the reptiles. The observation of breeding of all three species adjacent to the area during construction, and of high numbers of reptiles in the vicinity the following year, suggest that the environmental management was successful, at least in the short-term.

INTRODUCTION

The numbers and ranges of some reptile species have shown declines in parts of the UK (Beebee and Griffiths, 2000; Baker et al., 2004; Gleed-Owen & Langham, 2012). This is due in large part to human activities, through the loss of habitat because of changes in land use, construction and developments and, in some cases, persecution, despite all species being protected by law. However, in places where the habitat is protected and animals are undisturbed, high numbers can still be found.

In some areas of Scotland there are healthy populations of northern vipers (i.e. adders) *Vipera berus*, slow-worms *Anguis fragilis* and common lizards *Zootoca vivipara* (Reading et al., 1994; Reading et al., 1996; McInerny & Minting, 2016). One such area is the shore of Loch Lomond, to the north of Glasgow. Here, all three species are present with numbers monitored and their distribution, habitat preferences and breeding activity studied (McInerny, 2014a; McInerny 2014b).

At one site, where northern vipers, slow-worms and common lizards co-exist (McInerny, 2014a), a hydroelectric scheme was proposed in 2013. The development required the construction of a turbine powerhouse, and the laying of underground water pipes and electrical cables that passed through an area with high reptile density. This paper describes the environmental plan put in place to mitigate the effects of the development on the reptiles, and the surveying completed to monitor the process. The present paper may have value for others who are involved with similar developments and wish to avoid impacts on reptiles that are found to be present.

MATERIALS AND METHODS

Study site

The site (here kept anonymous to protect both the habitat and the reptiles) is an area of replanted native forest and forestry plantation on south and west facing hills flanking the east shore of Loch Lomond, with the upper regions leading to heather *Calluna vulgaris* moorland. It contains slopes and boggy areas, patches of exposed rock, and a small stream along the northern edge. The site is fenced, preventing the entry of red deer *Cervus elaphus*, and is rich in native fauna and flora. The forest consists of a mosaic of ash *Fraxinus* spp., birch *Betula* spp., oak *Quercus* spp. and rowan *Sorbus* spp., with an adjacent mature conifer plantation; these are interspersed with open areas containing bracken *Pteridium* spp., gorse *Ulex* spp., bramble *Rubus fruticosus* agg., heather, and other native flora. The lower parts were once a sheep-farm. Many stonewalls have collapsed and have been grown over by vegetation; these piles of covered rocks have created underground hibernation sites (hibernacula), suitable for reptiles.

Survey work

Up to 30 artificial cover objects, made from 50 cm by 50 cm roofing felt, were placed at suitable locations on the site in March 2012. These were inspected about once a week from early February until November, from 2012 to 2015, and were effective in revealing slow-worms. Most adders and common lizards were found not to use the felts, but were instead identified by visual inspection of sunning locations throughout the site. The survey methods used are described in McInerny (2014a), and followed published protocols (Sewell et al., 2013).

The number, age and gender of northern vipers, slow-worms and common lizards were noted on each visit. Individual vipers were recognised by inspection of photographs of head patterns, which are unique to each individual (Sheldon and Bradley, 1989; Benson, 1999); this allowed both counts to be recorded and minimum population numbers estimated. In contrast, population numbers of common lizards and slow-worms were not

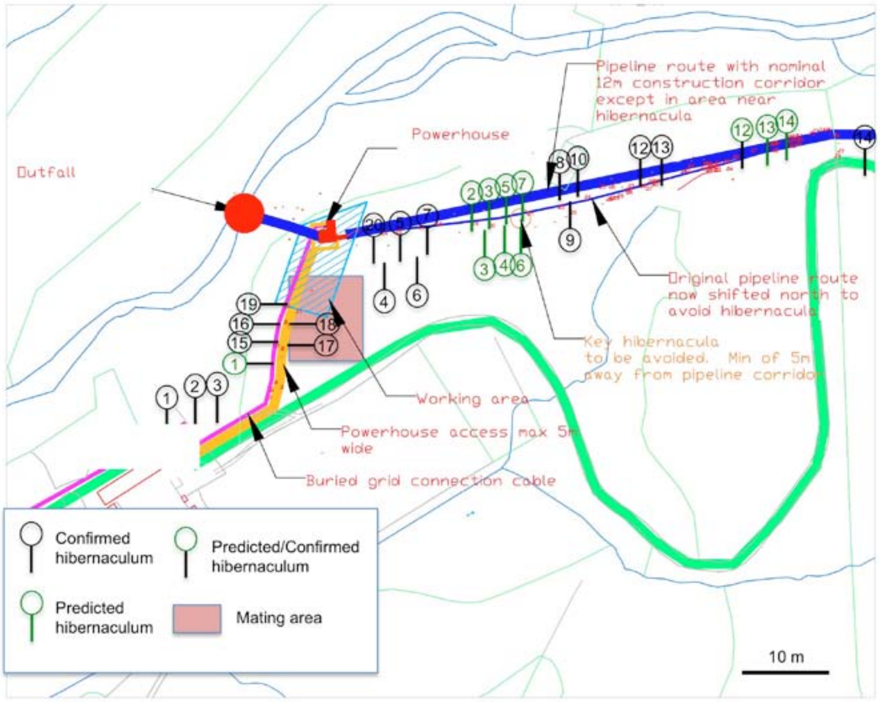


Figure 1. Map of the lower section of a hydroelectric development at Loch Lomond, showing the results of reptile surveys in spring 2013. The layout of the water pipe (blue line), the location of the water outfall (red dot), and the site of the powerhouse (red block) containing the turbines are indicated. The access roads (green and yellow lines) and underground electric cables (pink line) are also shown. The locations of numbered 'confirmed' and 'predicted' reptile hibernacula, where reptiles were seen at the same location on multiple days or 1-2 days, respectively, are plotted. An area where northern vipers mating activity was observed in April 2013 is mapped.

estimated, as individual recognition, though possible (Sewell et al., 2013), was not attempted. Instead, these were recorded as counts.

In total the site was visited 36 times in 2012, 47 times in 2013, 58 times in 2014, and 45 times in 2015. The results from the 2012 survey are published in McInerny (2014a).

Three additional surveys were commissioned in March/April 2013 by Clyde Ecology Ltd (www.clyde-ecology.com) and the developers in preparation for the development, where the author monitored reptile numbers and mapped underground hibernation sites the length of the proposed hydroelectric scheme. The location and numbers of reptile hibernacula were mapped by detecting the repeated sunning locations of reptiles in early spring when they were still near hibernation sites (Sewell et al., 2013). Hibernacula were designated as either 'confirmed' or 'predicted': confirmed was when reptiles were seen at the same location on multiple days, and predicted where reptiles were seen at a location for 1-2 days.

Hydroelectric scheme

The development was instigated in 2014. It involves the diversion of water at three intakes from a stream along an underground pipe, about 2 km long and 300 m down a hillside, to water turbines in a powerhouse, with the return of the water to the stream at an outfall; underground electric cables were required to link the powerhouse to the national grid.

Environmental mitigation plan

Based on the survey work it was discovered that the proposed hydroelectric scheme at the lower parts of the slope, coincided with or was adjacent to areas with highest numbers of the three reptile species (Fig. 1). The developers employed Direct Ecology Ltd (www.directecology.co.uk),

Figure 2. A Loch Lomond hydroelectric development. **A**. Arial view of the lower section of the site, similar to that shown in Fig. 1, August 2014. The fenced area encompassing the construction site, with powerhouse containing the turbines, the cleared areas where the pipes had been laid, and the movable heavy sheet 'gate' placed across the access road, are apparent. **B**. Reptile-proof fencing that surrounded the construction area, February 2014; this was 50 cm high and included 10 cm beneath the ground. **C**. The completed powerhouse, with reptile fencing removed, November 2014.

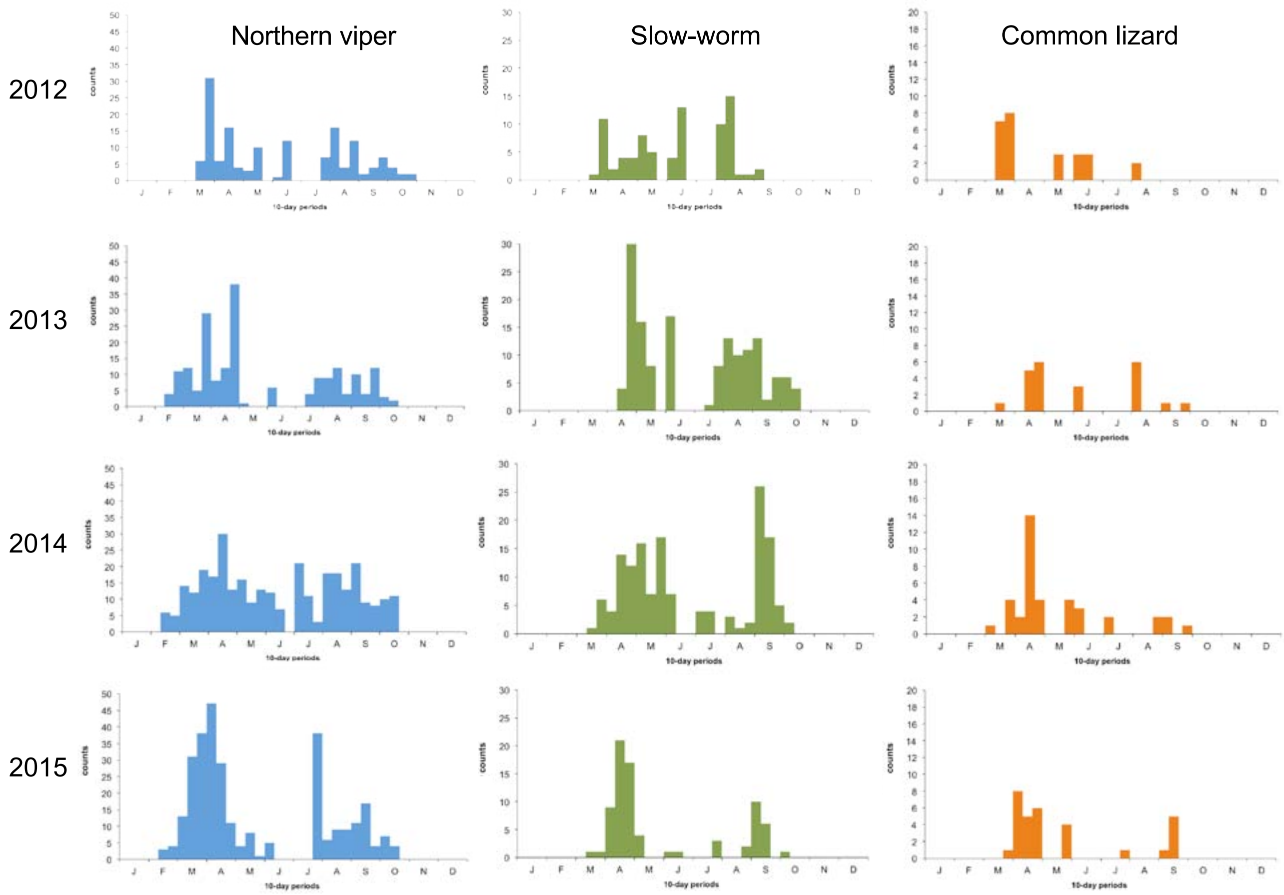


Figure 3. Numbers of northern vipers *V. berus*, slow-worms *A. fragilis* and common lizards *Z. vivipara* before, during and after a hydroelectric development at a Loch Lomond site, from 2012 to 2015. In each case, the reptile counts for 10 day periods are plotted.

who instigated a plan to mitigate effects of construction on the reptiles. First, this involved the revision of the route of the underground water pipe to avoid reptile hibernacula (Fig. 1). Next, a reptile-proof fence was erected around the development at the lower part of the slope, 50 cm high plastic fencing that included ~10 cm below the ground surface (Fig. 2A and 2B). The fencing was laid out to minimise impact on mapped hibernation sites, and installed during January 2014 when reptiles were hibernating. Once it was completed, 50 cm by 50 cm corrugated metal and roofing felt cover objects were placed within the fenced area and these were monitored by Direct Ecology staff for reptiles from March to April, with any found moved outside. One adder could not be caught; here, instead, the fencing was moved so that it was outside. Once the fenced area had been declared clear of reptiles, construction was allowed to proceed; this occurred in May. During construction, the integrity of the fencing was maintained; additionally, a movable heavy sheet 'gate' was placed across the access road (Fig. 2A). On completion of the works, in November/December 2014, the plastic fencing was removed (Fig. 2C); this coincided with the time when the reptiles had returned to hibernation.

RESULTS

Reptile numbers before the hydroelectric development, 2012-2013

High numbers of all three species were detected at the site during 2012 and 2013, with reptiles observed from mid-February to late October (McInerny, 2014a; Fig. 3).

In 2012, 40 individual northern vipers were observed, with 15 males, 24 females and one juvenile. In 2013, 79 individual northern vipers were counted, with 37 males, 39 females and three juveniles. Total counts were 149 in 2012, and 196 in 2013. For slow-worms and common lizards, where individuals were not distinguished, total counts revealed 81 slow-worms in 2012 and 149 in 2013. About 25 common lizard counts were recorded in both years.

For adders, mating activity and multiple gravid females were noted; many gravid slow-worms were also seen. Juveniles of three species were observed with, in 2012, total counts of two for adder, 15 for slow-worm and none for common lizard; and in 2013, six for adder, 35 for slow-worm and four for common lizard.

Reptile numbers during and after the hydroelectric development, 2014-2015

All three species were detected at the site, outside the construction area, during 2014 and 2015, with reptiles observed from mid-February to late October (Fig. 3).

In 2014, 151 individual northern vipers were observed, with 61 males, 78 females and 12 juveniles. In 2015, 148 individual adders were counted, with 78 males, 62 females and eight juveniles. Total counts were 316 in 2014 and 299 in 2015. This included a maximum day count of 26 snakes. In total over 200 different individual adders were recognised by their head patterns at the site, from 2012 to 2015. A number of individuals were present throughout the four years of the survey period, and in few cases these re-used the same hibernation sites each winter, some of which were close to the development. Slow-worms and common lizards were also observed with, in 2014, 148 and 39 total counts, and in 2015, 77 and 30, respectively.

Mating activity and gravid female northern vipers and slow-worms were observed in both years. Indeed, in 2014 during installation of the hydroelectric scheme, the wrestling of rival male adders, males courting and mating with females, and up to 12 sunning gravid females were noted within just a few metres of the construction area. Juveniles of three species were observed with, in 2014, total counts of 23 for northern vipers, 71 for slow-worm and one for common lizard; and in 2015, nine for northern vipers, 54 for slow-worm and one for common lizard.

When examining reptile numbers before (2012-13), during and after (2014-15) the development (Fig. 3), it appears that numbers of all three species have persisted. Though the numbers between years are not directly comparable, as there were differences in observer effort, with more visits in later years, similar numbers of animals were observed, suggesting that the populations have not decreased but have remained stable over the period.

DISCUSSION

This paper describes the monitoring of a population of three species of reptiles during the construction of a hydroelectric scheme, and the mitigation plan instigated to reduce its impact on their numbers, distribution and life cycles. The mitigation measures might well have played a role in the persistence of the populations in the short-term as reptile numbers did not decrease. Furthermore, there was no evidence that disturbance at the site resulted in animals leaving the area, nor that disturbance interrupted breeding. Indeed, it was apparent that the three species of reptiles were all tolerant of the noise and movements associated with the building work.

This preliminary study suggests that, with the support of the landowners and developers, and the instigation of an appropriate mitigation plan following a thorough survey of reptile numbers and their distribution, construction projects can occur at sites with high densities of reptiles without affecting their populations in the short-term. There will be continued monitoring at the site to investigate any possible longer terms effects, and to observe whether the reptiles recolonise the construction area itself.

ACKNOWLEDGEMENTS

I thank the landowners for their support in allowing me to monitor reptiles at the site. I also acknowledge their decision to consider the importance of the reptiles when planning the hydroelectric scheme, and the care that the developers and Direct Ecology Ltd took in implementing the mitigation plan. I thank Roger Downie (University of Glasgow), Pete Minting (Amphibian and Reptile Conservation - Trust), Beccy Osborn (Direct Ecology), and anonymous reviewers for comments on the manuscript. The survey work in 2014-2015 was supported by travel grants awarded by Clyde Ecology and the Glasgow Natural History Society from the Professor Blodwen Lloyd Binns bequest.

REFERENCES

Baker, J., Suckling, J. & Carey, R. (2004). *Status of the adder Vipera berus and slow-worm Anguis fragilis in England*. English Nature Research Report 546. English Nature, Peterborough, pp 44.

Beebee, T.J.C. & Griffiths, R.A. (2000). *Amphibians and Reptiles*. Harper Collins, London, pp 270.

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

Gleed-Owen, C. & Langham, S. (2012). *The Adder Status Project - a conservation condition assessment of the adder (Vipera berus) in England, with recommendations for future monitoring and conservation policy*. CGO Ecology Limited Report, pp 76.

McInerny, C.J. (2014a). Observations on a population of adders, slow-worms and common lizards on Loch Lomondside, Scotland. *The Glasgow Naturalist* 26: 63-68.

McInerny, C.J. (2014b). Habitat preferences of European adders at Loch Lomond, Scotland. *The Glasgow Naturalist* 26: 69-74

McInerny, C.J. & Minting P.J. (2016). *The Amphibians and Reptiles of Scotland*, Glasgow Natural History Society, Glasgow, pp 312.

Reading, C.J., Buckland, S.T., McGowan, G.M., Gorzula, S., Jayasinghe, G., Staines, B.W., Elston, D.A. & Ahmadi, S (1994). *Status of the Adder* Vipera berus *in Scotland*. Scottish Natural Heritage Research, Survey and Monitoring Report No. 38, pp 43.

Reading, C.J., Buckland, S.T., McGowan, G.M., Jayasinghe, G., Gorzula, S. & Balharry, D. (1996). The distribution and status of the adder (*Vipera berus L.*) in Scotland determined from questionnaire surveys. *Journal of Biogeography* 23: 657-667.

Sewell, D., Griffiths, R.A., Beebee, T.J.C., Foster, J. & Wilkinson, J.W. (2013). *Survey Protocols for the British Herpetofauna*. Amphibian and Reptile Conservation, Bournemouth, pp 22

Sheldon, S. & Bradley, C. (1989). Identification of individual adders, *Vipera berus*, by their head markings. *The Herpetological Journal* 1: 392-396.

Accepted: 15 December 2015

Characteristics of a snake community in northern Virginia, USA

CARL H. ERNST[1,*], TERRY R. CREQUE[2], JOHN M. ORR[2], ARNDT F. LAEMMERZAHL[3] & TRACI D. HARTSELL[4]

[1]Division of Amphibians and Reptiles, mrc 162, Smithsonian Institution, PO Box 37112, Washington, D.C. 20013-7012, USA.
[2]Department of Environmental Science and Public Policy, George Mason University, Fairfax, VA 22030, USA.
[3]Biology Department, George Mason University, Fairfax, VA 22030, USA.
[4]Homeland Security Investigations, 10720 Richmond Highway, Stop 5118, Lorton, VA 20598, USA.
[*]Corresponding author email: chernst@frontiernet.net.

ABSTRACT - The population characteristics of a community consisting of 16 species of snakes occurring in five microhabitats were studied for 24 years (1982 to 2006) at the Mason Neck National Wildlife Refuge, Fairfax County, Virginia, USA. The portion of the refuge studied included five varied microhabitats: an old farmstead, and old field, extensive woodlands, a pond, and a tidal marsh. The species morphological characteristics, adult male/female ratios, and juvenile/adult ratios are reported, as also are the snake biomass, numbers, richness of each microhabitat and changes in the fauna over the time period. Niche characteristics of the snake species are described. Comparisons are made with Middle Atlantic snake communities to the north and south of Mason Neck.

INTRODUCTION

Reports of ecological studies of individual species of North American snakes are common (Ernst & Ernst, 2003, 2011). However, studies of the structure and dynamics of communities consisting of several North American snakes are more rare (Ernst & Ernst, 2003).

To our knowledge, the only such published studies involving diverse snake communities in the Middle Atlantic States have been those by Meshaka (2010), Meshaka & Delis (2014) and Meshaka et al. (2008, 2009) at sites to the north in central and western Pennsylvania and Mitchell (2014) at another more southern site in central Virginia.

The snake community at the Mason Neck refuge consisted of 16 species (Table 1): *Agkistrodon contortrix* (L.) [copperhead, N = 24 individuals]; *Carphophis amoenus* (Say) [eastern worm snake, N = 238], *Coluber constrictor* L. [racer, N = 204], *Diadophis punctatus* (L.) [ring-necked snake, N = 54], *Heterodon platirhinos* Latreille [eastern hog-nosed snake, N = 11], *Lampropeltis calligaster* (Harlan) [yellow-bellied kingsnake, N = 6], *L. getula* (L.) [common kingsnake, N = 3], *L. triangulum* (Lacépède) [milk snake, N = 1], *Nerodia sipedon* (L.) [northern water snake, N = 67], *Opheodrys aestivus* (L.) [rough green snake, N = 6], *Pantherophis alleghaniensis* (Holbrook) [rat snake, N = 43], *Regina septemvittata* (Say) [queen snake, N = 6], *Storeria dekayi* (Holbrook) [DeKay's brown snake, N = 12], *Thamnophis sauritus* (L.) [common ribbon snake, N = 26], *T. sirtalis* (L.) [common garter snake, N = 55], and *Virginia valeriae* Baird and Girard [smooth earth snake, N = 16].

Earlier research on Mason Neck snakes were by Creque (2001), Ernst et al., (2012, 2014), Hansknecht et al., (1999), Hartsell (1993), Klimkiewicz (1972), and Orr (2003, 2006); and formed the major emphases of the research. Although our studies there began as examinations of various aspects of the ecology of *Carphophis amoenus*, according to Gibbons (2013), regardless of the original intent of studies that last longer than planned, they often provide empirical data needed to address important biological questions.

The results of our long-term research on the populations and community structure and dynamics of this northern Virginia snake assemblage are presented below.

MATERIALS AND METHODS

Field-site description

Collections were made at a 30-ha site on an Atlantic Coastal Plain peninsula jutting into the Potomac River at the Mason Neck National Wildlife Refuge, Fairfax County, VA (38°67'N, 77°10'W; ≈25-35 m elevation). The site was restricted and closed to the general public, and its microhabitats were maintained during the study. The peninsula's vegetation is composed primarily of mixed deciduous upland forest. The length of the peninsula is bisected by a gravel road. The study area included five different microhabitats: (A), An old farmstead consisting of mixed hardwoods, grass plots and a parking area at the terminal point of the peninsula where cover boards were placed and the debris from the original farmhouse and outbuildings provided cover for snakes; (B), a >3-ha field undergoing succession with the transecting gravel road to the south and surrounded on the other three sides by woods; cover boards were placed along its borders to join several wood piles and abandoned railroad ties. (C), a ≈2-ha freshwater pond fed by a brook to the south, surrounded by woods on two sides, the gravel road to the north, and a brook flowing northward to a tidal marshland. (D), a ≈5-ha tidal-freshwater marsh along the Potomac River to the north, and (E), an extensive mixed second and third growth woods separating the other four microhabitats.

Field materials and methods

Snake collections occurred over 24 years from April 1982 through August 2006, but predominately from 1990 to 2006, and were conducted mostly during the prime annual snake-activity period at this site (April-November; Ernst et al., 2012). Nine aged wooden boards and 14 abandoned sheets of roofing tin were provided as “cover boards” to shelter snakes (Grant et al., 1992). Most data were derived from hand collections because the use of drift fences was prohibited by Refuge policy (additional captures of some rare and secretive snakes may have occurred if this method had been available; Durso et al., 2011). We routinely examined natural hiding places (downed logs and rocks) and manmade debris (old wood railroad ties, cinder blocks, sections of an old concrete sidewalk, and an old brick spring house).

Data collected from each snake at capture included the date, 24-hour military time, microhabitat, its behaviour (separately moving on land or in water, basking, foraging/feeding [ingesting], courting/mating, or undercover/hibernating); maturity stage (male, female, or juvenile/immature based on size at attainment of sexual maturity; Ernst & Ernst 2003); and total body length (TBL) and tail length (TL) measured with a cloth measuring tape (large snakes) or a standard metric ruler (small snakes). Snout-vent length (SVL) was calculated by subtracting TL from TBL. We recorded the mass of each snake to the nearest 0.1 g with Pesola spring scales. Snakes heavier than 1000-g were weighed with an ACCulab portable electronic balance of 4000-g capacity. Standard scale-clipping was used to mark all snakes for future identification (Brown & Parker, 1976). Larger species were marked with coded passive integrated transponder (PIT) tags inserted subdermally to track their movements. Recapture data from the same date were not recorded. After processing, snakes were released at the point of capture. Snakes were considered active if they responded (moved) when handled.

Data analysis

Data were gathered over a relatively long period at different diel times, dates, and meteorological conditions, and used to determine the snake community characteristics/relationships (see Ernst et al., 2012, 2014 for snake annual and diel activity cycles and thermal ecology at the site).

RESULTS AND DISCUSSION

Species structure and numbers

The community structure of the snakes at Mason Neck during our years of research consisted of 16 species; a diverse species assemblage for a rather northern site. The number of encounters, morphological characters, biomass, adult sex ratio, and juvenile/adult ratio of each species are presented in Table 1.

In a previous short-term reptile census conducted at Mason Neck, Klimkiewicz (1972) reported *P. alleghaniensis* and *T. sirtalis* as abundant; *C. amoenus*, *C. constrictor*, *N. sipedon*, and *S. dekayi* common; *A. contortrix*, *D. punctatus*, *H. platirhinos*, *L. calligaster*, *L. getula*, *O. aestivus*, *Storeria occipitomaculata* (red-bellied snake), *T. sauritus*, and *V. valeriae* uncommon; and *Farancia erytrogramma* (rainbow snake), *L. triangulum*, *Pantherophis guttatus* (red corn snake), and *R. septemvittata* hypothetically occurring at the site.

In contrast, based on data in Table 1, we consider *C. amoenus* and *C. constrictor* very abundant; *A. contortrix*, *D. punctatus*, *N. sipedon*, *P. alleghaniensis*, *T. sauritus*, *T. sirtalis* common; *H. platirhinos*, *O. aestivus*, *S. dekayi* and *V. valeriae* uncommon; *L. calligaster*, *L. getula* and *R. septemvittata* rare; and *L. triangulum* extremely rare at Mason Neck.

Neither *P. guttatus* nor *S. occipitomaculata* were found during our years of research, although both have been reported, respectively, from Prince William County and Fairfax County, Virginia (Ernst et al., 1997). It is extremely unlikely that *F. erytrogramma* occurs in northern Virginia (Mitchell, 1994).

More recently, on 22 May, 2010, several groups of collectors surveyed the herpetofauna of the Mason Neck Refuge and parts of the adjacent Mason Neck State Park. They recorded 60 *C. amoenus*, 20 *N. sipedon*, 11 *C. constrictor*, 8 *P. alleghaniensis*, 5 *D. punctatus*, 3 *T. sauritus*, 1 *R. septemvittata*, 1 *S. dekayi*, and 1 DOR *H. platirhinos* (Orr & Mendoza, 2011). All 9 species had been previously found by us. However, they did not report *A. contortrix* and *T. sirtalis*, which were common during our research; *O. aestivus* and *V. valeriae*, recorded by us as uncommon; and *L. calligaster* and *L. getula* we considered rare; and the extremely rare *L. triangulum*. That a single *R. septemvittata* was found is noteworthy as it had not been collected by us since the 1980s. Undoubtedly, more snake species would have been recorded if the more current survey had included additional days and our specific study microhabitats.

Biomass and snake density

Total snake biomass at Mason Neck was 228.677 kg. Total biomass of the snake species was calculated by adding the masses of all new individuals captured of that species; total snake biomass at the five microhabitats was calculated by adding the masses of all snakes captured there (Table 2). Although the most common snake, *C. amoenus*, accounted for the greatest number of individuals (238) and captures (551), because of its small size and weight, it contributed only 0.66% of the total snake biomass. Most biomass was contributed by the largest two species *C. constrictor* (32.0%) and *P. alleghaniensis* (56.0%). The other 13 species accounted for approximately 11.7% of the total biomass although they amounted to 37.2% of the total 772 individual snakes captured during the study. Both size and biomass of the individual species is obviously correlated with their prey preference and mode of capture (Table 3).

Table 1. Captures (N), morphological characteristics, mass, adult sex ratio; juvenile/adult ratio of snake species at the Mason Neck National Wildlife Refuge, Fairfax County, Virginia, 1982-2006. All measurements in mm, snout vent length (SVL), mass in grams (g), males (M), females (F), juveniles (J), venomous (*). See text for additional data on individual snake species.

Species (N)	SVL Mean (Range)			Mean Mass	M	F	J	Adult M/F Ratio	Juvenile/ Adult Ratio
	M	F	J						
C. amoenus (551)	201 (160-254)	219 (168-268)	131 (50-178)	4.7	152	106	62	1.43/1.00	0.24/1.00
C. constrictor (145)	871 (580-1170)	882 (540-1232)	296 (240-400)	397.4	68	62	15	1.10/1.0	0.12/1.00
N. sipedon (66)	590 (411-825)	694 (451-819)	360 (155-475)	189.1	31	20	15	1.55/1.00	0.29/1.00
T. sirtalis (57)	437 (385-495)	359 (280-430)	196 (45-222)	60.4	31	13	13	2.38/1.00	0.30/1.00
P. alleghaniensis (44)	861 (465-1430)	1148 (781-1810)	398 (210-490)	297.2	25	18	1	1.86/1.00	0.23/1.00
D. punctatus (43)	23 (18-32)	24 (19-35)	12 (9-14)	1.6	12	21	10	0.57/1.00	0.30/1.00
T. sauritus (27)	44 (39-50)	36 (29-43)	19 (15-22)	189.0	18	4	5	4.50/1.00	0.23/1.00
A. contortrix (23) *	65 (54-86)	71 (62-83)	31 (21-43)	205.1	7	10	6	0.70/1.00	0.35/1.00
V. valeriae (19)	141 (104-187)	211 (170-261)	114 (105-120)	5.4	6	5	8	1.2/1.00	0.73/1.00
H. platirhinos (12)	548 (457-716)	604 (480-718)	232 (230-233)	197.4	6	4	3	1.50/1.00	0.30/1.00
S. dekayi (12)	220 (180-270)	230 (190-270)	150 (140-180)	5.5	6	5	2	1.20/1.00	0.20/1.00
O. aestivus (8)	480 (370-590)	480 (450-540)	-	5.5	3	5	-	0.60/1.00	-
L. calligaster (6)	-	-	180 (170-190)	4.5	-	-	6	-	-
L. getula (3)	780 (700-850)	-	-	28.5	3	-	-	-	-
R. septemvittata (2)	390	340	-	100.3	1	1	-	1.00/1.00	-
L. triangulum (1)	-	-	180	7.0	-	-	1	-	-

Microhabitat use and species density

Occupancy of the five microhabitats (Table 2) at Mason Neck by the individual snake species varied; and was probably determined by the availability of the particular snake's diet preferences (Ernst & Ernst, 2003; Vitt, 2001), although the presence of cover and suitable environmental temperatures and humidity which retarded desiccation (Elick & Sealander, 1972) probably also played important roles.

The presence of five different microhabitats allowed a greater number of prey species. Twelve snakes (75% of total species) were captured at the farmstead (microhabitat A) and in the woods (E), 10 species (62.5%) at the mostly open old field (microhabitat B), but only four species (25.0%) were found at either the pond (C) or marshland (D). Snake biomass was greatest at the farmstead, old field and woodland microhabitats due to the greater presence of the two heaviest snakes, *Coluber* and *Pantherophis*.

Terrestrial *C. amoenus* were only found at the farmstead (A, 55.9% of its captures), under cover along the ecotonal borders of the old field (B, 15.4% of captures), and throughout the woodlands (E, 28.8% of captures). *C. constrictor*, usually terrestrial, occurred in four biohabitats: A, 38.0%, B 45.7%, D, the marsh, 0.5%, and E, 15.8%. It was the most heat tolerant of the snakes at the old field (Ernst et al., 2014); and often found crawling in the open at noon on very hot days; with the exception of *H. platirhinos* (one individual), the other snakes found at B were confined to the more shaded ecotonal borders of the field where more cover was available. The terrestrial/arboreal *P. alleghaniensis*, was captured in all five microhabitats: A, 72.1%, B, 2.3%, E, 22.3%, and one each (2.3%) was surprisingly found swimming in the pond (C)

Table 2. Snake biomass and numbers for microhabitats at the Mason Neck National Wildlife Refuge, Fairfax County, Virginia, USA, 1982-2006. N = captures. * = venomous.

Species (N)	Old Farmstead (N)	Old Field (N)	Pond (N)	Woodland (N)	Marsh (N)	Total Species Biomass
C. amoenus (320)	0.840 kg (194)	0.232 kg (44)	-	0.433 kg (82)	-	1.505 kg
C. constrictor (145)	27.815 kg (70)	33.378 kg (45)	-	11.523 kg (29)	0.397kg (1)	73.113 kg
N. sipedon (66)	0.189 kg (1)	-	11.348 kg (60)	-	0.946 kg (5)	12.483 kg
T. sirtalis (57)	1.510 kg (25)	0.242 kg (4)	1.389 kg (23)	0.302 kg (5)	-	3.443 kg
P. alleghaniensis (44)	9.232 kg (31)	0.298 kg (1)	0.298 kg (1)	2.680 kg (10)	0.298 kg (1)	128.061 kg
D. punctatus (43)	0.154 kg (28)	0.044kg (8)	-	0.039 (7)	-	0.237 kg
T. sauritus (27)	-	0.018 kg (1)	0.467 kg (26)	-	-	0.485 kg
A. contortrix (23)*	3.500 kg (17)	-	-	1.235 kg (6)	-	4.735 kg
V.valeriae (19)	0.063 kg (12)	-	-	0.037 (7)	-	0.100 kg
H. platirhinos (12)	0.789 kg (4)	0.987 kg (5)	-	0.592 kg (3)	-	2.368 kg
S. dekayi (12)	0.548 kg (8)	0.006 kg (1)	-	0.018 kg (3)	-	0.572 kg
O. aestivus (8)	-	0.055 kg (1)	-	0.382 kg (7)	-	0.437 kg
L. calligaster (6)	-	-	-	0.045 kg (6)	-	0.045 kg
L. getula (3)	0.285 kg (1)	0.285 kg (1)	-	0.285 kg (1)	-	0.855 kg
R. septemvittata (2)	-	-	-	-	0.201 kg (2)	0.201 kg
L. triangulum (1)	0.007 kg (1)	-	-	-	-	0.007 kg
Total biomass	44.932 kg	35.545 kg	13.502 kg	17.571 kg	1.842 kg	228.677 kg
# species (captures)	12 (357)	10 (111)	4 (110)	12 (566)	4 (9)	16 (753)

and crawling in the marsh wetlands (D). *T. sirtalis* was found in microhabitats A (43.9%), B (7.0%), C (40.4%), and E (8.8%), but surprisingly not in the marsh (D). It is the most microhabitat generalist of the Mason Neck snakes, and does not require proximity to water (Carpenter, 1952); in contrast, *T. sauritus* was usually found in brush near water at the pond (C, 96.1%) and only once at the nearby old field (B, 3.8%). *D. punctatus* was captured only at the farmstead (A, 65.1%), ecotonal border of the old field (B, 18.6%) and in the woods (E, 16.3%; often behind the bark of trees). *V. valeriae* was found at the farmstead (A, 63.2%) and in the woods (E, 36.8%). Most of the aquatic *N. sipedon* were recorded at the pond (C, 90.9%) and marsh (D, 7.6%), although one (1.5%) was captured at the farmstead (A). Both *R. septemvittata* were collected in the marsh (D). The terrestrial/arboreal *O. aestivus* were, with one exception (old field B, 12.5%), confined to the woods (E, 85.5%). The venomous *A. contortrix*, was captured at the farmstead (A, 73.9%) and woods (E, 26.1%), where rodents were most abundant. The three species of *Lampropeltis* were rarely found: six hatchling *L. calligaster* under a log in microhabitat E, one adult *L. getula* each at A, B. and E, and a single juvenile *L. triangulum* at A. *Heterodon platirhinus* was found at the farmstead (A, 33.3%), old field (B, 41.7%), and woodland (E, 25.0%). S. dekayi were capture at the farmstead (A, 66.7%), woodland (E, 25%), and old field border (B, 8.3%). The abundance, richness and biomass per microhabitat of each Mason Neck snake species are presented in Table 2.

Niche partitioning

The breadth of the ecological niche of a snake allows it to occupy only particular microhabitats, and this leads to formation of particular species groups at specific microhabitats (Reinert, 1993). The niche characteristics of each Mason Neck snake are summarised in Table 3. As expected, the more aquatic species (*N. sipedon*, *R. septemvittata* and *T. sauritus*) were found predominately at the two most-moist microhabitats. The more generalist *T. sirtalis* was captured in all microhabitats, except, surprisingly, the marsh. The other more terrestrial species were found, with few exceptions at the old farmstead, woodland, and old field. The two arboreal species, *O. aestivus* and *P. alleghaniensis* occurred mostly at the old farmstead and woodlands where trees were common.

Presence of the primary prey (Ernst et al., 1997; Ernst & Ernst, 2003) played an important role in where the individual snake species foraged: *Agkistrodon, Coluber* and *Pantherophis* where rodents were common; and the worm-eaters *Carphophis*, *Diadophis*, *Storeria*, and *T. sirtalis* were found where this prey was most abundant. Amphibian predators such as *Nerodia* and the two species of *Thamnophis* were commonly found at the more wet microhabitats where frogs occurred. The other major amphibian predator, *H. platirhinos*, fed on toads (*Anaxyrus americanus* and *A. fowleri*) and spotted salamanders (*Ambystoma maculatum*; Ernst & Laemmerzahl, 1989), more terrestrial amphibians found predominately in the woodland or ecotone between the old field and adjacent woods.

Size and ontogeny of snakes are known to be correlated

Table 3. Niche characteristics of snakes at the Mason Neck Wildlife Refuge, Fairfax County, Virginia. *, data taken from Ernst and Ernst, 2003.

Species	Primary Foraging Habitat	Foraging Mode	Cycle Activity	Primary Prey	Primary Prey Detection	Capture Mode
C. amoenus	Terrestrial, Subterranean	Active Hunter	Nocturnal	Worms	Odor, sight (?)	Grab/swallow
C.constrictor	Terrestrial	Active Hunter	Diurnal	Small mammals (rodents, shrews) Lizards, small snakes, nesting birds	Sight, odor	Grab/swallow
N. sipedon	Aquatic	Active Hunter	Diurnal/ Crepuscular (anuran breeding season)	Fish, amphibians	Sight, odor	Grab/swallow
T. sirtalis	Terrestrial, Semiaquatic	Active Hunter	Diurnal/ Crepuscular (anuran breeding season)	Anurans, salamanders, worms, voles	Sight, odor	Grab/swallow
P. alleghaniensis	Terrestrial, Arboreal	Active Hunter	Diurnal	Small mammals (rodents, shrews, moles, chipmunks); squirrels (arboreal); birds; birds' eggs (arboreal)	Sight, odor	Constrict, Grab/ swallow
D. punctatus	Terrestrial	Active Hunter	Nocturnal	Salamanders, small anurans, insects, worms	Odor, sight	Grab/swallow (Envenomation)
T. sauritus	Terrestrial, Semiaquatic	Active Hunter	Diurnal/ Crepuscular (anuran breeding season)	Small anurans, salamanders, worms	Sight, odor	Grab/swallow
A. contortrix	Terrestrial	Ambusher, Active Hunter	Nocturnal/ Crepuscular, Seasonally Diurnal	Small mammals (rodents, shrews), ground nesting birds, insects (seasonal)	Body heat, sight, odor	Envenomation, Grab/swallow
V. valeriae	Terrestrial	Active Hunter	Nocturnal	Worms, slugs, insect larvae	Odor, sight	Grab/swallow
H. platirhinos	Terrestrial	Active Hunter	Diurnal	Toads, Ambystomid salamanders	Sight, odor	Grab/swallow (Envenomation?)
S. dekayi	Terrestrial	Active Hunter	Nocturnal/ Crepuscular	Worms, slugs	Odor, sight	Grab/swallow
O. aestivus	Arboreal, Terrestrial	Active Hunter	Nocturnal/ Crepuscular, Semidiurnal terrestrial	Insects, millipedes, isopods, snails*	Sight, odor	Grab/swallow
L. calligaster (juveniles)	Terrestrial	Active Hunter, Ambush (?)	Nocturnal	Insects; small salamanders, snakes and lizards, newborn mice/shrews*	Sight, odor	Constrict, Grab/ swallow
L. getula	Terrestrial	Active Hunter, Ambush (?)	Diurnal/Nocturnal (?)	Snakes, lizards, small mammals (rodents, shrews)	Sight, odor	Constrict, Grab/ swallow
R. septemvittata	Aquatic, Semiaquatic	Active Hunter	Diurnal (?)	Crayfish	Sight, odor	Grab/swallow
L. triangulum (juvenile)	Terrestrial	Active Hunter, Ambush (?)	Diurnal/ Nocturnal (?)	Young mice, shrews, salamanders, insects*	Sight, odor	Constrict, Grab/ swallow

with the size of their major prey (Arnold, 1993; Ernst & Ernst, 2003), and this was true at Mason Neck. With the exception of juveniles: adult snakes with invertebrate primary prey were the smallest (*Carphophis*, *Diadophis*, *Opheodrys*, *Storeria*, *Thamnophis*, *Virginia*); those that fed chiefly on amphibians tended to have medium lengths.

Prey preferences were the major factor differentiating the niches of the two *Thamnophis*, which were separated by the size of the amphibian species on which they predominately preyed (Carpenter, 1952). At Mason Neck, the larger *T. sirtalis* preys on larger ones (anurans: *A. americanus*, *A. fowleri*; *Lithobates catesbeianus* [larvae and recently transformed], *L. clamitans*, *L. palustris*, *L. sphenocephalus*, *L. sylvaticus*; salamanders: *A. maculatum*, *Plethodon cinereus*; but also some small snakes, lizards, and rodents). The shorter, more slender, *T. sauritus* preys on smaller animals (anurans: *Acris crepitans*; Hyla *chrysoselis-versicolor* complex, *H. cinerea*; *Pseudacris crucifer*, *P. feriarum*; salamanders: *Desmognathus fuscus*, *Eurycea bislineata*, *Hemidactylium scutatum*, and a few insects). Both species readily consume available earthworms.

Local rodent and bird predators were the largest snakes (*Coluber*, *L. getula*, *Pantherophis*). The largest prey we observed were a grey squirrel (*Sciurus carolinensis*) and eastern chipmunks (*Tamias striatus*) by both *Coluber* and *Pantherophis*. The two more arboreal snakes partitioned the tree niche by prey size (*Opheodrys*, insects and small invertebrates; *Pantherophis*, rodents, birds and their eggs).

The annual and daily activity patterns and thermal ecology of Mason Neck's snakes have been previously reported by Ernst et al. (2012, 2014). *Carphophis*, *Diadophis*, *Storeria* and *Virginia* have abbreviated annual cycles due to their more narrow range of operating body temperatures, and become scarce during the hot/dry months of the year, probably because of the greater possibility of desiccation and the scarcity of surface earthworms. The other species were generally active, with few exceptions, from late March/early April to October/early November.

Most captures of all species occurred during 0800-1600 hours. Unfortunately, nocturnal research at the Refuge was not permitted and the Refuge was locked as darkness approached. Therefore we were dependent on previous literature reports of nocturnal activity by some species present (see Ernst & Ernst, 2003), and the fact that *Carphophis*, *Diadophis*, *Storeria* and *Virginia* were almost exclusively found under cover during the daylight hours. *A. contortrix* is nocturnal/crepuscular (Ernst & Ernst, 2003), and most were found under cover during the daylight hours, but some were active and captured as late as sunrise. Prey daily cycles probably influenced the foraging time of Mason Neck's snakes. Prey activity cycles also played an important role in setting both snake seasonal and diurnal activity cycles. Mason Neck *Heterodon* had an annual cycle strictly correlated with that of its amphibian prey.

The microhabitat and diet preferences, and both diel and annual activity cycles of Mason Neck *A. contortrix*, *C. amoenus*, *C. constrictor*, *D. punctatus*, *P. alleghaniensis*, *N. sipedon*, and *S. dekayi* closely match those of their Kansas congeners reported by Fitch (1982).

Capture data assembled during our 24 year study indicates that the Mason Neck's snakes have evolved their microhabitat preferences (Table 2) by adapting their foraging strategies and times to those of their primary prey (Table 3) and to the daily and annual cycles of these prey animals (Ernst et al., 2012).

Comparisons with other Middle Atlantic snake communities

Few studies of Middle Atlantic snake communities have been reported, and the microhabitats at these localities are different; making direct comparisons to Mason Neck difficult. In addition, these were conducted over shorter durations at piedmont or mountain localities composed of different microhabitats of varied dimensions and vegetation, had different species diversity, and used different collection methods than at Mason Neck (see the papers for details).

Two Pennsylvania studies north of Mason Neck (Meshaka, 2010; Meshaka et al., 2009) concentrated on snakes in Pennsylvania grasslands, and a third to the south (Mitchell, 2014) had about equal concentration in both fields and hardwood forest in the piedmont of Cumberland County, Virginia.

The 2010 study by Meshaka occurred in fields and mixed forest in the mountains of Westmoreland County. Those of Meshaka et al. (2008, 2009) were in piedmont grasslands in Dauphin and Lebanon counties. The Westmoreland study (Meshaka, 2010) included several different species than occur at Mason Neck, making it hard to compare the two sites; so only the snakes collected in its grassland microhabitat will be compared. *T. sirtalis* (756), *S. occipitomaculata* (123) and *D. punctatus* (88) dominated, with *L. triangulum*, *O. vernalis*, *N. sipedon*, and *C. horridus* also collected. At the two Pennsylvania piedmont sites, *T. sirtalis*, *C. constrictor*, and *P. alleghaniensis* dominated, with a few *D. punctatus*, *H. platirhinos*, *N. sipedon*, and *S. dekayi* present. Only 19 snakes were collected in the Virginia grassland by Mitchell (2014): *C. amoenus* (10), *S. occipitomaculata* (5), *S. dekayi* (4); but Mitchell thought his capture method provided an incomplete estimate of larger species (possibly *Coluber*, *Pantherophis* were missed).

Snakes captured, mostly in the ecotonal border, of Mason Neck's coastal plain field were *Carphophis* (44), *Diadophis* (8), *Heterodon* (4), *S. dekayi* (1), and *T. sauritus* (1). *Coluber* (45) was the most common snake in the open field; but *T. sirtalis* (4) and *Heterodon*, *L. getula*, *O. aestivus* and *Pantherophis* were each caught once (Table 2). *L. getula* and *O. aestivus* are rare in Pennsylvania and have been only reported from the most southeastern counties; and *Carphophis* is only known from the more mountainous and eastern regions of the Commonwealth (Hulse et al., 2001); otherwise the species reported from piedmont Pennsylvania sites are similar residents.

The most comparable study to Mason Neck was that of Meshaka & Delis (2014) at a Franklin County, Pennsylvania locality containing 12 natural or disturbed sites in wetlands, forest, thickets and open field microhabitats. Eight species were recorded, with 2-6 at each microhabitat. The three field habitats yielded six species: *Coluber* (28 individuals), *L. triangulum* (6), *Diadophis* (5), *Agkistrodon* (3), *T. sirtalis* (3), and *Pantherophis* (1). *Coluber* (5), *T. sirtalis* (2), and *L. triangulum* (1) were found in a thicket microhabitat. Three forest sites yielded *Diadophis* (23), *T. sirtalis* (29), *Coluber* (10), *L. triangulum* (5), and *Pantherophis* (2). *T. sirtalis* (38) and *N. sipedon* (16) dominated at two pond sites.

The greater species diversity at Mason Neck's microhabitats (Table 2) reflects our use of differentiated capture techniques and a much longer study. *Carphophis* was the most common snake at both of Mitchell's (2014) microhabitats. This was also true in our woodlands, but

Coluber (not captured by Mitchell) was equally common as *Carphophis* in our field ecotone. Its relative abundance at microhabitats of both studies probably reflects the presence of its major earthworm prey. This may also be true of *S. dekayi* in Mitchell's study. It is surprising that only one *T. sirtalis* was captured by Mitchell, as we found it more generalist in both habitat and diet preference (Tables 2 and 3). In fact, it was the most ubiquitous snake occurring at microhabitats of the Middle Atlantic community studies. Comparison of Meshaka & Delis (2014) and our study indicates that the more diverse the microhabitats at a site, the greater the snake diversity that can be supported.

The Mason Neck snake community through time

A summary of captures of individuals of each snake species between 1982 and 2006 is presented in Table 4. It gives the impression that some species increased in numbers over the period, while others declined. However, there were significant differences in total collections during the three decades which make statistical comparisons difficult and probably invalid.

Snakes were collected on 527 days from 1982-2006, and snakes were found on all days. During the 1980s (89 days, 16.9%), only Ernst was actively researching at Mason Neck, with only very occasional help from a few graduate students. His research then concentrated on the ecology of the turtle, *Terrapene carolina*, and snakes were only secondarily collected as encountered. During the 1990s (185 days, 35.1%), serious snake study began by Ernst and three graduate students (Hartsell, 1993; Creque, 2001; Orr, 2003, 2006). During this decade field trips (including up to 18 students from Ernst's Vertebrate Biology and Herpetology courses at George Mason University) were also taken to Mason Neck. Exact records of how many students and the duration of their collecting each trip were not recorded. However, the great increase in snakes captured then indicates more intense collecting, and is more indicative of the total numbers of both species and their populations present. Study from 2000-2006 (253 trips, 48%) was conducted by Ernst, Creque and Orr, and was the most intense study period. Unfortunately, daily time durations were not recorded. The lack of records of how many persons and the total time spent each trip make exact calculations of changes in snake populations impossible to determine; although generalities can be drawn.

More serious study during the 1990-2006 revealed more individuals of almost all species, and added *L. getula*, *L. triangulum* and *V. valeriae*. The two species not detected from the 1980s were *L. calligaster* and *R. septemvittata*. The six captured *L. calligaster* were recently hatched among their egg shells under a log in deep woodland; indicating reproduction was occurring at Mason Neck, although adults have not been collected. Due to its nocturnal and secretive habits (Ernst & Ernst, 2003), that this snake has not been detected since the 1980s does not mean that it has disappeared from Mason Neck. However, *R. septemvittata* may have had a reduction in numbers since the 1980s. This was a period of "acid rain" in Virginia, which had an adverse effect on the crayfish prey of the snake. But, one

Table 4. Comparison of numbers (N) of individuals captured in each decade of study of 16 species at the Mason Neck National Wildlife Refuge. * = decades of most concentrated study (see text).

Species (N)	1982-1989	1990-1999*	2000-2006*
C. amoenus (551)	105	223	223
C. constrictor (145)	19	75	51
N. sipedon (66)	4	37	25
T. sirtalis (57)	8	22	27
P. alleghaniensis (44)	5	31	8
D. punctatus (43)	3	17	23
T. sauritus (27)	4	15	8
A. contortrix (23)*	8	8	7
V. valeriae (19)	-	5	14
H. platirhinos (12)	4	6	2
S. dekayi (12)	4	3	5
O. aestivus (8)	3	5	-
L. calligaster (6)	6	-	-
L. getula (3)	-	3	-
R. septemvittata (2)	2	-	-
L. triangulum (1)	-	1	-
Total Captures (1019)	**175**	**451**	**393**
Total Species (16)	**13**	**14**	**11**

was found by Orr & Mendoza (2014), so a few probably still exist at the site.

Several snakes were not captured during the 2000's, and this can be attributed to their relative scarcity (*Regina*, the three species of *Lampropeltis*) and the abbreviated collecting period. *O. aestivus* was also not captured by us or by Orr & Mendoza (2014), and may have actually declined. The snake is principally arboreal (Ernst & Ernst, 2003) and may have been missed; but another factor may have negatively affected its numbers. Northern Virginia trees experienced increased destruction by invasive Gypsy moths (*Lymantria dispar*) during the 1980s and early 1990s. Two attempts at reducing the moth population were made at Mason Neck. In 1989, the predatory wasp, *Meteorus pulchricornis*, was released, and during 1991-1995 a pesticide containing the microbe *Bacillus thuringiensis* was aerially sprayed over the refuge. These treatments may have drastically reduced the invertebrate prey of Opheodrys. Although we have no direct proof of this, three commonly found lizards (*Plestiodon fasciatus*, *P. laticeps*, *Scincella lateralis*) and the tree frog (*Hyla cinerea*), all insect predators and previously plentiful at Mason Neck, were reduced to only a few observable individuals during this period. Although anecdotal, this is an indication of the possible effect of such treatments on reptiles whose insect prey has been reduced.

CONCLUSIONS

Mason Neck still maintains a rich, diverse snake fauna due to its five different microhabitats (Table 2) which make available different prey species and ecological niches (Table 3). Such localities containing varied microhabitats are still plentiful in the Middle Atlantic Region; but, if they are to remain available in the future to support rich snake communities, they must be preserved.

ACKNOWLEDGEMENTS

We wish to thank the staff of the Mason Neck National Wildlife Refuge for permission to conduct research on restricted public areas of the Refuge. Quite a few biology students from George Mason University took part in collection trips during the long term study; their help was significant. We especially thank Drs. Walter E. Meshaka, Jr. and Joseph C. Mitchell for generously providing data concerning their snake community studies.

REFERENCES

Arnold, S.J. (1993). Foraging theory and prey-size-predator-size relations in snakes, pp. 87-115. In Seigel, R.A. & Collins, J.T. (Eds.), *Snakes Ecology & Behavior*. New York, NY: McGraw-Hill, Inc.

Brown, W.S. & Parker, W.S. (1976). A ventral-scale clipping system for permanently marking snakes (Reptilia, Serpentes). *Journal of Herpetology* 10: 247-249.

Burbrink, F.T. (2001). Systematics of the eastern rat snake complex (*Elaphe obsoleta*). *Herpetological Monographs* 15:1-53.

Carpenter, C.C. (1952). Comparative ecology of the common garter snake (*Thamnophis s. sirtalis*), the ribbon snake (*Thamnophis s. sauritus*), and Butler's garter snake (*Thamnophis butleri*) in mixed populations. *Ecological Monographs* 22: 235-258.

Creque, T.R. (2001). Composition, growth, and ecology of a snake community at Mason Neck Wildlife Refuge, Northern Virginia. Unpublished Ph.D. dissertation, George Mason University, Fairfax, VA.

Durso, A.M., Wilson, J.D. & Winne, C.T. (2011). Needles in haystacks: Estimating detection probability and occupancy of rare and cryptic snakes. *Biological Conservation* 144:1508-1515.

Elick, G.E. & Sealander, J.A. (1972). Comparative water loss in relation to habitat selection in small colubrid snakes. *American Midland Naturalist* 88:429-439.

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., Creque, T.R., Orr, J.M., Hartzell, T.D. & Laemmerzahl, A.F. (2014). Operating body temperatures in a snake community of northern Virginia. *Northeastern Naturalist* 21:247-258.

Ernst, C.H. & Ernst, E.M. (2003). *Snakes of the United States and Canada*. Washington, D.C.: Smithsonian Institution Press, 668 pp.

Ernst, C.H. & Ernst, E.M. (2011). *Venomous Reptiles of the United States, Canada, and Northern Mexico Volume 1*: Heloderma, Micuroides, Micurus, Pelamis, Agkistrodon, Sistrurus. Baltimore, MD.: The Johns Hopkins University Press, 352 pp.

Ernst, C.H. & Laemmerzahl, A.F. (1989). Eastern hognose snake eats spotted salamander. *Bulletin of the Maryland Herpetological Society* 25:25-26.

Ernst, C.H., Orr, J.M., Creque, T.R., Laemmerzahl, A.F. & Hartsell T.D. (2012). Annual and daily activity of snakes in northern Virginia, USA. *Herpetological Bulletin* 121:23-28.

Fitch, H.S. (1982). Resources of a snake community in prairie-woodland habitat of northeastern Kansas, pp. 83-97. In Scott, N.J. Jr. (Ed.), *Herpetological communities. U.S. Department of the Interior, Fish and Wildlife Service Wildlife Research Report* 13:iii-239.

Gibbons, J.W. (2013). A long-term perspective of delayed emergence (aka overwintering) in hatchling turtles: Some they do and some they don't, and some you just can't tell. *Journal of Herpetology* 47:203-214.

Grant, B.W., Tucker, A.D., Lovich, J.E., Mills, A.M., Dixon, P.M. & Gibbons, J.W. (1992). The use of coverboards in estimating patterns of reptile and amphibian biodiversity, pp. 379-403. In McCullough, D.R. & Barrett, R.H. (Eds.). *Wildlife 2001*. London, England: Elsevier Science Publications.

Hansknecht, K.A., Creque, T.R. & Ernst, C.H. (1999). *Thamnophis sauritus sauritus* (Eastern Ribbon Snake). *Hibernaculum. Herpetological Review* 30:104.

Hartsell, T.D. (1993). Thermal ecology and annual activity cycle of the eastern worm snake, *Carphophis amoenus amoenus*. Unpublished M.Sc. thesis. Fairfax, VA. George Mason University.

Hulse, A.C., McCoy, C.J. & Cenesky, E.J. (2001). Amphibians and Reptiles of Pennsylvania and the Northeast. Ithaca, NY: Cornell University Press, 419 pp.

Klimkiewicz, M.K. (1972). Reptiles of Mason Neck. *Atlantic Naturalist* 27:20-25.

McCoy, C.J. 1982. Amphibians and Reptiles in Pennsylvania: Checklist, Bibliography, and Atlas of Distribution. *Carnegie Museum of Natural History Special Publication* 6:1-91.

Meshaka, W.E., Jr. (2010). Seasonal activity and breeding seasons of snakes from Powdermill Nature Reserve in western Pennsylvania: The importance of site-specific data in land-management programs. *Herpetological Conservation and Biology* 5:155-165.

Meshaka, W.E., Jr., & Delis, P.R. (2014). Snake assemblage structures and seasonal activity patterns on a military base in south-central Pennsylvania: Land management implications for snake conservation. *The Journal of North American Herpetology* 2014:7-20.

Meshaka, W.E., Jr., Marshall, S.D. & Guiher, T.K. (2008). Seasonal activity and reproductive characteristics of an oldfield-grassland snake assemblage: Implications for land management. *Herpetological Bulletin* 105:35-40.

Meshaka, W.E., Jr., Marshall, S.D., Guiher, T.J. & Zemba, L. (2009). Grassland snake assemblages in central and western Pennsylvania and northeastern Ohio, USA. *Herpetological Bulletin* 110:8-19.

Mitchell, J.C. (1994). The Reptiles of Virginia. Washington, D.C.: Smithsonian Institution Press, 352 pp.

Mitchell, J.C. (2014). Amphibians and reptile communities in hardwood forest and old field habitats in the Central Virginia Piedmont. *Banisteria* 43:79-89.

Orr, J. & Mendoza, L. (2010). Herpetofaunal survey of Mason Neck State Park and Mason Neck National Wildlife Refuge. *Catesbeana* 31:59-72.

Orr, J.M. (2003). Microhabitat use by the Eastern Worm Snake, *Carphophis amoenus*. Unpublished M.Sc. thesis, Fairfax, VA.: George Mason University.

Orr, J.M. (2006). Microhabitat use by the eastern worm snake, *Carphophis amoenus*. *Herpetological Bulletin*. 97:29-35.

Reinert, H.K. (1993). Habitat selection in snakes, pp. 201-240. In Seigel, R.A. & Collins, J.T. (Eds.) *Snakes Ecology & Behavior*. New York, NY.: McGraw-Hill, Inc.

Vitt, L.J. (2001). Communities, pp. 335-365. In Seigel, R.A., Collins, J.T. & Novak, S.A. (Eds.) *Snakes, Ecology and Evolutionary Biology*. Caldwell, NJ.: The Blackburn Press.

Accepted: 29 December 2015

The Herpetological Bulletin 135, 2016: 24-25

Leptophis ahaetulla marginatus: Parrot snake reproduction data

JULIANA LEHN LINARDI

Centro de Conservação de Fauna Silvestre, Companhia Energética de São Paulo. Avenida Brasil Norte, s/n, Ilha Solteira, São Paulo, Brazil.
Email: juliana.linardi@cesp.com.br

Leptophis ahaetulla marginatus (Cope, 1862) is a small colubrid (14.0g±2.1) with diurnal and semiarboreal habits. Although this snake is known to eat small lizards, lizard tails, young birds, and bird eggs, it primarily consumes anurans, 90% of which belong to *Scinax* genera (Albuquerque et al. 2007). *L. a. marginatus* is found throughout South America, southeastern Bolivia, Uruguay, Paraguay and Brazil, particularly the states of Mato Grosso, Mato Grosso do Sul and São Paulo (Albuquerque 2008, Bernils 2012). *L. a. marginatus* is neither on the International Union for Conservation of Nature List - IUCN List (IUCN 2014) or the Brazilian Red List (Machado et al. 2008), and is currently classified in the "Least Concern" category on the São Paulo State red list (Bressan et al. 2009).

The present observations were made on 2nd February 2012, in a lowland area in the city of Promissão in São Paulo State, Brazil, where the Marsh Deer Conservation Center is located. In this area, several adult individuals were frequently seen in bushes and trees, and also inside houses and barns. In one property (21°18'21.69"S 49°47'53.32"O), a barn brick wall had been demolished and a clutch of 49 eggs discovered inside a cement brick (39 x 19 x 14 cm) at 60 cm above the ground. The eggs were found adhered to each other on a thin bed of sand and dried leaves, but not adhered to the brick. The nest entrance was not discovered. Only 12 out of 49 eggs were healthy and viable. 37 eggs were moldy and non-viable. A necropsy exam on one egg showed an embryo in its final stage of development. The remaining 11 eggs were incubated in a terrarium with humidified sand and polystyrene foam plate, maintained at 27 - 31°C between 61 and 91 percent humidity. In 15 days, 10 out of 11 neonates hatched successfully. Measurements including total length, tail and head length, and head width were obtained with a tape measure and caliper rule; body weight was measured with Pesola spring scales. One of the 10 hatchlings presented a tail deformity which was curved and smaller; therefore, its measurements were not included in the final data. The biometry of the nine neonates is listed in Table 1.

The neonates were not sexed. The hatched neonates presented a similar colour pattern to that of the adults, but more grey. All hatchlings were released at the location they were collected. The clutch found in this report differs from previous publications with a greater number of eggs. Twelve were probably from a single female since they were adhered to each other and in the same stage of development. Rand (1969) reported small *L. ahaetulla* egg clumps of two, three and four eggs, but did not indicate if they were from one or multiple females. In addition, the neonates biometry was smaller compared to our data. More recently Cruz Lizano et al., (2013) reported clutches of 5 eggs and Albuquerque (2008) described two *L. a. marginatus* females with nine and ten well developed eggs in her oviduct. Cruz Lizano (2013) reported the hatching period in Costa Rica is from May to November after approximately a 89 day incubation. Our data indicate the hatching period of the *L. a. marginatus* in western São Paulo State region can extend to February and that this species occupies lowlands and anthropized areas. *L. a. marginatus* females possibly visit their own or a different nest site for egg laying in the same season or throughout the year.

Table 1. Biometry (TTL-total length in cm; TLL-tail length in cm; HDL-head length in cm; HDW-head width in cm; and BDW-body weight in g) and analysis (MI-minimum; MA-maximum; ME-media; SD-standard deviation; VC-variation coefficient) of nine *L. a. marginatus* neonates.

Specimen	TTL	TLL	HDL	HDW	BDW
1	32,5	12,0	1,2	0,5	1,5
2	32,0	10,5	1,1	0,5	2,4
3	34,2	12,5	1,1	0,4	2,5
4	31,4	11,9	1,1	0,5	1,2
5	30,3	10,9	1,2	0,5	2,0
6	32,6	12,4	1,2	0,4	2,2
7	32,2	12,2	1,2	0,5	2,6
8	31,5	11,8	1,1	0,4	2,2
9	29,5	10,1	1,2	0,5	2,0
MI	29,5	10,1	1,1	0,4	1,2
MA	34,2	12,5	1,2	0,5	2,6
ME	31,8	11,6	1,2	0,5	2,1
SD	1,4	0,9	0,1	0,1	0,5
VC	4,3	7,5	4,6	10,7	22,3

REFERENCES

Albuquerque, N. R., Galatti, U. & Di-Bernardo, M. (2007). Diet and feeding behaviour of the neotropical parrot snake (*Leptophis ahaetulla*) in northern Brazil. *Journal of Natural History* 41: 1237-1243.

Albuquerque, N. R. (2008). Revisão taxonômica das subespécies de *Leptophis ahaetulla* (Linnaeus, 1758) (Serpentes, Colubridae). Unpublished PhD Thesis. Pontifícia Universidade Católica do Rio Grande do Sul.

Bernils, R. S. & Costa, H. C. (2012). Brazilian reptiles: List of species. Version 2012.1. Eletronic Database accessible at http://www.sbherpetologia.org.br/. Sociedade Brasileira de Herpetologia. (Accessed: 2014, October 31).

Bressan, P. M., Kierulff, M. C. M. & Sugieda, A. M (coord.). (2009). *Fauna Ameaçada de Extinção no Estado de São Paulo: Vertebrados*. São Paulo: Fundação Parque Zoológico de São Paulo, Secretaria do Meio Ambiente. 648 pp.

Cruz-Lizano, I., Gonzalez-Maya, J. F. & Escobedo-Galván, A. H. (2013). *Leptophis ahaetulla* (giant parrotsnake) reproduction. *Herpetological Review* 44: 332.

IUCN. (2014). The IUCN Red List of Threatened Species. Version 2014.2. URL: www.iucnredlist.org.

Machado, A. B. M., Drummond, G. M., & Paglia, A. P. (2008). Livro vermelho da fauna brasileira ameaçada de extinção. Brasília and Belo Horizonte:Ministério do Meio Ambiente and Fundação Biodiversitas. v II, 908 pp.

Rand, A. S. (1969). *Leptophis ahaetulla* eggs. *Copeia* 1969: 402-402.

Accepted: 1 October 2015

The Herpetological Bulletin 135, 2016: 26-27

Observations of oviposition and calling in Cuban treefrogs, *Osteopilus septentrionalis*, from The Bahamas

GEOFFREY R. SMITH[1] & JOHN B. IVERSON[2]

[1]Department of Biology, Denison University, Granville, OH 43023 USA
[2]Department of Biology, Earlham College, Richmond, IN 47374 USA
[1]Corresponding author email: smithg@denison.edu

Cuban Treefrogs (*Osteopilus septentrionalis*) are potential threats to native amphibians and reptiles as competitors or predators of native species (see Meshaka, 2001). The known distribution of the Cuban Treefrog has been expanding in recent years as introduced populations are documented (e.g., Kraus, 2009), and further expansion is likely with projected climate changes (Rödder & Weinsheimer, 2009).

Knowledge of the reproduction and the timing of reproduction of Cuban Treefrogs throughout their native and introduced ranges might be useful in understanding their ability to expand their range. However, published observations on the timing of reproduction in the Cuban Treefrog are somewhat rare, especially given their rapidly expanding range. Cuban Treefrogs typically breed in temporary pools, and breeding appears associated with rainfall or thunderstorms (e.g., Meshaka, 2001; Henderson & Powell, 2009), and can take place over an extended range of months (see Meshaka, 2001; Henderson & Powell, 2009).

We report observations on the reproduction of Cuban Treefrogs in the northern Exuma Islands, The Bahamas. While conducting a population census of Allen Cays Iguanas (*Cyclura cychlura inornata*) as part of a long-term monitoring program, we made observations related to the reproduction of Cuban Treefrogs on Leaf Cay (24.75°N, 76.84166°W; see Iverson et al., 2004 for additional description). On 18 May 2015 we observed Cuban Treefrog tadpoles (≈ 0.5-0.75 cm in body length) in shallow puddles formed in holes and depressions in the limestone close to the splash zone. These puddles were relatively shallow (water depth ≈ 10 – 20 cm). On 19 May 2015 we observed new Cuban Treefrog egg masses in multiple (> 5) shallow puddles in the same vicinity of the tadpoles seen on 18 May 2015. We heard calling by the Cuban Treefrogs on the evenings of both 18 and 19 May 2015. It rained throughout the day on 18 May, and there was also rain on 19 May.

The timing of reproduction on Leaf Cay is consistent with the range of breeding times of Cuban Treefrogs in other locations in The Bahamas. Meshaka (2001) documented oviposition on New Providence from March-November, with calling being continuous during that period. Oviposition and calling on Grand Bahama was observed from March-September (Meshaka, 2001). Smith et al. (2009) observed metamorphs and a range of tadpole stages on Southwest Allens Cay on 14 May 2008.

Our observations of the use of shallow water, and the successful production of tadpoles in such pools is consistent with previous observations. Cuban Treefrogs frequently breed in shallow water that is often quite warm, and indeed they are often not observed in pools < 30°C mean afternoon temperature (Meshaka, 2001). Their larvae can also apparently tolerate very warm water of ≥ 41°C (Meshaka, 2001), which is likely to be the case in the pools we observed on Leaf Cay. Furthermore, the salinity in some of these pools must have been quite high given the salty crust deposits along the margin of some of the pools. Previous observations suggest that Cuban Treefrog eggs can tolerate exposure to salty water (Powell et al., 2005).

Cuban Treefrogs only recently arrived in the Allen Cays. They were not observed in a survey of the Exumas done during 1990-1992 (Franz et al., 1993), and we first observed them on Southwest Allen's Cay in May 2001, with successful breeding first observed in 2008 (Smith et al., 2009). The observations reported here, to our knowledge, represent the first observation of Cuban Treefrogs on Leaf Cay in the northern Exumas, only the sixth record for the entire 365-island chain of the Exumas (see Buckner et al., 2012), the first observation of oviposition in the Allen Cays and the Exumas, and the first report of calling in the Exumas.

ACKNOWLEDGMENTS

We thank Mrs. Sandra Buckner, the Bahamas National Trust, the Bahamas Department of Agriculture, Bahamas Environment, Science and Technology Commission, and 7 C's Charters. Financial support provided by the late Dr. Ned and Sally Test, the Cope Museum Fund of Earlham College, and Denison University (Horizon Fund, Battelle Fund).

REFERENCES

Buckner, S.D., Franz, R. & Reynolds, R.G. (2012). Bahama Islands and Turks & Caicos Islands. *Bulletin of the Florida State Museum of Natural History* 51: 93-110.

Franz, R., Dodd, C.K. Jr. & Buden, D.W. (1993). Distributional records of amphibians and reptiles from the Exuma Islands, Bahamas, including the first reports of a freshwater turtle and an introduced gecko. *Caribbean Journal of Science* 29: 165-173.

Henderson, R.W. & Powell, R. (2009). *Natural History of West Indian Reptiles and Amphibians*. Gainesville, University Press of Florida, 520 pp.

Iverson, J.B., Hines, K.N. & Valiulis, J.L. (2004). The nesting ecology of the Allen Cays rock iguana, *Cyclura cychlura inornata* in the Bahamas. *Herpetological Monographs* 18: 1-36.

Kraus, F. (2009). *Alien Reptiles and Amphibians. A Scientific Compendium and Analysis*. Dordrecht, Springer, 563 pp.

Meshaka, W.E. Jr. (2001). *The Cuban Treefrog in Florida: Life History of a Successful Colonizing Species*. Gainesville, University Press of Florida, 191 pp.

Powell, R., Henderson, R.W. & Parmerlee, J.S. Jr. (2005). Reptiles and Amphibians of the Dutch Caribbean: St. Eustatius, Saba, and St. Maarten. St. Eustatius National Parks Foundation, Gallows Bay, St. Eustatius, Netherlands Antilles.

Rödder, D. & Weinsheimer, F. (2009). Will future anthropogenic climate change increase the potential distribution of the alien invasive Cuban treefrog (*Anura: Hylidae*)? *Journal of Natural History* 43: 1207-1217.

Smith, G.R., Pieper, L. & Iverson, J.B. (2009). *Osteopilus septentrionalis*. Reproduction. *Herpetological Review* 40: 207.

Accepted: 3 November 2015

Feeding observation on *Bothriechis marchi* in Parque Nacional Cusuco, Honduras

JOSE MARIO SOLIS[1,2,3,*] & TOM BROWN[2]

[1]Facultad de Ciencias, Escuela de Biología, Universidad Nacional Autónoma de Honduras, Departamento de Francisco Morazán, Tegucigalpa, Honduras
[2]Wallacea, Hope House, Old Bolingbroke, Lincolnshire PE23 4EX, UK
[3]Red Mesoamericana y del Caribe para la Conservación de Anfibios y Reptiles (MesoHERP), Honduras
[*]Corresponding author email: jm9biol@yahoo.es

INTRODUCTION

The geographic distribution of the green Palm-Viper genus *Bothriechis* is from south-eastern Oaxaca, Mexico, southward through Central America and into South America as far as south-western Venezuela, east of the Andes and north-western Peru west of the Andes, (McCranie 2011; Wallach, et al., 2014). The little-studied endemic Palm-Viper from Honduras, *Botrhiechis marchi sensu lato*, occurs in disjunct populations at low, moderate, and intermediate elevations on the Atlantic versant from north-western to northcentral, on localities as the Cordillera Nombre de Dios, Cordillera de Merendon, and Sierra Sulaco, (Köhler, 2009; McCranie, 2011; Townsend et al., 2013). This moderate-size pit-viper is relatively slender, essentially uniformly coloured (in adults, blotched in juveniles), arboreal (rarely seen on the ground), with a relatively long prehensile tail, (Campbell and Lamar, 2004; McCranie, 2011) may utilise a variety of microhabitat when hunting or resting, also found in vegetation above streams or rivers (1-2m high) and crawling across boulders in streambeds, (McCranie, 2011; Townsend and Wilson, 2008). In this note we report on three observations of predation by this snake in the cloud forest at Parque Nacional Cusuco, located between the departments of Cortes and Santa Barbara in north-western of Honduras, (Townsend and Wilson, 2008).

The Mexican mouse *opossum Marmosa mexicana* is widely distributed across tropical and subtropical forests and shrubby habitats below 1,600 m elevation from Mexico to Panama. (Rossi et al., 2010). The Mexican deer mouse, *Peromyscus mexicanus* occurs from Mexico, along the Atlantic coast, from south San Luis Potosí to the Isthmus of Tehuantepec, and along the Pacific coast, from the Guerrero-Oaxaca border to central Chiapas; the upper foothills and middle elevation mountains in Guatemala, through El Salvador, Honduras, and Nicaragua, to the highlands of Costa Rica and west Panamá (Chiriquí region), (Musser and Carleton, 2005). *Plectrohyla dasypus*, is an endemic moderate sized tree-frog, that is known from 1300 to 1900 m elevation in the lower montane wet forest formation in the Sierra de Omoa of northwestern of Honduras, (McCranie and Castañeda, 2007; Townsend and Wilson, 2008).

Figure 1. Sub-adult *B. marchi* (ca. 600 mm approximate SVL) predating on a *P. mexicanus* in El Parque Nacional Cusuco, Honduras. Photograph: T. Brown.

Figure 2. Sub-adult *B. marchi* (ca. 400 mm approximate SVL) predating on a *P. dasypus* in El Parque Nacional Cusuco, Honduras. Photograph: T. Brown.

OBSERVATIONS

No previous studies have described the natural diet of *B. marchi*. Our first observation was made on 15th July 2013, around 06:25hrs, when the first author observed and photographed an adult *B. marchi* (ca. 800mm total length) taken by the head and trying to swallow one *M. mexicana*, the snake was on the ground in the middle of the path at El Danto Camp (15 31 40.8 N, 88 16 41.7 O, 1562 m above the see level). The second observation was on 25th July 2013 at 20:36, when the second author observed and photographed a sub-adult *B. marchi* (ca. 600mm total length) in the process of eating one *P. mexicanus*, (Fig. 1), alongside a stream at El Danto Camp (15 31 29.5 N, 88 16 36.3 O, 1565m above the see level), the individual was roughly 2 meters above ground level; loosely coiled in an open, sparsely vegetated, low branching tree. The third observation was made on 30th June 2015, at around 16:04hrs, when the second author photographed a sub-adult *B. marchi* (ca. 500mm total length) predating a *P. dasypus metamorph*, at Guanales Camp (15 29 21.6 N, 88 14 01.9 O, 1271m above the see level). The frog emerged from a stream on a branch in front of the viper when it was grasped and held (Fig. 2).

To the best of our knowledge these are the first recorded instances of *B. marchi* predating on small mammals (*M. mexicana* and *P. mexicanus*), and also this is the first confirmed predation on frogs of the genus *Plectrohyla*. The indication of dietary diversification within this species diet is promising for its long-term survival, and improves or knowledge of this species.

ACKNOWLEDGEMENTS

We sincerely thank Operation Wallacea for their great support. We are also grateful to Roberto Downing and Marcial Erazo of Expediciones Cusuco for all the logistics. A special thanks to Operation Wallacea's dedicated members of staff; Jonathan Kolby, Sara Ramirez, Dr. Steve Green and Dr. Neil Reid (*P. mexicanus* identification) and the first author wants to dedicate this to Kaelyn A. Jenny for their inspiration and her great support.

REFERENCES

Campbell, J.A. & Lamar, W.W. (2004). *The Venomous Reptiles of the Western Hemisphere*. Comstock. Publ. Assoc., Ithaca, New York. Vol. I:i-xviii, 1-476.

Kohler, G. (2009). *Reptiles of Central America*. Herpetonon. Offenbach, Germany. 361 pp.

McCranie, J.R. & Castañeda, F.E. (2007). *Guía de Campo de los Anfibios de Honduras*. Bibliomania, Salt Lake City, Utah. USA. x + 304 pp.

McCranie, J.R. (2011). The Snakes of Honduras. Systematics, Distribution, and Conservation. Society for the Study of Amphibians and Reptiles. *Contributions to Herpetology* 26: 1–714.

Musser, G.G., & Carleton, M.D. (2005). Superfamily *Muroidea*. Pp. 894–1531 in *Mammal Species of the World: a Taxonomic and Geographic Reference* (D.E. Wilson & Reeder, D.M. eds.). 3rd ed. Johns Hopkins University Press, Baltimore, Maryland.

Rossi, R.V., Voss, R.S. & Lunde, D.P. (2010). A revision of the *didelphid marsupial* genus *Marmosa*. Part 1. The species in Tate's "Mexicana" and "Mitis" sections and other closely related forms. *Bulletin of the American Museum of Natural History* 334: 1–83.

Townsend, J.H., & Wilson, L.D (2008). *The Amphibians & Reptiles of Cusuco National Park, Honduras*/ Los Anfibios y Reptiles del Parque Nacional Cusuco, Honduras. Bibliomania, Salt Lake City, Utah. USA. x + 322.

Townsend, J.H., Medina-Flores, M., Wilson, L.D., Jadin, R.C. & Austin, J.D. (2013). A relict lineage and new species of green palm-pitviper (Squamata, Viperidae, Bothriechis) from the Chortís Highlands of Mesoamerica. *ZooKeys*: 77–105. http://dx.doi.org/10.3897/zookeys.298.4834.

Wallach, V., Williams, K. L., & Boundy, J. (2014). *Snakes of the World: Catalogue of the Living and Extinct Species*. Taylor and Francis, CRC Press, 1237 pp.

Accepted: 11 November 2015

Interspecific amplexus between male *Rhacophorus prominanus* and female *Polypedates leucomystax* from Peninsular Malaysia

SHAHRIZA SHAHRUDIN

School of Pharmaceutical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia
Email: shahriza20@yahoo.com

Polypedates leucomystax, the four-lined tree frog, is a common species of frog, which can be characterised by having a distinct tympanum, a supratympanic fold extending from eye to shoulder, and often possessing four longitudinal dorsal stripes (Berry, 1975). It is a moderate to large-sized species of Rhacophorid, having a snout-vent length (SVL) between 37-50 mm for males and 57-75 mm for females (Grismer, 2011). Distributed throughout Bangladesh, Brunei, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Singapore, Thailand and Vietnam (IUCN, 2015). *Rhacophorus prominanus* is a medium-sized tree frog, with a snout-vent length of males and females reaching up to 62 and 75 mm respectively (Amphibia My, 2009). Commonly, *R. prominanus* inhabits primary rainforest or clearings near primary forest (Berry, 1975), while *P. leucomystax* can be encountered in lowland or disturbed forests (Ibrahim et al., 2008; Grismer, 2011), and also around human habitations (Berry, 1975; Ibrahim et al., 2008; IUCN, 2015). Both species spawn their eggs in the moisture of foam nests (IUCN, 2015; Ibrahim et al., 2008). Typically *R. prominanus* breeds in small forest pools and puddles, including the beds of intermittent streams (IUCN, 2015). The latter species breeds around water tanks, rain water puddles or on vegetation overhanging the small pools of water (Berry, 1975).

Reports of interspecific amplexus have been documented in various frog species worldwide (Rangel, 2013; Stynoski et al., 2013; Vivek et al., 2014; Sodre et al., 2014) but none for frogs from Peninsular Malaysia. In this paper, interspecific amplexus between a male *R. prominanus* and female *P. leucomystax* is reported for the first time.

On 6 December 2014, between 2100-2200 hours, the amplexed pair of male *R. prominanus* and female *P. leucomystax* were observed at Sungai Sedim Receational Forest, Kedah, Malaysia (5˚ 25'N, 100˚ 46'E; elevation < 200 m asl) (Fig. 1). The frogs were sitting on dead leaves, approximately 1.5 meter from a rock pool. The moderate-sized rock pool is about 4-5 m length, 2-3 m width and 5-50 cm depth, and exposed directly to the sunlight. Low vegetation (< 1 m tall) and creeping plants bordered the pool. The bed of the pool was composed of sand and gravel and covered by leaf litter and twigs. Air temperature and humidity at the site was 23ºC and 76% respectively.

This amplexed pair exhibited axillary amplexus. The chin and belly of *R. prominanus* were flattened and touched the dorsal part of *P. leucomystax*. The female *P. leucomystax* was in normal posture but its belly was slightly in contact with the substrate. The cloaca of the male frog was positioned on top of the female cloaca and the eyes of both species were fully opened. After approximately one minute in motionless posture, the amplexed pair moved away to the nearest rock pool. We captured the frogs and measured their snout-vent length (SVL) (RP=47 mm, PL=60 mm) and mass (W) (RP=8 g, PL=15 g) using digital calliper and electronic balance.

Figure 1. Interspecific amplexus between male *R. prominanus* and female *P. leucomystax.*

During courtship, the male frogs emitted advertisement calls, which are species-specific to attract conspecific females (Duellman & Trueb, 1986; Wells, 2007; Kuramoto & Dubois, 2009). Differences in anuran advertisement calls can reduce interspecific mating (Wells, 2007), however the advertisement call of a male can be interrupted by a noisy environment or interfered with by the calls of other species, which may lead to the interspecific amplexus. Other factors, including overlapping in reproduction activities (Hobel 2005), smaller number of females (Wogel et al, 2005), confusion of chemical signal (Mollov et al, 2010), low selectivity toward females (Machado & Bernarde, 2011), long-term absence of conspecific females (Vivek et al, 2014) and explosive breeding (Machado & Bernarde, 2011; Vivek et al, 2014) may also contribute.

ACKNOWLEDGEMENTS

I thank the Universiti Sains Malaysia, Penang for the facilities and amenities. This research project was funded by Universiti Sains Malaysia, Short Term Grant (304/PFARMASI/6312127).

REFERENCES

Amphibia My (2009). Amphibians and Reptiles of Peninsular Malaysia. <http://amphibia.my>. Downloaded on 25 November 2015.

Berry, P.Y. (1975). *The Amphibians Fauna of Peninsular Malaysia*. Tropical Press, Kuala Lumpur. 133 pp.

Duellman, W.E. & Trueb, L. (1986). *Biology of Amphibians*. McGraw-Hill. New York. 670 pp.

Grismer, L.L. (2011). *Amphibians and Reptiles of the Seribuat Archipelago*. Edition Chimaira, Frankfurt. 239 pp.

Hobel, G. (2005). *Rana palustris* (Pickerel Frog) and *Ambystoma maculatum* (Spotted Salamander) Reproduction Behavior. *Herpetological Review* 36: 55-56.

Ibrahim, H.J., Shahrul Anuar, M.S., Norhayati, A., Chan, K.O. & Mohd Abdul Muin, M.A. (2008). *The Common Amphibians and Reptiles of Penang Island*. The State Forestry Department of Penang. 116 pp.

IUCN (2015). The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>. Downloaded on 04 March 2015.

Kuramoto, M. & Dubois, A. (2009). Bioacoustic Studies on Three Frog Species from the Western Ghats, South India. *Current Herpetology* 28: 65-70.

Machado, R.A. & Bernarde, P.S. (2011). Multiple and Heterospecific Amplexi Between the Toads *Rhaebo guttatus* and *Rhinella marina* (Anura: Bufonidae). *Herpetology Notes* 4: 167-169.

Mollov, I.A. (2010). Cases of Abnormal Amplexus in Anurans (Amphibia: Anura) from Bulgaria and Greece. *Biharean Biologist* 4: 121-125.

Rangel, G.F.M. (2013). *Leptodactylus fuscus* (Rufous frog) and *Elaschistocleis ovalis* (Oval Frog) Reproductive Behaviour. *Herpetological Review* 44: 123.

Sodre, D., Martins, A.A.V. & Vallinoto, M. (2014). Heterospecific Amplexus Between the Frog *Leptodactylus macrosternum* (Anura: Leptodactylidae) and the Toad *Rhinella cf. granulosa* (Anura: Bufonidae). *Herpetology Notes* 7: 287-288.

Stynoski, J.L., Castro, E. & Ramirez, O.V. (2013). *Rhaebo haematiticus* (Litter Toad) and *Craugastor fitzingeri* (Fitzingers Rain Frog) Reproductive Behavior. *Herpetological Review* 44: 129-130.

Vivek, S., Dinesh, M., Kumar, K.R., Divaker, Y. & Sharma, K.K. (2014). Interspecies Mating Interactions Between *Duttaphrynus stomaticus* (Marbled Toad) and *Sphaerotheca breviceps* (Indian Burrowing Frog) at the Central Aravalli Foothills, Rajasthan, India. *Herpetology Notes* 7: 139-140.

Wells, K. D. (2007). *The Ecology and Behavior of Amphibians*. Chicago and London. The University of Chicago Press. 1400 pp.

Wogel, H., Abrunhosa, P.A. & Pombal-Junior, J.P. (2005). Breeding Behaviour and Mating Success of *Phyllomedusa rohdei* (Anura, Hylidae) in South-eastern Brazil. *Journal of Natural History* 39: 2035-2045.

Accepted: 26 November 2015

New locality of *Salamandra algira* in Algeria

KHALED MERABET*, MOKRANE KARAR, ABDELHAK DAHMANA & AISSA MOALI

Laboratoire de Recherche en Ecologie et Environnement, Faculté des Sciences de la Nature et de la Vie, Université de Bejaia, 06000 Bejaia, Algeria.
*Corresponding author email: kaled.merabet@gmail.com

The North African *Salamandra algira* is confined to the humid and sub-humid forests of Algeria and Morocco and Spain (Ceuta) in the form of isolated populations that have many genetic differences (e.g. Beukema et al., 2013; Escoriza et al., 2006; Escoriza & Ben Hassine, 2014a). Its presence in Tunisia is doubtful (Bogaerts et al., 2013) but its presence in Algeria has been reported by several authors (see Escoriza & Ben Hassine, 2014b) including in coastal areas, for example, Annaba, Kabylia, Blida Atlas and Oran (Bons, 1972; Veith, 1994). Escoriza & Ben Hassine (2014b) additionally reported a new area of occurrence based on two breeding sites found around the village of Zitouna (Wilaya of Skikda). During field work (12 April 2014) in the newly reported area, we discovered a new locality for the species at Talmous (36.7755156 N, 6.7563405 E) located 733 m above sea level. Five larvae (one individual is shown in Fig. 3) were found in a small stream situated in oak forest (Fig. 2).

As already reported by Escoriza & Ben Hassine (2014b) this region should represent a continuous area of occurrence as it contains suitable conditions for this species, moreover this new record is situated between two localities where the species is known to occur, namely Zitouna and Edough massif (40 Km and 70 Km respectively) as shown in the Fig. 1.

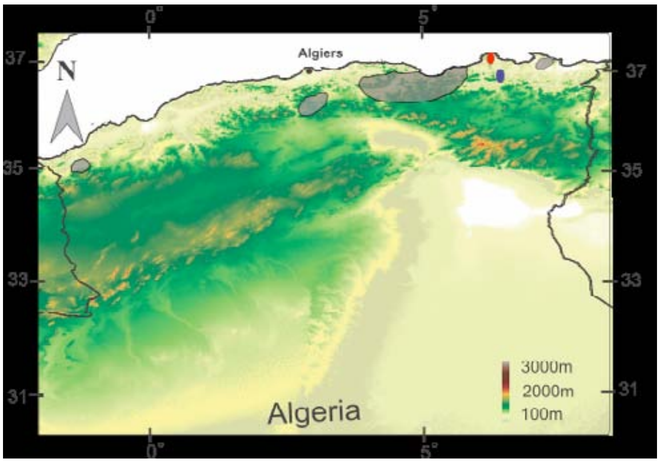


Figure 1. Distribution map of *S. algira Bedriaga*, 1883 in Algeria. Grey area, distribution according to Donaire et al., (2009). The red dot, the recent record provided by Escoriza & Ben Hassine (2014b). Blue dot, is the new site found.

Figure 2. Habitat of *S. algira* in Talmous (Skikda)

Figure 3. Larvae of *S. algira* found in Talmous

REFERENCES

Bogaerts, S., Donaire Barroso, D., Pasmans, F., Böhme, W. & Carranza, S. (2013). Do North African Fire Salamanders, Salamandra algira, occur in Tunisia? *Herpetology Notes* 6: 301-306.

Beukema, W., de Pous, P., Donaire-Barroso, D., Bogaerts, S., García -Porta, J., Escoriza, D., Arribas, O.J., El Mouden, E.H. & Carranza, S. (2013). Review of the systematics, distribution, biogeography and natural history of Moroccan amphibians. *Zootaxa* 3661: 1-60.

Bons, J. (1972). Herpétologie Marocaine 1. Liste commentée des amphibiens et reptiles du Maroc. *Bulletin de la Société des Sciences Naturelles et Physiques du Maroc* 52: 107-126.

Escoriza, D., Comas, M.M., Donaire, D. & Carranza, S. (2006). Rediscovery of *Salamandra algira Bedriaga*, 1883 from the Beni Snassen massif (Morocco) and phylogenetic relationships of North African Salamandra. Amphibia-Reptilia 27: 448-455.

Escoriza, D. & Ben Hassine, J. (2014a). Microclimatic variation in multiple *Salamandra algira* populations along analtitudinal gradient: phenology and reproductive strategies. *Acta Herpetologica* 9: 33-41.

Escoriza, D. & Ben Hassine, J. (2014b). *Salamandra algira* (North African fire salamander): New distribution area in Algeria. *Herpetological Bulletin* 128: 24-25.

Donaire-Barroso, D., Martínez-Solano, I., Salvador,A., García-París, M., Recuero, E.G., Slimani, T., El Mouden, E.M., Geniez, P., Mateo, J. (2009). *Salamandra algira*. The IUCN Red List of Threatened Species 2009: e.T59464A11927380. http://dx.doi.org/10.2305/IUCN.UK.2009.RLTS.T59464A11927380.en. Downloaded on 01 December 2015

Veith, M. (1994). Morphological, molecular and life history variation in *Salamandra salamandra* (L). *Mertensiella* 4: 355-397.

Accepted: 2 December 2015

Evidence of malformation in the European cave salamander, *Hydromantes flavus*

ENRICO LUNGHI[1,2,3,*], MARCO MULARGIA[4], MANUELA MULARGIA[4]

[1]Universität Trier Fachbereich VI Raum- und Umweltwissenschaften Biogeographie, Campus I, Gebäude N Universitätsring 15, 54286 Trier, Germany
[2]Natural Oasis, Via di Galceti 141, 59100 Prato, Italy
[3]Museo di Storia Naturale dell'Università di Firenze, Sezione di Zoologia "La Specola", Via Romana 17, 50125 Firenze, Italy
[4]Speleo Club Nuoro. Via Tunisi 3, 08100 Nuoro Italy
[*]Corresponding author email: enrico.arti@gmail.com

The Mont Albo cave salamander *Hydromantes flavus* (see Wake, 2013) is one of eight European cave salamander species, most of which are endemic to Italy (Lanza et al., 2006a). Three species are distributed in continental Italy and in south-eastern France, whilst five species, including *H. flavus*, are endemic to Sardinia (Lanza et al., 2006b). The distribution of *H. flavus* is restricted to the Mount Albo massif (Lanza et al., 2006b). Similar to other *Hydromantes* species, the Mount Albo cave salamander is usually found in habitats characterised by high moisture and cold temperatures (Lanza et al., 2006a); therefore, it is not difficult to find this species in hypogean habitats (Ficetola et al., 2012; Lunghi et al., 2015).

European *Hydromantes* are characterised by regeneration abilities that allow recovery of excised body parts (Salvidio, 1997; Scaravelli et al., 2002). The ability to regenerate enables reproduction of body parts including retaining the function (Straube & Tanaka, 2006). Regeneration represents a very complex developmental stage, during which salamanders have to deal with several factors (i.e. predators, genetics, pollution, parasites), which may induce malformations (Blaustein & Johnson, 2003; Bowerman et al., 2010). Some of the most common malformations affect limbs, toes and tail, which does not always compromise the survival of the individual (Williams et al., 2008). Irregular tail regeneration in European cave salamanders has already been observed by Salvidio (1997) but did not report the instance of a forked tail.

In September 2015, during a survey on Mount Albo nine individuals of *H. flavus* were found in a small cave located in Siniscola district. A female found in the middle of the cave, had almost half of the tail forked (Fig. 1a-b). The following morphometric features were taken: SVL = 7.5 cm; upper part of tail (length from cloaca to the fork) = 3.2 cm; dorsal length of the left part of the fork = 2.1 cm, dorsal length of the right part of the fork = 2.2 cm; forelimb length = 2.4 cm; hindlimb length = 2.1 cm; head length = 1.8 cm; head width = 1.4 cm. Except for the tail, all measures are within the range of those known for the species (Lanza et al., 1995).

The left part of the tail was the same colour as the rest of the body, while the background colour of the right was lighter (Fig. 1b); no differences were detectable on the ventral side of the tail (Fig. 1c). The salamander was able to move both parts of the fork; the shape of the left was regular except for the last portion (about 5 mm) which appeared poorly developed (Fig. 1b), while the right was normal, but showing a peculiar posture terminally (Fig. 1a-c). Moreover, the tail showed several irregularities on its shape (Fig 1a) possibly suggesting past stressful events. The female was found to be in good health and was gravid: six eggs were visible through her abdominal wall.

Figure 1. Female of *H. flavus* with forked tail (a). Details of the upper part of the fork (b) and of the lower part (c).

ACKNOWLEDGEMENTS

We thank C. Corti, G. F. Ficetola and R. Manenti for suggestions and for an early review of the manuscript. We also thank two reviewers for improvements to our manuscript with their recommendations. The permit to handle *Hydromantes* species has been issued by the Italian Ministero dell'Ambiente e della Tutela del Territorio e del Mare: Prot. n. 9384/PNM, 12/05/2015.

REFERENCES

Blaustein, A.R. & Johnson, P.T.J. (2003). The complexity of deformed amphibians. *Frontiers in Ecology and the Environment* 1: 87-94.

Bowerman, J., Johnson, P.T.J. & Bowerman, T. (2010). Sublethal predators and their injured prey: linking aquatic predators and severe limb abnormalities in amphibians. *Ecology* 91: 242-251.

Chiari, Y., Van der Meijden, A., Mucedda, M., Lourenc,J.M., Hochkirch, A. & Veith, M. (2012). Phylogeography of Sardinian cave salamanders (Genus *Hydromantes*) is mainly determined by geomorphology. *PLoS ONE 7*: e32332.

Ficetola, G.F., Pennati, R. & Manenti, R. (2012). Do cave salamanders occur randomly in cavities? An analysis with *Hydromantes strinatii*. *Amphibia-Reptilia* 33: 251-259.

Lanza, B., Andreone, F., Bologna, M.A., Corti, C. & Razzetti, E. (2006b). *Fauna d'Italia*. *Amphibia*. Bologna, Calderini. xi + 537 pp.

Lanza, B., Caputo, V., Nascetti, G. & Bullini, L. (1995). Morphologic and genetic studies of the European plethodontid salamanders: taxonomic inferences (genus *Hydromantes*). *Monografie XVI*. *Museo Regionale di Scienze Naturali*. 366 pp.

Lanza, B., Pastorelli, C., Laghi, P. & Cimmaruta, R. (2006a). A review of systematics, taxonomy, genetics, biogeography and natural history of the genus *Speleomantes* Dubois, 1984 (Amphibia Caudata Plethodontidae). *Atti del Museo Civico di Storia Naturale di Trieste* 52: 5-135.

Lunghi, E., Manenti, R. & Ficetola, G.F. (2015). Seasonal variation in microhabitat of salamanders: environmental variation or shift of habitat selection? *PeerJ 3*: e1122.

Salvidio, S. (1997). Tail injuries in *Speleomantes ambrosii*. In *Herpetologia Bonnensis* [Proceedings of the 8th Ordinary General Meeting of the Societas Europaea Herpetologica, 23-27 August 1995, Bonn, Germany], pp. 313-316. W. Böhme, W. Bischoff & T. Ziegler (Eds.). Societas Europaea Herpetologica. Bonn.

Scaravelli, D., Laghi, P. & Pastorelli, C. (2002). Rinvenimento in natura di *Speleomantes italicus* (Dunn, 1923) con un arto rigenerato. In *Primo convegno nazionale biologia dei geotritoni europei genere Speleomantes, Genova e Busalla (GE), 26 e 27 ottobre 2002, Programma e Riassunti,* p. 22.S. Salvidio & M.V. Pastorino (Eds.). Università di Genova, Genova, .

Straube, W.L. & Tanaka, E.M. (2006). Reversibility of the Differentiated State: Regeneration in Amphibians. *Artificial Organs* 30: 743-755.

Wake, D.B. (2013). The enigmatic history of the European, Asian and American plethodontid salamanders. *Amphibia-Reptilia* 34: 323-336.

Williams, R.N., Bos, D.H., Gopurenko, D. & DeWoody, J.A. (2008). Amphibian malformations and inbreeding. *Biology Letters* 4: 549-552.

Accepted: 8 December 2015

The Herpetological Bulletin 135, 2016: 36-37

Salvator merianae (black and white tegu) scavaging around the nests of *Fregata magnificens* (frigatebird)

EDELCIO MUSCAT[1]*, FABIO OLMOS & ELSIE ROTENBERG[1]

[1]Projeto Dacnis. Estrada do Rio Escuro 4754, CEP 11680-000, Ubatuba, São Paulo, Brazil
*Corresponding author email: edelciomuscat@terra.com.br

The black and white tegu *Salvator merianae* is a sizable lizard (120-140 cm TL, 2.5-7 kg) with the largest range in its genus, occurring in the north of Argentina, Uruguay, Paraguay and in most of Brazil outside of the Amazon (Péres Jr., 2003). Adaptable, it occupies most of the South American biomes, both in forest and in open habitats (Péres Jr., 2003).

Tegus are generalists that feed on a wide variety of invertebrates and vertebrates, carrion, fruit and fungi (e.g. Sazima & D'Angelo, 2013). The adults are hunters capable of capturing mammals and birds, and are known predators of nests (Sazima & Haddad, 1992; 1996; Cicchi, 2006).

S. merianae occurs naturally in several coastal islands in the south-southeast Brazilian seaboard, where it can cohabit with some species of marine birds. Here we report the first observations of *S. merianae* individuals foraging in a breeding colony of frigatebirds *Fregata magnificens* and the interactions between these species.

Alcatrazes island (135 ha) and associated islets are located 35 km off the coast of São Paulo, around 24°06'03" S, 45°41'25" W. With steep topography, Alcatrazes is partially covered by forest dominated by palm trees and has extensive areas of exposed rock (Muscat et al., 2014). Alcatrazes is considered one of the main marine bird reproductive areas in this part of the Brazilian coast. *A F. magnificens* breeding colony is situated in an area dominated by the small tree *Guapira opposita* (Nyctaginaceae) and the *liana Capparis decilnata* (Capparacea), in the northwest side of the island.

Observations of individuals of *S. merianae* associated with the *F. magnificens* breeding colony were made opportunistically during visits to Alcatrazes on 19 November 2012 and 17 September 2013. In the 13 August 2015 expedition, observations were carried out in a planned form, during a 2-hour period, with three observers in strategic points around the colony.

On 19 November 2012, during an expedition to Alcatrazes island in which *F. magnificens* nestlings were banded, one *S. merianae* was observed, motionless and alert, under the nests. The disturbance caused by the capture of the birds for ringing made one of the nestlings regurgitate a mass of semi-digested fish. The lizard ran to the location as soon as it heard the sound of the food hitting the ground and immediately ate it.

On 17 September 2013 we again observed the same behaviour. A lizard was motionless under the nests but quickly ran to catch a mass of fish regurgitated by *F. magnificens* as soon as it hit the ground. On this occasion a photographic record of the specimen in the breeding colony was made (Fig. 1).

Figure 1. *S. merianae* scavaging on fish that have been regurgitated by *F. magnificens*. Photograph, Edelcio Muscat

On 13 August 2015, several *S. merianae* were observed foraging and thermoregulating on the fringe and in the interior of the nesting colony, but they were never close to each other. Every so often one individual would penetrate the colony and forage there consuming regurgitated food. The regurgitated material was geotagged at 24°06'04" S, 45°41'48" W.

Corroborating these observations, an adult male *S. merianae* (325 + 585mm TL, 940g) who was found dead in the nesting colony on 09 September 2013 by Dr. Karina Nunes was preserved in the herpetology collection of Instituto Butantan (catalogue number IBSPCR. 657). On dissection, its stomach contents revealed fish remains, suggesting it had fed on the material regurgitated by the birds.

S. merianae is an adaptable species that will consume dead fish when given the opportunity (Sazima & D'Angelo, 2013). Thus, is not unexpected that lizards have learned to use fish that birds have dropped. The relation between *S. merianae* and *F. magnificens* seems to benefit solely the lizards, which, in the breeding colony, have a food source that demands very little effort.

ACKNOWLEDGMENTS

The authors would like to thank Marli Penteado (ESEC Tupinambás) and Alex Mariano (Projeto Dacnis) for their field contributions; Karina Nunes (Instituto Butantan) for the data on the stomach contents of the preserved specimen; and Guiseppe Puorto, Curator of the Herpetological Collection, Special Laboratory of Zoological Collections, Instituto Butantan, for the catalogue information on the preserved specimen. Comments by reviewers improved the original version of the manuscript.

REFERENCES

Cicchi, P.J.P. (2006). *Tupinambis merianae* (Tegu). Diet. *Herpetological Review* 37: 347.

Muscat, E., Saviolli, J.Y., Costa, A., Chagas C.A., Eugênio, M., Rotenberg, E.L. & Olmos, F. (2014). Birds of the Alcatrazes archipelago and surrounding waters, São Paulo, southeastern Brazil. *Checklist* 10: 729–738.

Péres Jr., A.K. (2003). Sistemática e conservação do gênero Tupinambis (*Squamata, Teiidae*). Unpublished doctoral thesis, Universidade de Brasília, 192p.

Sazima, I. & D'Angelo, G.B. (2013). Range of animal food types recorded for the tegu lizard (*Salvator merianae*) at an urban park in South-eastern Brazil. *Herpetology Notes* 6: 427-430.

Sazima, I. & Haddad, C.F.B. (1992). Répteis da Serra do Japi: notas sobre história natural. In: *História Natural da Serra do Japi*, pp 221-236. Morellato, L.P.C., Ed., Campinas, Editora da Unicamp/FAPESP.

Accepted: 15 December 2015

The Herpetological Bulletin 135, 2016: 38-39

Good invasion ability is not enough: Predation on the pond slider (*Trachemys scripta*) by the wels catfish (*Silurus glanis*) in the Czech Republic

ZDENĚK MAČÁT[1*] & DANIEL JABLONSKI[2]

[1]Department of Ecology and Environmental Sciences, Palacký University in Olomouc, Šlechtitelů 27, 78371, Olomouc, Czech Republic
[2]Department of Zoology, Comenius University in Bratislava, Mlynská dolina B-1, 842 15, Bratislava, Slovakia
[*]Corresponding author email: zdenek.macat@gmail.com

The pond slider, *Trachemys scripta* is an alien and invasive species of turtle in Europe (Cadi and Joly, 2004), including the Czech Republic (Brejcha, 2015). Allochthonous populations were established in the various natural freshwater ecosystems and this species has been cited as the most widely invasive reptile species in the world (Kraus, 2009) and is listed in among 100 of the "World's Worst" invaders (Lowe, 2000). The import of *T. s. elegans* has been banned by European Commission Regulation due to its ability to expand its range and believed negative impact on native species (Kopecký et al., 2013). Knowledge in respect to its abundance in Europe and potential interactions with native species are of hence of great value.

Here we report predation on *T. scripta* by a wels catfish *Silurus glanis*. The observation was made at a water dam Větřkovice near Kopřivnice town, Czech Republic (49.6175°N, 18.1885°E; WGS 84; 325 m elev.) on 5th October 2014 when an adult cadaver (ca 190 cm) of a wels catfish was observed floating on the surface. The dead fish was removed from the water and inside its mouth we found a dead adult female *T. scripta* (carapace length approximately 25 cm). Three quarters of the turtles body was inside of the head of the fish (Fig. 2). This finding is a new record of the distribution of the *T. scripta* in the Czech Republic (see Fig. 1).

In the Czech Republic, there are no native fresh water turtle species (the only Central European species *Emys*

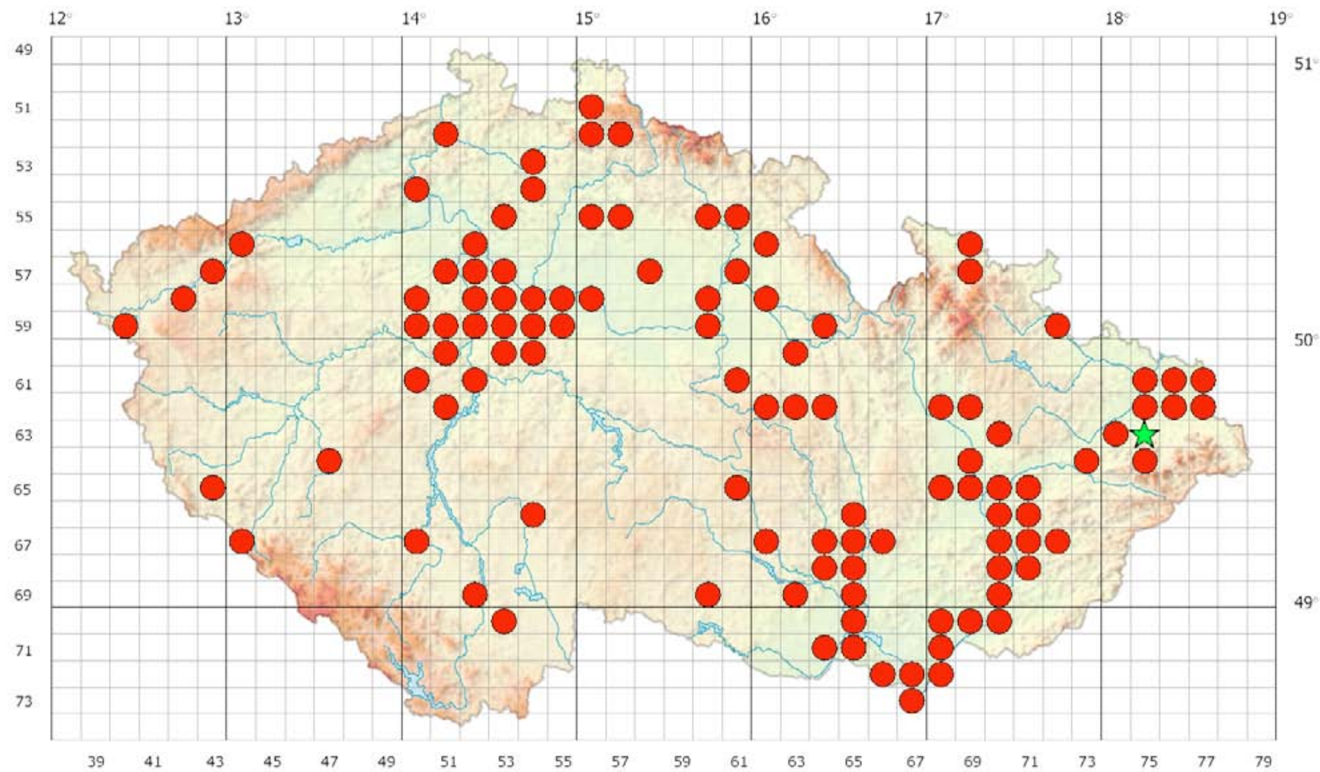


Figure 1. Occurrence of *T. scripta* in the Czech Republic (dots) with our observation (star; modified from © Nature Conservation Agency of the Czech Republic).

Figure 2. Cadaver of *S. glanis* with dead *T. scripta* lodged in the mouth.

orbicularis is probably extinct; Moravec and Široký, 2015). Therefore, we assume that this observation was an uncommon event since freshwater turtles can only be an important part of the diet *S. glanis* when there is a high abundance of turtles and simultaneously low abundance of fish prey. Predation on the Emydid turtles or other freshwater turtle species are known predominantly from the birds (e.g. Shively, 2014) and mammals (e.g. Seigel, 1980). However, our observation could indicate that fish predation on *T. scripta* could be a factor in regulation if there was successful *T. scripta* reproduction. Juvenile turtles, for example, would be easily obtainable prey for these fish as is presented in literature (e.g. Blamires and Spencer, 2013). On the other hand, this observation could suggest that adult turtles in the food of fishes represent a potential risk of mortality from predation attempts on *T. scripta*.

ACKNOWLEDGEMENTS

We would like to thank J. Dorotíková for providing information about the observation, M. Rulík for revision of manuscript draft and two reviewers for their comments.

REFERENCES

Blamires, S.J. & Spencer, R.J. (2013). Influence of habitat and predation on population dynamics of the freshwater turtle *Myuchelys georgesi*. *Herpetologica* 69: 46 – 57.

Brejcha, J. (2015): Želva nádherná - aktuální status druhu v České republice. In *Fauna ČR: Plazi - Reptilia*, pp. 445 – 448. Moravec, J. (Ed.). Academia, Praha.

Cadi, A. & Joly, P. (2004). Impact of the introduction of the red-eared slider (*Trachemys scripta elegans*) on survival rates of the European pond turtle (*Emys orbicularis*). *Biodiversity & Conservation* 13: 2511 – 2518.

Kraus, F. (2009). *Alien Reptiles and Amphibians: a Scientific Compendium and Analysis*. Springer, New York, 576 pp.

Kopecký, O., Kalous, L. & Patoka, J. (2013). Establishment risk from pet-trade freshwater turtles in the European Union. *Knowledge and Management of Aquatic Ecosystems* 410: 2.

Lowe, S., Browne, M., Boudjelas, S. & De Poorter, M. (2000). 100 of the World's Worst Invasive Alien Species A selection from the Global Invasive Species Database. The Invasive Species Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN).

Moravec, J. & Široký, P. (2015). *Trachemys scripta* (Schoepff, 1792) - želva nádherná. In *Fauna ČR: Plazi - Reptilia*, pp. 438 – 445. Moravec, J. (Ed.). Academia, Praha.

Seigel, R.A. (1980). Predation by Raccoons on Diamondback Terrapins, *Malaclemys terrapin T. Journal of Herpetology* 14: 87 – 89.

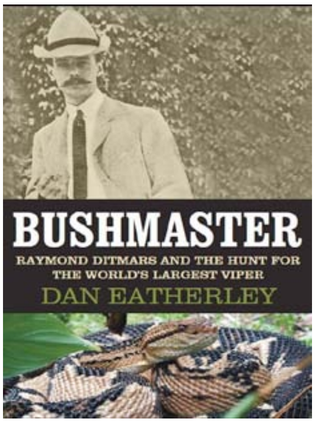
Shively, S. (2014). Freshwater Turtles Species; Predation. *Herpetological Review* 45: 313 – 314.

Accepted: 20 December 2015

Bushmaster: Raymond Ditmars and the Hunt for the World's Largest Viper

Dan Eatherley

USA Arcade Publishing, USA, 2015, 303 pp. ISBN 978-1-62872-511-7. (Hardback)



I found this book easy to read, interesting, informative and enjoyable: part quest, history, biography and natural history. The main title could refer to both the snake (*Lachesis muta*; *Lachesis* after one of the Fates of mythology and *muta* meaning silent) and to the hunter, the redoubtable Ray Ditmars, curator of reptiles (and latterly also mammals and insects) at the New York Zoological Gardens, often known as the Bronx Zoo, for most of his working life. The book should be for anyone with an interest in reptiles, zoos, wildlife in general.

Dan Eatherley became interested in bushmasters and then Ditmars while researching a never-made natural history TV film on dangerous snakes. Several of the older herpetologists he worked with claimed Ditmars' books as formative influences, and Eatherley was surprised never to have heard of him. The book recounts Ditmars' life, intercut with Eatherley's quest to find more about him by visiting places he had worked and speaking to people with some connection. He found remarkably little surviving archive material: Ditmars' widow destroyed his papers, photographs and films and the Zoo had a big document clear-out in the 1950's, so the occasional letters and archive material Eatherley found were precious.

Ditmars (1876-1942) grew up in New York, first near Central Park, then quite wild in places, and later in the Bronx, semi-rural at the time. From an early age he was passionate about wildlife, especially snakes, catching them and keeping them at home (not to his parents' delight, but they were generally tolerant). He taught himself reptile husbandry, founded the Harlem Zoological Society at 16, and at 18 was attending meetings of the New York Linnean Society. At just 17, he left school and took what we would now call an internship at the American Museum of Natural History working under Professor Beutenmuller; the job, to curate and catalogue a donated collection of more than a quarter million specimens of insects, mainly lepidoptera. Ditmars spent his free time collecting, looking after and photographing reptiles, and corresponding with enthusiasts at home and abroad, particularly R. R. Mole in Trinidad, who sent a consignment of snakes, including a bushmaster, possibly not realising that Ditmars was only 21!

The meagre museum salary was inadequate to support Ditmars' reptile hobby, so he moved to journalism at the New York Times in 1898. Around this time, the New York Zoological Society (now the Wildlife Conservation Society) had chosen a site for their new zoo in the Bronx, where the Ditmars family now lived. Ditmars, with no academic qualifications but plenty of hands-on experience, got the job of keeper of reptiles. He moved his personal collection to the zoo as it opened in 1899, and remained in the job till his death in 1942.

Ditmars was part showman, part innovator. He realised the zoo needed customers and kept its profile high through popular illustrated lectures and stories in the press about exotic and dangerous animals. The stream of accessible books he wrote were about animals, mainly reptiles, and his own experiences with them. He was among the first to realise the potential of moving pictures for educating and entertaining about wildlife; his first major film, 'The book of nature'(1914) ran for 37 consecutive weeks at the Strand Theatre on Broadway, and his 1922 film 'Evolution' was re-released in 1925 to coincide with the notorious Scopes trial in Tennessee where a schoolteacher was indicted for the 'crime' of teaching about human evolution. Ditmars even appeared on television (1939).

All Ditmars' early animal collecting was done in the USA, though the zoo exchanged and bought specimens from many countries. In the late 1920's, Ditmars' tropical fieldwork began, usually accompanied by his wife and two daughters, and later by his assistant Arthur Greenhall. In Honduras, he assisted with the United Fruit Company's efforts to prevent so many workers from dying from snake bites; in Panama, he captured and brought to the zoo the first vampire bat to be exhibited. His interest in the bushmaster became something of an obsession: his supply from Mole in Trinidad (who died in 1926) had dried up, and none of the snakes survived long in captivity. Ditmars' next tropical visits were to Trinidad in 1934-8, with a principal aim of collecting bushmasters. Did he ever find one, or did Dan Eatherley 80 years later? I won't spoil the suspense by revealing that, but the Trinidad trips were generally productive: Ditmars returned to his early interests in insects, collecting leaf cutter ant colonies for the zoo; amphibians too – I first came across Ditmars' name when researching an article on the giant tadpoles of the paradoxical frog, *Pseudis paradoxa*, which Ditmars had captured in Trinidad in 1936.

Summing up, Ditmars is well worth remembering for his efforts to educate the public about snakes, and the collaborations he had with scientists interested in finding antidotes to snake-bites (remarkably, Ditmars was never bitten himself). Because his writings were mainly for a popular audience, they have dated and he did not publish significant research himself, unlike his close contemporary William Beebe, keeper of birds at the Bronx Zoo, but still known for his discovery of new species around the tropical world. The book is also fascinating for its picture of zoo practice at the time: things have definitely changed for the better.

Some grumbles: the book has an adequate index, but no bibliography or notes on sources; the central section of 16 pages of photographs is not referred to in the text; the Trinidadian coriander-like herb is *chadon beni*, not chado benny; and the history of Simla, the research station founded by Beebe in Trinidad's Northern Range is somewhat mis-represented.

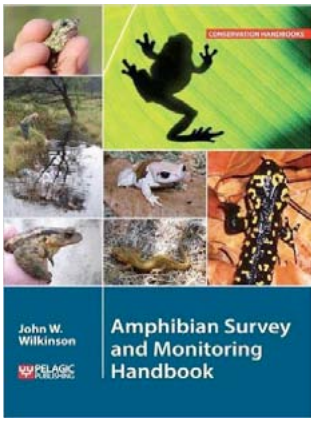
ROGER DOWNIE
Institute of Biodiversity, Animal Health & Comparative Medicine, College of Medical, Veterinary & Life Sciences
University of Glasgow, UK
E-mail: Roger.Downie@glasgow.ac.uk

Accepted: 15 December 2015

Amphibian Survey and Monitoring Handbook

John W.Wilkinson

Pelagic Publishing, Exeter, 2015, 120 p. ISBN 978-1-78427-003-2



After a brief introduction to amphibians, this handbook comprises three main chapters, covering before, during and after survey work, followed by a resources chapter. The book is short (the three main chapters are less than 90 pages), but packed full of information. It is written in a chatty, often jocular style (much use of interjections with exclamation marks), and is easy to read. However, I wonder who it is aimed at. The general style seems aimed at people who have never surveyed amphibians, nor who have ever written a scientific report before, but the content ranges from extremely basic advice to much more complex matters such as radio-tracking. Another issue is geographical scope. Wilkinson admits that his main experience is in the UK and the book's main emphasis is on the kinds of surveying that could be done in Britain; for example, he gives considerable attention to Habitat Suitability Index (HSI) assessment for great crested newts (I am not aware of HSI's for other species). However, he does try to internationalise by referring to amphibians found elsewhere and by mentioning resources needed to work in other countries, but the level of detail provided is too little and too selective to be of much use. My guess is that a young UK amphibian researcher planning survey work abroad might find the book a helpful introduction, but not much more, and that a researcher in, say Brazil, would find it of very limited use.

I found myself listing unexpected omissions and points I would take issue with: here are some. For 20 years, the main sourcebook for amphibian survey work has been Heyer et al. (1994); this is listed under 'other useful textbooks' in chapter 5, but ought surely to be in the early preparations chapter; more surprisingly, Dodd's recent book (2010: Amphibian Ecology and Conservation), which provides an authoritative update on methodology, is not even cited. IUCN is not in the index and the IUCN Red List for amphibians is not mentioned in the text (though some photographs of amphibians have their IUCN status mentioned). In addition, the two main websites on amphibian diversity, taxonomy and conservation (Amphibian Species of the World; Amphibia Web) are not mentioned. This is very surprising, and is not because of lack of space: they could fill the dead space in Box 1.1 on page 8. The section on great crested newt surveying does not mention the requirement to demonstrate training when applying for a licence. The discussion of risk assessments says that many organisations will have a lone worker policy; I feel this is unsatisfactory for a book aimed at beginners, and including working outside the UK, especially when considering lone female workers; my institution would simply not allow this. Chapter 4 includes a substantial section on report writing; this is not specific to amphibian surveying at all, and many books and courses cover how to do this, so I wonder on its inclusion here; the section surprisingly omits any advice to have the draft report read over by a knowledgeable person before submitting it. Chapter 4 also briefly goes into mark-recapture methods, including toe-clipping, but only superficially mentions the ethical issues: should we really be encouraging newcomers to the field to use this controversial method?

Overall, the author's enthusiasm and encouragement is refreshing, and I learned some useful pieces of information, but I feel there is considerable room for improvement, especially in a short book priced at £29.99.

ROGER DOWNIE
Institute of Biodiversity, Animal Health & Comparative Medicine, College of Medical, Veterinary & Life Sciences
University of Glasgow, UK
E-mail: Roger.Downie@glasgow.ac.uk

Accepted: 25 November 2015

HERPETOLOGICAL BULLETIN REPORT

January 2016

During 2015 a total of 115 manuscripts were submitted to Herpetological Bulletin for publication with an additional 2 (not included in the table below) rejected without review. This represents a 216% increase in submissions compared to 2014. Full paper submissions increased by 240%. Acceptance rate overall is now down to 44.3%.

The target for 2016 is a continuation of publication of papers in the next available issue once they have been accepted. Due to the large increase in submissions and hence workload (see below) we have invited Professor Rick Hodges to become Associate Editor, which we are pleased to say he accepted. Rick`s expertise is in the British herpetofauna, but also has knowledge of other areas. Stuart Graham will also continue as an Associate Editor. Importantly, Sarah Berry has indicated that she is willing to continue as Managing Editor.

The Table below provides the details with comparable figures for 2014 shown in parentheses.

	Submitted	**Accepted**	**Percent accepted**
Full papers	**48** (20)	**23** (11)	**47.9** (55.0)
Short Notes	**9** (11)	**3** (7)	**33.3** (63.6)
Natural History Notes	**58** (22)	**25** (12)	**43.1** (54.5)
Total	**115** (53)	**51** (34)	**44.3** (56.6)

A review of herpetological activities at Froglife Trust by Kathy Wormwald was published in the Spring issue of 2015.

The following people gave their time and expertise reviewing manuscripts for Herpetological Bulletin during 2015:

Pim Arntzen; Roger Avery; Francis Baines; John Baker; Chris Barratt; Aaron Bauer; Trevor Beebee; Adam Bland; Xavier Bonnet; William Branch; Francois Brischoux; Rebecca Cattell; Alan Channing; Roger Downie; Daniel Escoriza; Helen Fearnley: Carl Ernst; Chris Gleed-Owen: Richard Griffiths; Stuart Graham; Adrian Hailey; Jihène Ben Hassine; James Hicks; Rick Hodges; Ivan Ineich; Laurence Jarvis; Robert Jehle; Jeff Lemm: Todd Lewis; Ben Limburn; Jeffrey Lovich; Luca Luiselli: John D Lynch; Roger Meek; Robert Mendyk; Konrad Merbert; Walter Meshaka; Christopher J Michaels; Göran Nilson; Steve Richards; John Rudge; Andres E Seijas; Trevor Smith; Mark Stidworthy; Ben Tapely; Christine Tilley; Romulus Whitaker; John Wilkinson; Stuart Woodley; Marco Zuffi.

Roger Meek, Roger Avery
Editors

BRITISH HERPETOLOGICAL SOCIETY COUNCIL 2015/2016

THE HERPETOLOGICAL BULLETIN

Contents: Issue 135, Spring 2016

Registered Charity No. 205666