The HERPETOLOGICAL BULLETIN

Number 104 – Summer 2008

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 full-length papers of mostly a semi-technical nature, book reviews, letters from readers, society news, 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).

ISSN 1473-0928
© The British Herpetological Society. All rights reserved. No part of this publication may be reproduced without the permission of the Editor.

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

Guidelines for contributing authors

1. Contributions should be submitted preferably in electronic form, either by e-mail or as text files on CD, DVD, or 100 mb zip disk, in Windows format only. The Bulletin is typeset directly from the author's electronic file, so wherever possible all manuscripts should be prepared using standard word-processing software. Articles should be arranged in the following general order: *Title; Name*(*s*) of author(s); *Address*(*es*) of authors (please indicate corresponding author); *Abstract* (optional - if included should not exceed 10% of total word length); *Text; Acknowledgements; References; Appendices.* Footnotes should not be included. Refer to this issue for style and format information.
2. High resolution scanned images (TIFF or JPEG files) are the preferred format for submission of 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 numbers.
3. Authors will be informed promptly of receipt of their manuscript and given a time-scale within which it will be published. Acknowledgement of the receipt of work ***does not*** indicate acceptance for publication. Contributions are liable to assessment for suitability and ethical issues and all articles included in the main 'Research' section are subject to 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.
4. Authors are supplied with a portable document file (pdf) of their published article and also receive a complimentary copy of the full printed issue. Slides, artwork, and other original material will be returned following publication.
5. The significance and importance of some articles may be such that the Editor will offer the author a year's free subscription to the Society for their work.
6. The Editor is keenly aware that contributors may find some of these instructions difficult to comply with and is anxious that the pages of the Bulletin should remain open to as wide a range of correspondents as possible. Therefore, if an author has concerns about the suitability of a manuscript, or would like help in preparing it, please contact the Editor to discuss.

Further information for contributing authors is available at: http://www.thebhs.org

The views expressed by the 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 Editor, Peter Stafford, c/o Dept. of Botany, The Natural History Museum, Cromwell Road, London, SW7 5BD. *E-mail: herpbulletin@thebhs.org.* Books submitted for review purposes should be sent directly to the Reviews Editor, Neil D'Cruze (contact details on inside back cover of this issue).

Front cover illustration. Eastern box turtle (*Terrapene carolina carolina*) at nesting site. © G. Wilson. See article on page 22.

New editor needed

After eight highly enjoyable years, I have decided to step down as the editor of *Herpetological Bulletin*; at the next (2009) Annual General Meeting, the Society will therefore be seeking to recruit some one new to take over this role. If interested please contact myself (herpbulletin@thebhs.org) or the Secretary, Trevor Rose (secretary@thebhs.org).

Job description: the editor is responsible for all matters concerning publication and management of the *Bulletin*. He/she will be required to produce four quarterly issues (spring, summer, autumn, winter), undertaking the appraisal of submitted papers and seeking specialist independent advice where appropriate from external reviewers. Other responsibilities include arranging book reviews, furnishing authors with a set of page proofs for checking, and liasing with the printer. Following publication, the editor will also arrange for the return of photographs/illustrative material and provide authors with a complimentary pdf of their article and copy of the full printed issue in which it appears. Preferred candidates will ideally have a broad knowledge of herpetology in all its applications, as well as an understanding of general publication procedures, and have e-mail/internet access. Experience in the use of desk-top publishing and image processing software is also necessary. Editorship of the *Bulletin* can be a relatively time-consuming task, but does not usually require a commitment of more than three hours per week. *Peter Stafford*

Report on the BHS field visit to Jersey - May 2008

Jan Clemons, BHS Conservation Officer

Jersey has a unique herpetofauna and supports three species of amphibian and four species of reptile. These include the Agile Frog (*Rana dalmatina*), European common toad or Crapaud (*Bufo bufo*), Palmate newt (*Triturus helveticus*), Green lizard (*Lacerta bilineata*), Wall lizard (*Podarcis muralis*), Grass snake (*Natrix natrix*), and Slow worm (*Anguis fragilis*). It was decided to organise a field trip for BHS members to experience Jersey's herpetofauna at close range with local experts. Twelve BHS members met at Jersey airport, scrambled into the mini-bus and lost no time in a perfect weather window to visit the island's key Wall lizard sites at L'Etacqueral and Gorey castle. We observed at both sites large and healthy populations of Wall lizards. It has been rumoured that these lizards had been originally released by French soldiers but there are now plans to take their genetic profile and compare it with that of their French counterparts. This should put the record straight as it would be nice to think they may be indigenous to Jersey.

On Sunday morning we visited Ouaisne (pronounced *way-nay*) Common and after an absence of ten years I was impressed by the improvement in the management of the Common for the Green lizard and Agile frog on this protected and designated site. Ouaisne Common is only eight hectares in size but is the richest site for herpetofauna in Jersey. It is the only site for the Agile frogs on the island and niche habitats for them such as dunes and grassland slacks continue to increase in total area as more management work is undertaken. Green lizards, Slow worms and Grass snakes are also present.

Within a few minutes the first Green lizard was sighted followed by many others. All were males within their separate territories displaying their vivid green bodies to hopefully entice the females. This was a wonderful opportunity to practice our photographic skills.

This year the Agile frogs spawned in the first week of February. A new record of 27 clumps was made and half the spawn were transferred to the new sterile facility at Jersey Zoo where they will be 'head started' and released back. This year's peak count was 32 animals per night, which is the first time it has reached double figures. The conservation aim is 200 clumps (see later).

There is also a Common toad or Crapaud mystery at Ouaisne. Hundreds were recorded in 1990 but since then they have not spawned. Just a few adult toads have been seen in the area since but no spawning has been recorded either on the reserve or in nearby garden ponds.. No one knows why (chytrid?) but this does correlate with the increasing success of the Agile frog. Correlation, however, does not imply cause and this growing Agile frog population may simply be due to

B HS members at Ouaisne Common.

scenes in the herpetology section were all critically endangered and biosecurity was rigorous. Each room was species specific and a separate pair of gloves was used when handling individual animals. Foot baths of disinfectant were stationed at every door. All these precautions minimise the spread of diseases and parasites. The overall aim is to increase the captive population and three species were of particular interest.

improvement of their habitat. The mystery is deepened by the fact that, in Jersey, toads spawn before the Agile frogs, meaning that their disappearance cannot be due to their spawn being eaten by frog tadpoles!

Heaps of rotting vegetation for Grass snake egg laying sites have been created adjacent to the large lake at Ouaisne and there is a good Grass snake population in the area (though they are as difficult as ever to find!). The rarity of the Agile frog and the decline of toads on the island threaten this snake's long-term survival there and research into its conservation in Jersey is urgently required.

In the afternoon we visited a toad pond at La Granche Point. The pond has been deepened because the toads breed in early January and the pond usually dries up by early summer. The tadpoles we observed had plenty of water left so should have sufficient water to see them through metamorphosis.

We also visited a Palmate newt pond at Les Carrieres where netting resulted in capturing a large male palmate newt. The tail filament and webbed hind feet of the males were particularly evident. All the sites visited are legally protected and designated as SSSI (Site of Special Scientific Interest).

On Monday morning we visited Jersey Zoo and the Durrell philosophy is as strong as ever. The amphibian and reptile species we saw behind the

Mountain chicken (*Leptodactylus fallax*)

This is one of the largest frog species in the world. Their avian name originates from the fact that they live on mountains on Montserrat and Dominica and taste like chicken. Their large legs are the national dish in Montserrat and in addition to this pressure since 1995, over 75% of the island has been affected by a volcano. The volcano has destroyed much of the frog's remaining rainforest habitat making it critically endangered. The captive breeding programme began in 1999 with 13 frogs rescued from their still smouldering habitat and last year 63 frogs were bred. The Mountain chicken is famous for its foam nest which looks like a giant marshmallow and is guarded by the male. This captive bred frog population is a 'safety-net' if the wild population becomes extinct.

Jamaican boa (*Epicrates subflavus*)

We saw the captive breeding facility for the Jamaican boa or Yellowsnake, which is threatened with extinction and is usually killed by the locals on sight. Together with habitat destruction, predation by introduced dogs, cats, mongooses and pigs it has suffered a long history of decline. In 1976, seven boas were brought to Jersey. Since then 450 snakes have been bred and have been distributed to other zoos worldwide.

Agile frog (*Rana dalmatina*)

After viewing the facilities indoors we were led outside to view some shipping containers. At the time of writing one of them has been converted to accommodate the head start programme for Jersey's most endangered amphibian, the Agile frog. At Ouaisne we saw the results of the effort in providing the correct habitat for Jersey's only frog and now we could see the other half of the project. The container is biosecure and we couldn't go in but through the windows we saw our first Agile frogs. Despite only being tadpoles it was very impressive and the tadpoles were swimming actively in oxygenated tanks, The tadpoles are injected with a VIE (visible implant elastomer) which is visible under black light. Originally used to estimate the size of fish populations VIE can be used to monitor the planned reintroductions. The strict biosecurity will be permanent until release.

I would like to thank John Wilkinson, Nina Cornish and John Pinel for leading the field visits and the wealth of knowledge they all imparted about Jersey's herpetofauna. The BHS are particularly indebted to Jersey Zoo's herpetology section and Ben Tapley for allowing us to go behind the scenes, and to Mr Gordon Collas and the Jersey Government for providing free transport. Finally, for members to get a good idea of the success of the field visit I include comments from attending VHS members:

'It is always nice to visit Jersey and I am familiar with most of the reptile sites but it was lovely to see the wall lizards at L'Etacquerel (where I've not been before) and especially to note that they appear to be abundant and thriving even though the fort has been restored as a recreational facility. It is a salient reminder that the needs of leisure/community/conservation of biodiversity are not mutually incompatible - a lesson that a lot of UK local authorities could learn'.

'Thank you very much for organising a marvellous trip. I am a big Gerrald Durrell fan, and one of the highlights was staying at Jersey Zoo, and going behind the scenes to view the breeding programmes for endangered reptiles and amphibians. The other highlight was seeing wild Green lizards and Wall lizards. It was very impressive that local knowledge allowed us to view these reptiles within minutes of our arrival at the sites where they occur'.

'We both thoroughly enjoyed the trip. The venue was ideal, and as usual the conversation with like minded and knowledgeable enthusiasts was both infomative and enjoyable, one is never too old to learn. I was particularly impressed by the levels of biosecurity at the zoo to prevent cross infection, and the professionalism and commitment of the staff which you don't realise from just a visit to the zoo. You do feel that the future of the endangered species they deal with is in good hands. I look forward to the next trip, wherever it is'.

'New to the world of herps we genuinely felt that a door was being generously held widely open for us. We found the trip encouraging, interesting and enjoyable and plan to sign up for more. Seeing wild herps with local experts left us with a much better understanding of how populations and habitats can be actively managed even with some development. Going behind the scenes at the zoo was fascinating and provided an insight into captive breeding we could never have achieved without the help of BHS. The depth of knowledge and passion of other BHS members was contagious and has caused us to order our first specialist herp books. Trip highlights included a beautiful male green lizard basking in the sun, a moss toad up close and the warmth of the BHS members'.

'This visit gave me the chance to step outside my normal boundaries and see how conservation can be effective through organisations working together such as the Jersey government and Durrell's work with the Agile frog. It was also interesting to see habitat management for herps being implemented as well as the obvious chance to see species that I don't come across every day. Apart from that there was the social side and finding that although it was a diverse group of people in both age and background we all had one uniting thing - Herpetofauna conservation'.

Further Information:

www.eco-active.je/Biodiversity/Jersey+Amphbian+and+Reptile+Group+(JARG)

www.durrellwildlife.org

The Alpine newt in northern England

IAN BOND[1] and GORDON HAYCOCK[2]

[1] *105 Davison Road, Darlington, DL1 3DS, U.K.* ian.bond105@ntlworld.com [corresponding author]

[2] *Thomson Ecology, 94-96 Pegholme, Wharfebank Business Centre, Ilkley Road Otley, LS21 3JP, U.K.* Gordon.Haycock@thomsonecology.com

THE Alpine newt is probably the most successful introduced species of Urodele in Britain (Wisniewski, 1989). It is thought to have been established in Britain since the 1920s when a population was introduced into ponds in Newdigate, Surrey (Beebee & Griffiths, 2000). It has been recorded in an increasing number of areas over the years but its status and distribution would still seem to be poorly known. Lever (1977), refers to the Newdigate site as the single colony in Britain as does the Atlas of Amphibians and Reptiles in Britain (Arnold, 1995). However Fraser (1983) mentions a second colony in Shropshire that had commenced with 7 individuals in 1970 and had grown to 30 adults by 1977. Other colonies have subsequently been recorded in Argyll (Irving,1987), Northampton (Blackwell, 2002) and Kent (Sewell, 2006). Beebee & Griffiths (2000) list six general areas where populations of the species have been recorded; south-east London, Sunderland, Shropshire, Birmingham, Brighton and central Scotland. The Alpine newt populations in the Sunderland area were documented by Brian Banks (Banks 1989) in an article for the Herpetological Bulletin. This article seeks to update the article by Banks and lists a number of other sites where the species would seem to be established in northern England.

Alpine newts in Sunderland

Banks (1989) identified two sites in the Sunderland area where Alpine newts were recorded. One, a garden pond at grid ref NZ383552, had been filled in by the time the 1989 article was written. The second site was a stream-fed, concrete lined pond in Doxford Park, grid ref NZ375528, which Banks believed had been filled in, in 1987. In fact the Doxford Park pond exists, although a new retail park has cut off its feeder stream, which is believed to be the reason why sticklebacks are no longer present (Stephenson, pers. comm.). It still has a complete lack of aquatic vegetation but has a loose layer of decaying leaves some 10 cm deep on the pond floor; the latter making accurate amphibian counting very difficult as amphibians of all species tend to disappear into it.

Lee Stephenson, who worked as a gardener at Doxford Park in 1990, was aware of the presence of Alpine newts at that time and has occasionally encountered them since. A brief survey by John Durkin and Terry Coult in 2003 failed to find the species; the newt eggs that they found on dead leaves in the pond proving to be those of Smooth newt and Great crested newt. However the presence of the Alpine newts is apparently well known to the local children who report ‘dinosaur newts’, ‘blue newts’ and ‘little newts’ and who claim to be supplying a local pet shop with the ‘blue’ ones.

On June 11th 2007, one of the authors, IB, did a torch survey of Doxford Park. Approximately one-third of the pond’s perimeter was surveyed with five Alpine newts (3 male, 2 female) and ten Smooth newts (5 male, 5 female) being recorded. One of the smooth newt males was virtually devoid of pigment. No Great crested newts were seen but a small number of very large Common frog tadpoles were present. Given that the survey was likely to have been done a little past the peak period for breeding newts and the very effective camouflage afforded by the dead leaves then it is likely that a fairly healthy population of newts exists despite the lack of aquatic vegetation and the depredations of the local children.

Alpine newts in Cleveland

The species is apparently well established in the Eaglescliffe area. Bob Brown, a countryside ranger based in Stockton, recorded them in the garden pond of a friend’s house in Carradale Close, Eaglescliffe, NZ423139, in the late 1990s. The origin of these newts isn’t known as the pond was present when his friend moved in and the house was sold a couple of years ago so it is not known whether the pond still exists. However Alpine newts have also been recorded in the ponds of several other gardens on this estate by Robert Scaife. It is believed that the populations in some of these ponds may have started accidentally with the transfer of aquatic plants between ponds but the species has been seen crossing an estate road at night thus demonstrating some dispersal ability (R. Scaife, pers. comm.). The species is also established at three rural sites on the western boundary of Eaglescliffe; Eliff's Mill, NZ408141, a small nature reserve with a complex of ponds which harbours six amphibian species; a pond on the community forest site of Coatham Stob, NZ4015 and a private nature reserve at an undisclosed location. The latter site has a particularly healthy population of Alpine newts. Alpine newts were first noticed there in 2003 when a small number were seen in one of the ponds; the population has increased year on year and in 2007 they were common in virtually all of the ponds. The ponds on this site are all fairly small and of artificial construction being mainly concrete lined with some subsequently reinforced with liners. They are close together and surrounded by large areas of natural and semi-natural habitats comprised of rank grassland, scrub and pine woodland; the site also has all three native newt species. Although the three rural sites are within 2 km of each other, at least two of them have had imports of aquatic vegetation, a common practice in the management of newly created wetland sites. It is possible that the Alpine newt populations could have stemmed from accidental introduction of eggs as is likely to be the case with the Palmate newts which are considered not to be native to the Tees Lowlands.

In 2004 one of the authors, IB, was brought an unidentified, emaciated newt that had been found in a wheel-wash pit at Carlin Howe near Guisborough, as part of an ecological survey. The newt, which proved to be an Alpine, subsequently died but one of the consultants doing the ecological survey confirmed that several of this type had been found in some of the ponds at the western end of the site. Carlin Howe, NZ6017, is a complex of ponds in the base of a former quarry; all three native species are also present. The ecological survey was to inform a planning application to use the site for landfill. Should this require a translocation project for the newt populations it might raise some interesting dilemmas if the number of Alpine newts proves to have expanded.

Alpine newts of Lower Wharfedale

Lower Wharfedale includes the northern reaches of Leeds and Bradford Districts and the south-eastern portion of Harrogate Borough. Burley-in-Wharfedale sits between the two main towns of Otley and Ilkley, but is a sizeable settlement in its own right. Alpine newts were first believed to have been introduced to Wharfedale via the local primary schools in the 1990s. At the time, primary schools were keeping alpine newts for study purposes, and then children were allowed to take the newts home over the holidays. By hook or by crook, Alpine newts inevitably escaped or were 'set free' and released into garden ponds (Freda Draper, pers. comm.). Reference to the records held by Nevil Bowland (who is the amphibian and reptile recorder for Wharfedale Naturalists Society) show that by spring 2001 Alpine newts were known to be present in five garden ponds in Burley, centred on a known release site on Stirling Road (SE 159463). Interestingly, Alpine newt was also recorded in a garden pond in this year near Otley Golf Course (SE 183449) some 2 km away. It is not known whether this represents dispersal, or a further release. Further records of good numbers exist for spring 2002 and, in 2003, 39 individuals were rescued from a pond being in-filled in a garden in the Stirling Road area. Also this year the first confirmed records of Alpine newt at Sun Lane Nature Reserve appear (SE 156467). This Reserve is approximately 400 m from Stirling Road, with intervening habitat consisting of a residential area. Alpine newts were subsequently recorded from the Reserve in 2005 and 2006. From a survey undertaken in March 2007 GH confirmed that a breeding population of Alpine newts occurs at Sun Lane Nature Reserve alongside Smooth newt (breeding), Common toad (in abundance) and Common frog (breeding). Freda has also reported Alpine newt co-existing with Palmate newts over a number of years.

Alpine newts in Sheffield

Other records in South and West Yorkshire are scarce. Colin Howes at Doncaster Museum does not hold any records and Richard Sunter (the Yorkshire Naturalists Union recorder) has records only for Wharfedale as previously described (up to 2004). John Newton of South Yorkshire Amphibian and Reptile Group has knowledge of a release of Alpine newts in the Sheffield area (SK372821). The release of a small number of adults took place approximately

Figure 1. Male Alpine Newt in bottle trap. Alpines were the most numerous newt species caught in the 2008 chytrid swabbing survey at Sun Lane. © J. Mortimer.

15 years ago and, after a lag phase, the population at this pond has grown rapidly in recent years. Alpine newts are now reported to be the dominant newt present! Happily they are coexisting with Smooth newt and Great crested newt at this site.

Overall, it is difficult to draw many conclusions from this data, except to confirm that thriving populations of Alpine newt currently exist in localities in Yorkshire on the fringes of the uplands. In Burley it is likely that these were introduced upwards of ten years ago, and that breeding has been successful. A similar pattern has been reported in Sheffield. In both cases Alpine newts have certainly increased in numbers and dispersed, but appear to co-exist with our native amphibians. It is has been suggested that the Wharfedale population has been successful due to the influence of the adjacent uplands, with lower winter temperatures and acid waters from the moor matching conditions found in areas of Europe where this species is native. The question in this case must be why it isn't a component of our native fauna? Could low powers of dispersal be a factor, or is it simply a twist of post-glaciation fate (in the same way that Great crested and Palmate newts failed to colonise Ireland)?

In the same way it is difficult to know what all of these clusters of records mean in terms of Alpine newt colonisation of Britain. Clearly the species can thrive in a variety of situations, not just garden ponds, and populations seem to be able to establish from what must be small numbers of founders. Beebee (2007) considers that Alpine newts have the potential to spread widely in Britain and expresses surprise that they haven't already, however there is no clear evidence that they are dispersing far beyond sites where they have been introduced. In fact it is equally plausible that Alpine newt populations will suffer the same effects of fragmentation as beset other amphibian species (Griffiths, 1995) and gradually disappear through local extinctions.

Research work on the Alpine newt would be welcome – in particular it would be useful to examine the niche overlap between Alpine newts and native newts in an effort to quantify the extent to which Alpine newts are competing with native amphibians for resources. Clearly the same ponds are used for breeding and so there is the potential for inter-specific competition for egg-laying sites and food for the efts, equally there may be competition between adults for food and resting places. It may be that the niches are subtly different, allowing a harmonious co-existence. However, as it is not clear what triggers the uncontrolled expansion of a non-native species in the wider countryside at the expense of native fauna, a study examining the potential impact of Alpine newts on native amphibians would certainly help to put these herpetologists' minds at ease!

ACKNOWLEDGEMENTS

The authors would like to thank the following people for supplying information on Alpine newts in northern England: Freda Draper and Nevil Bowland of Wharfedale Naturalists Society; John Newton; Rob Scaife; Lee Stephenson; John Durkin; Maxine Reid; Bob Brown; Jonathan Pounder.

REFERENCES

Arnold, H. R. (1995). *Atlas of Amphibians and Reptiles in Britain*. *ITE Res. Publ.* **No. 10**.

Banks, B. (1989). Alpine Newts in north east England. *Herpetol. Bull.* **30**, 4–5.

Beebee, T. (2007). Thirty years of garden ponds. *Herpetol. Bull.* **99**, 23–28.

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

Blackwell, K. (2002). *Triturus alpestris* in Britain *Herpetol. Bull.* **79**, 32.

Fraser, D. (1983). *Reptile and Amphibians in Britain*. London. Bloomsbury Books.

Griffiths, R. (1995). *Newts and Salamanders of Europe*. London: T&AD Poyser Ltd.

Irving, D. (1987). New amphibian records for Argyll. *Brit. Herpetol. Soc. Bull.* **20**, 31.

Lever, C. (1977). *The Naturalised Animals of the British Isles*. London: Hutchinsons.

Sewell, D. (2006). http://www.open.ac.uk/daptf/froglog/Froglog76.pdf

Wisniewski, P. (1989). *Newts of the British Isles*. Shire Natural History.

Tail mock-strike and hemipenis display in the Coral snakes, genus *Micrurus* (Elapidae): epiphenomenon or deimatic behaviour?

HERBERT SERAFIM[1] and MARCELO RIBEIRO DUARTE[2]

[1]*Depto. de Genética e Biologia Evolutiva, Instituto de Biociências, USP, CEP 05508-900, São Paulo, SP, Brazil*. hserafim@usp.br

[2]*Laboratório de Herpetologia, Instituto Butantan, São Paulo, SP, Brazil.* mrduarte@butantan.gov.br [author for correspondence]

THE relationship between aposematic coloration and the consequential avoidance by predators has been established by multiple studies (Brodie Jr. & Brodie III, 1980; Brodie III, 1993; Buasso *et al*., 2006). As an additional defensive strategy, tail display behaviours are widespread among most snake families, both in harmless species and dangerously venomous species (e.g. coral snakes, genus *Micrurus* - Greene, 1973; Wüster & Cox, 1992). It is often assumed that this behaviour can have survival value when the snake is attacked by a predator Greene (1973).

The coral snakes of the genus *Micrurus* are represented in Brazil by 24 species (SBH, 2008), and there are dozens of mimic species belonging to several genera Campbell & Lamar (2004). Some coral snakes, such as the subspecies of *Micrurus frontalis*, exhibit defensive tail display behaviour and will protrude one or the other hemipenis when handled violently or molested (Allen, 1940; Azevedo, 1960; Sazima & Abe, 1991; Roze, 1996). Among Brazilian coral snakes, only *M. corallinus* and *M. limbatus* do not use a defensive tail display (Roze, 1996). In this note we report on the tail display behaviour of *M. altirostris* (formerly *M. frontalis altirostris*) in a staged encounter in captivity and compare our observations with those of *M. frontalis* in the wild.

In the summer of 1999 an adult male *M. altirostris* (*ca*. 110 cm total length) from São Miguel D´Oeste, SC, southern Brazil, (26º43´S, 53°31´W, 645 m altitude) was sent to Instituto Butantan, São Paulo, southeastern Brazil. On its arrival, the snake was released on the ground (*ca*. 10:00 h) and immediately engaged in tail display behaviour. Despite the repetitive action of raising and curling its tail, hemipenis eversion did not occur regularly, and when this behaviour was observed the organ was extruded rapidly and only for a very brief period, even when stimulated gently with a stick (Figures 1A-B). Concomitantly, tail mock-strikes were sometimes observed after strong stimulation.

During fieldwork in Conceição do Mato Dentro, MG, southeastern Brazil (19°15´40´´S, 43°31°58´´W, 1.364 m altitude) an adult male *Micrurus frontalis* (*ca*. 100 cm total length) was found (12th December 2006 at 15:00 h in rocky fields - "campo rupestre"), in which and a rare form of hemipenis display behaviour was observed and photographed. When unintentionally approached, the snake exhibited defensive tail display behaviour including complete hemipenis eversion (Figure 2) lasting two minutes, and at least two more minutes when gently aggravated with a stick. Hemipenis eversion has been interpreted as an additional threat for predators (Allen, 1940; Azevedo, 1960; Roze, 1996) as well as deimatic behaviour (Allen, 1940), whereas Greene (1988) and Wüster & Cox (1992) suggest that this is probably an epiphenomenon of the tail display.

An interesting aspect of these recent observations is the fact that an applied stimulus resulted in very rapid and almost unnoticed hemipenis eversion in *M. altirostris*, and may adequately fit the hypothesis of epiphenomenon. Alternatively, the mock-strike and curled-over-the-back 'wagged' tail in this species (Figure 1C), as well as the resemblance of the defensive display to that of *Naja* species (elevation of the anterior portion of the body and formation of a "hood"), may reinforce the hypothesis that the tail display of one species might mimic the head or the tail of another, as proposed by Greene (1973). That a single human approach in the field resulted in hemipenis eversion for at least four minutes in *M. frontalis*, however, is more consistent with the hypothesis of deimatic behaviour, even if it can result in injury to one of the hemipenes by the potential predator.

ACKNOWLEDGEMENTS

We thank Paulo T. Sano (IBUSP) for help during fieldwork, and Wolfgang Wüster (University of Bangor, School of Biological Sciences, Wales, U.K.) for revisionary comments and suggestions.

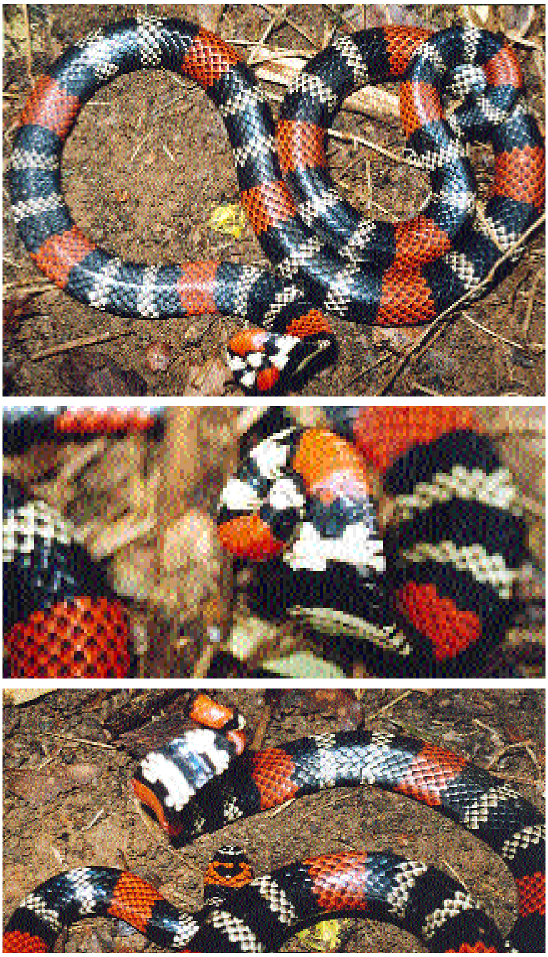


Figure 1. Defensive tail display in *Micrurus altirostris* from São Miguel D´Oeste, SC (26º 43´S, 53° 31´W, 645 m). Top: Defensive position after be gently stimulated by stick Note the head hidden under coils. Centre: Detail of the tail raising and curling, and subtle right hemipenis eversion. Bottom: Curled over the back and 'wagged' tail. Note the resemblance of this tail display behaviour with *Naja* defensive display (elevation of anterior portion of the body and formation of 'hood'). Photographs © H. Serafim and M. R Duarte.

Figure 2. Top: Defensive tail display of *Micrurus frontalis* from Conceição do Mato Dentro, MG (19° 15´ 40´´S, 43° 31° 58´´W, 1.364 m). Bottom: Close-up of everted hemipenis.

REFERENCES

Allen, C. E. (1940). Behaviour of *Micrurus frontalis frontalis*. *Copeia*: 51–52.

Azevedo, A. C. (1960). Notes on coral snakes. II. A new observation on the behaviour of *Micrurus frontalis multiventris* and its relationship with folklore. *Iheringia* **14,** 11–13.

Brodie Jr., E. D. & Brodie III, E. D. (1980). Differential avoidance of mimetic salamanders by free ranging birds. *Science* **208**, 181–183.

Brodie III, E. D. (1993). Differential avoidance of coral snake banded patterns by free-ranging avian predators in Costa Rica. *Evolution* **47**, 227–235.

Buasso, C. M., Leynaud, G. C. & Cruz, F. B. (2006). Predation on snakes of Argentina: effects of coloration and ring pattern on coral and false coral snakes. *Stud. Neotr. Fauna Environ.* **41**, 183–188.

Campbell, J. A. & Lamar, W. W. (2004). *The Venomous Reptiles of the Western Hemisphere*. Ithaca, New York: Cornell University Press. 774 pp.

Greene, H. W. (1973). Defensive tail display by snakes and amphisbaenians. *J. Herpetol.* **7**, 143–161.

Greene, H. W. (1988). Antipredator mechanisms in reptiles. In: *Biology of the Reptilia*, *Ecology B - Defense and Life History*, pp. 1–152. Gans C. & Huey R.B. (Eds.). New York: Alan R. Liss Inc.

Roze, J. A. (1996). *Coral Snakes of the Americas - Biology*, *Identification*, *and Venoms*. Malabar, Fla.: Krieger Publishing Company. 328 pp.

Sazima, I. & Abe, A. (1991). Habits of five brazilian snakes with coral-snake pattern, including a summary of defensive tactics. *Stud. Neotr. Fauna Environ.* **26**, 159–164.

SBH. (2008). Brazilian reptiles - List of species. URL: http://www.sbherpetologia.org.br/checklist/repteis.htm. Accessed 21st August 2008..

Wüster, W. & Cox, M. J. (1992). Defensive hemipenis display in the Kukri Snake *Oligodon cyclurus*. *J. Herpetol.* **26**, 238–241.

Communal egg-laying and nest-sites of the Goo-eater, *Sibynomorphus mikanii* (Colubridae, Dipsadinae) in southeastern Brazil

HENRIQUE B. P. BRAZ[1, 2, 3], FRANCISCO L. FRANCO[1] and SELMA M. ALMEIDA-SANTOS[1]

[1] *Laboratório de Herpetologia, Instituto Butantan, 05503-900, São Paulo SP, Brasil*

[2] *Programa de Pós-graduação Interunidades em Biotecnologia, Universidade de São Paulo, São Paulo SP, Brasil*

[3] *Corresponding author*: h_braz@butantan.gov.br

FOR oviparous reptiles without parental behaviour, female nest-site selection plays a significant role in the evolution of life histories (Resetarits, 1996; Shine, 2004). Nevertheless, nest-sites and oviposition modes of neotropical snakes are relatively unknown, mostly because mothers are so successful at hiding their eggs that nests are rarely found in nature. Additionally, much emphasis has been placed on life history components such as body size, number and size of offspring, and age at maturity (Stearns, 1992; Resetarits, 1996). Snakes oviposit under rocks, logs, or any other surface cover, in preformed subterranean chambers (Packard & Packard, 1988) and within nests of other animals such as alligators (Hall & Meier, 1993), ants and termites (Riley *et al.*, 1985). With regard to oviposition modes, snakes oviposit both in solitary and communal nests (Vaz-Ferreira *et al.*, 1970; Graves & Duvall, 1995; Blouin-Demers *et al.*, 2004). Communal oviposition is a widespread phenomenon and occurs when several females, conspecifics or not, share the same nest cavity to deposit their eggs (Graves & Duvall, 1995). Among neotropical species, reports of nest-sites and communal nests are scarce and are mostly related to colder climates (e.g. Vaz-Ferreira *et al.*, 1970; Cadle & Chuna, 1995). Recently, Albuquerque & Ferrarezzi (2004) reported one communal nest for the neotropical colubrid snake *Sibynomorphus mikanii* in an anthropized area in southeastern Brazil. Herein we describe another three nest-sites, nesting areas and oviposition modes of the goo-eater snake *Sibynomorphus mikanii* in southeastern Brazil.

Sibynomorphus mikanii is a dipsadine colubrid snake that feeds on slugs (Laporta-Ferreira *et al.*, 1986; Oliveira, 2001) and is distributed in Central, Atlantic and Meridional Brazilian uplands in cerrado and tropical forest areas (Franco, 1994). Females oviposit from September (early spring) to February (mid-summer) and clutch size varies from three to 10 eggs, averaging 5.9 eggs (Oliveira, 2001). On 5th February 2007, 41 eggs and 11 empty shells (Figure 1C) were found together inside a hole, 20 cm below ground surface, at the edge of a degraded wood inside Instituto Butantan (IBSP), São Paulo city, Brazil. The nest (hereafter nest #1) was situated 17 m away from the wood and 9 m away from the backyard of a house on a slightly steep slope (Figure 1A). A small hole (50 mm diameter), at the side of the nest may have provided access for the snakes (Figure 1B). Temperature at the same depth around the nest averaged 27.3°C (range = 27 - 28°C). Four empty shells contained fluids indicating recent hatchings whereas seven were completely desiccated. Two dead hatchlings were found near the nest (± 1 m away). Nest #2 and #3 were discovered by a farmer in two different spots, in a 5000 m^2 house backyard, in Vargem city, Brazil. Nest #2 was discovered under dry grass accumulated after ground weeding and contained nine eggs. Nest #3 was found 30 m away from nest #2 under a large rock (30 x 60 x 15 cm) and had a total of 12 eggs. Eggs were donated to IBSP on 1st March 2007, some days after collection and by this time one egg had hatched. In the laboratory, we counted four fresh empty shells and 17 eggs (three dehydrated and one parasitized by fungi). In both backyards, dogs circulated freely over the nesting areas. After the donation of the eggs, the farmer found a dead hatchling of *Sibynomorphus mikanii* near nest #3.

Eggs were measured, weighed (Table 1), and incubated in laboratory at 27°C (temperature of

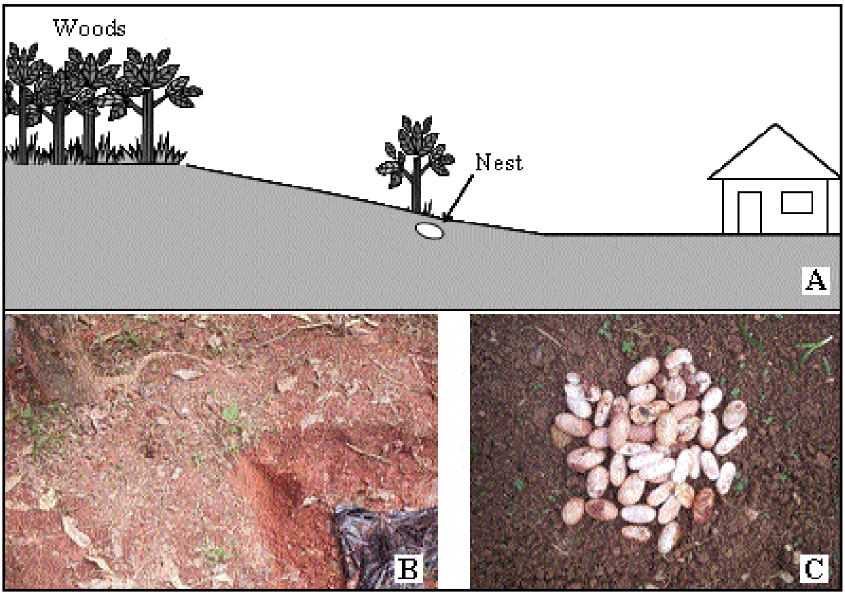


Figure 1. (A) Diagrammatic vertical section of the terrain surrounding nest #1; (B) view of the destroyed nest and its likely entrance; (C) Eggs of *Sibynomorphus mikanii* found within nest #1.

nest #1). Fungal infection precluded eight eggs (19.5 %) from nest #1 and five eggs (45.5 %) from nest #2 and #3 from hatching. Eggs were dissected but we were unable to find or to identify the embryos. One hatchling from nest #2 died half emerged from the eggshell. Thus, 33 successful hatchings from nest #1 occurred between 6th February and 16th April 2007, whereas from nest # 2 and #3 five occurred between 1st March and 31st May 2007. Hatchlings were measured, weighed, and sexed by eversion of hemipenis (Table 1). Based on mean clutch size of the species (5.9 eggs; Oliveira, 2001), we inferred that nearly seven to nine different oviposition events may have occurred in nest #1 (six to 17), one to two in nest #2 (one to three), and two in nest #3 (two to four) in the current reproductive season. These assumptions are strengthened if we take into consideration hatching dates (seven in nest #1 and three in nest #2 and #3). Although communal oviposition in nest #1 and #3 is evident, there is some doubt over nest #2 as it is quite possible that one single female laid the nine eggs.

Nest-sites and nesting areas are described for few species of neotropical snakes (e.g. Vaz-Ferreira *et al.*, 1970; Cadle & Chuna, 1995; Albuquerque & Ferrarezzi, 2004). Despite the fact that some snakes dig a hole in the soil to oviposit (e.g. Burger & Zappalorti, 1986), most species apparently are unable to construct a nest and rely on pre-existing sites for oviposition (Packard & Packard, 1988). This seems to be the case for *Sibynomorphus mikanii* (Albuquerque & Ferrarezzi, 2004; this study). Although eggs of nest #1 were found inside a hole, it is unlikely that any female of *Sibynomorphus mikanii* actually excavated it because the soil was very compacted. Moreover, in the laboratory, gravid *Sibynomorphus mikanii* tend to hide the eggs under the water bowl or under rocks instead of burying them (H.B.P. Braz and S.M. Almeida-Santos, *unpublished data*). In addition, other dipsadine snakes also oviposit in pre-existing sites (Brandão & Vanzolini, 1985; Riley *et al.*, 1985; Cadle & Chuna, 1995; Greene, 1997).

Thermal conditions are often suggested as a factor driving maternal choice of nest-site (Blouin-Demers *et al.*, 2004; Shine, 2004) because incubation temperature affects offspring phenotypes (Deeming, 2004) and therefore may influence organismal fitness (Elphick & Shine, 1998; Brown & Shine, 2004). Females frequently oviposit in forest clearings (Fowler, 1966; Brodie *et al.*, 1969; Covacevich & Limpus, 1972; Burger & Zappalorti, 1986; Albuquerque & Ferrarezzi, 2004) and nests located in these areas generally are hotter than nests located in shaded areas because shading reduces insolation and heating of the soil (Magnusson & Lima, 1984; Shine *et al.*, 2002). As well as nest #1, several nests have also been found in slopes (e.g. Brodie *et al.*, 1969; Covacevich & Limpus, 1972; Burger, 1976; Albuquerque & Ferrarezzi, 2004; James & Henderson 2004) and factors like direction and slope influence the absorption of solar radiation (Burger, 1976). Thus, mothers may have selected these sites seeking to maximize sunlight exposure to accelerate embryonic development or optimize phenotypic traits of the resulting hatchlings. Thermal conditions also may be the major factor influencing communal nesting behaviour. Temperatures in communal nests are usually higher than in solitary ones (e.g. Blouin-Demers *et al.*, 2004) due to metabolic heat generated by embryos (Burger, 1976; Ewert & Nelson, 2003). Therefore, communal nesting might be adaptive because higher temperatures in nests enhance hatchling phenotypes (Blouin-Demers *et al.*, 2004). However, studies on the thermal and hydric requirements of *Sibynomorphus mikanii* embryos are needed to test these assumptions.

In parallel, egg aggregations also offer other potential advantages such as protection (Graves & Duvall, 1995; Jackson, 1998) and predator satiation (Eckrich & Owens, 1995; Graves & Duvall, 1995). If communal oviposition offers such advantages to hatchlings (e.g. phenotype improvement, predator satiation), why, then, would one female oviposit in a solitary nest as is likely to have occurred in nest #2? Blouin-Demers *et al*. (2004) suggested that the disadvantages of solitary nests may be compensated by lower risk of egg parasitism by fungi. Additionally, in communal nests competition for water is larger than in solitary nests (Marco *et al.*, 2004; Radder & Shine, 2007). This modifies hydric exchange between the eggs and the environment and the consequences to hatchling phenotypes may be more detrimental to aggregated eggs (Marco *et al.*, 2004). Thus it is reasonable to suggest that there are trade-offs between these two modes of egg-laying that result in similar fitness payoffs (Blouin-Demers *et al.*, 2004).

In summary, there are two (but nonexclusive) reasons for the occurrence of communal nesting behaviour: scarcity of suitable nesting sites (e.g. optimum moisture and temperature; protection against predators) or this behaviour is adaptive, that is, increases reproductive success due to aggregation in large clusters. Our findings plus literature data indicate a preference of gravid *Sibynomorphus mikanii* to nest communally even when similar potential nest-sites were present in nesting areas. We suggest that such widespread behaviour might result from adaptation. However, the adaptive significance of communal oviposition remains unknown.

Measurements	**Nest #1**	**Nest #2 and #3**
Eggs	*n* = 41	*n* = 13
Length (mm)	27.9 ± 2.7	25.7 ± 3.0
Width (mm)	14.5 ± 2.0	12.6 ± 0.9
Mass (g)	3.5 ± 0.9	2.5 ± 0.4
Hatchlings	*n* = 33	*n* = 5
SVL (mm)	171.8 ± 13.5	170.0 ± 5.8
TL (mm)	34.0 ± 4.7	29..4 ± 2.6
Mass (g)	2.3 ± 0.4	2.0 ± 0.5
Sex (male/female)	19/14	2/3

Table 1. Measurements of eggs and hatchlings of three natural nests of the Goo-eater snake *Sibynomorphus mikanii*. SVL = Snout-vent length; TL = Tail length.

ACKNOWLEDGEMENTS

We thank D. A. C. Martins, and the staff of Vigilância Sanitária de Vargem for the material donation and information. B. M. Graves and D. W. Owens kindly provided references. This study was supported by FAPESP (07/51977-3).

REFERENCES

Albuquerque, C. E. & Ferrarezzi, H. (2004). A case of communal nesting in the Neotropical snake *Sibynomorphus mikanii* (Serpentes, Colubridae). *Phyllomedusa* **3**, 73–77.

Blouin-Demers, G., Weatherhead, P .J. & Row, J. R. (2004). Phenotypic consequences of nest-site selection in black rat snakes (*Elaphe obsoleta*). *Can. J. Zool.* **82**, 449–456.

Brandão, C. R. F. & Vanzolini, P. E. (1985). Notes on incubatory inquilinism between Squamata (Reptilia) and the Neotropical fungus-growing ant genus *Acromyrmex* (Hymenoptera: Formicidae). *Papeis Avulsos Zool*. **36**, 31–36.

Brodie, E. D., Jr., Nussbaum, R. A. & Storm, R. M. (1969). An egg-laying aggregation of five species of Oregon Reptiles. *Herpetologica* **25**, 223–227.

Brown, G. P. & Shine, R. (2004). Maternal nest-site choice and offspring fitness in a tropical snake (*Tropidonophis mairii*, Colubridae). *Ecology* **85**, 1627–1634.

Burger, J. (1976). Temperature relationships in nests of the northern diamondback terrapin, *Malaclemys terrapin terrapin*. *Herpetologica* **32**, 412–418.

Burger, J. & Zappalorti, R. T. (1986). Nest site selection by pine snakes, *Pituophis melanoleucus*, in the New Jersey Pine Barrens. *Copeia* **1986**, 116–121.

Cadle, J. E. & Chuna, P. M. (1995). A new lizard of the genus *Macropholidus* (Teiidae) from a relictual humid forest of northwestern Peru, and notes on *Macropholidus ruthveni* Noble. *Breviora* **501**, 1–39.

Covacevich, J. & Limpus, C. (1972). Observations on community egg-laying by the yellow-faced whip snake, *Demansia psammophis* (Schlegel) 1837 (Squamata: Elapidae). *Herpetologica* **28**, 208–210.

Deeming, D. C. (2004). Post-hatching phenotypic effects of incubation in reptiles. In: *Reptilian Incubation: Environment, Evolution, and Behaviour*, pp. 229–251. Deeming, D.C. (Ed.). Nottingham: Nottingham University Press.

Eckrich, C. E. & Owens, D. W. (1995). Solitary versus arribada nesting in the olive ridley sea turtles (*Lepidochelys olivacea*): a test of the predator-satiation hypothesis. *Herpetologica* **51**, 349–359.

Elphick, M. J. & Shine, R. (1998). Longterm effects of incubation temperature on the morphology and locomotor performance of hatchling lizards (*Bassiana duperreyi*, Scincidae). *Biol. J. Linn. Soc.* **63**, 429–447.

Ewert, M. A. & Nelson, C .E. (2003). Metabolic heating of embryos and sex determination in the American alligator, *Alligator mississippiensis. J. Therm. Biol.* **28**, 159–165.

Fowler, J. A. (1966). A communal nesting site for the smooth green snake in Michigan. *Herpetologica* **22**, 231.

Franco, F. L. (1994). O gênero *Sibynomorphus* Fitzinger, 1843 no Brasil (Colubridae: Xenodontinae, Dipsadini). Unpublished M.Sc. Dissertation. Pontifícia Universidade Católica do Rio Grande do Sul, Brazil.

Graves, B. M. & Duvall, D. (1995). Aggregation of squamate reptiles associated with gestation, oviposition, and parturition. *Herpetol. Monogr.* **9**, 102–129.

Greene, H. W. (1997). *Snakes: the Evolution of Mystery in Nature*. Berkeley: University of California Press. xiv + 351 pp.

Hall, P. M. & Meier, A. J. (1993). Reproduction and behavior of western mud snakes (*Farancia abacura reinwarditii*) in american alligator nests. *Copeia* **1993**, 219–222.

Jackson, D. (1989). Turtles use of alligator nests. *In*: *Crocodiles and Alligators*, p. 145. Ross, C.A. (Ed.). London: Merchurst Press.

James, A. & Henderson, R. W. (2004). Communal nesting site in the snake *Liophis juliae* in Dominica, West Indies. *Carib. J. Sci.* **40**, 263–265.

Laporta-Ferreira, I.L., Salomão, M.G. & Sawaya, P. (1986). Biologia de *Sibynomorphus* (Colubridae-Dipsadinae) – Reprodução e hábitos alimentares. *Rev. Bras. Biol.* **46**, 793–799.

Magnusson, W.E. & Lima, A.P. (1984). Perennial communal nesting by *Kentropyx calcaratus*. *J. Herpetol.* **18**, 73–75.

Marco, A., Díaz-Paniagua, C. & Hidalgo-Vila, J. (2004). Influence of egg aggregation and soil moisture on incubation of flexible-shelled lacertid lizard eggs. *Can. J. Zool.* **82**, 60–65.

Oliveira, J. L. (2001). Ecologia de três espécies de dormideira, *Sibynomorphus* (Serpentes: Colubridae). Unpublished M.Sc. Dissertation. Universidade de São Paulo, Brazil.

Packard, G. C. & Packard, M. J. (1988). The physiological ecology of reptilian eggs and embryos. In: *Biology of the Reptilia*, *Vol. 16. Ecology B*, *Defense and Life History*, pp. 523–606. Gans, C., Huey, R.B. (Eds.). New York: C. Alan R. Liss Inc.

Radder, R. S. & Shine, R. (2007). Why do female lizards lay their eggs in communal nests? *J. Anim. Ecol.* **76**, 881–887.

Resetarits, W. J., Jr. (1996). Oviposition site choice and life history evolution. *Amer. Zool.* **36**, 205–215.

Riley, J., Stimson, A. F. & Winch, J. M. (1985). A review of Squamata ovipositing in ant and termite nests. *Herpetol. Rev.* **16**, 38–43.

Shine, R. (2004). Adaptive consequences of developmental plasticity. In: *Reptilian Incubation: Environment*, *Evolution, and Behaviour*, pp. 187–210. Deeming, D.C. (Ed.). Nottingham: Nottingham University Press.

Shine, R., Barrott, E. G. & Elphick, M. J. (2002). Some like it hot: effects of forest clearing on nest temperatures of montane reptiles. *Ecology* **83**, 2808–2815.

Stearns, S. C. (1992). *The Evolution of Life Histories*. Oxford: Oxford University Press. 249 pp.

Vaz-Ferreira, R., Zolessi, L.C. & Achával, F. (1970): Oviposicion y desarrollo de Ofídios y Lacertilios em hormigueros de *Acromyrmex*. *Physis.* **29**, 431–459.

Snakebites in a rural area in northern Vietnam – a southeast Asian context

SÖREN ERIKSSON

Jönköping University, Box 1026, SE-551 11 Jönköping, Sweden. Soren.Eriksson@ihh.hj.se

THE majority of venomous snakes are found in the world's tropical regions, and the majority of snakebites occur in rural areas of these regions where many people have to cope with snakes literally in their own backyard. Actual statistics are usually unreliable, especially when attempting to attribute cases to specific species. Snakebite statistics are not systematically reported in most countries. Many cases do not find their way into official records, and for many developing countries they may be of local interest only. Very few countries possess a reliable epidemiological reporting system capable of providing precise data on snakebites. The lack of accurate statistics has prompted researchers to rely on scientific reports and other publications in an attempt to understand these issues.

The first comprehensive review of the global snakebite situation was made by Swaroop and Grab (1954). This survey estimated the total number of snakebite deaths in the world (excluding China, the USSR and the central European countries) at between 30 000 and 40 000 annually. Of this total, the highest figures were those for Asia (25 000–35 000), followed by South America (3000–4000). North America (including Mexico), Europe and Oceania had relatively few snakebite related deaths (300–500, 50 and 10, respectively). For Africa, the authors thought that the annual total number of deaths was around 400–1000. It was difficult for them to provide any approximate estimate for lack of reliable records.

The authors stressed that the available statistical data were mostly unreliable and at best could serve to provide only an approximate and highly conservative estimate of the snakebite problem. Reexamining the study it is not hard to find many inaccuracies. It is, however, important to stress that the lack of reliable sources from that period must have been part of the problem. The authors did not have at their disposal authoritative data and sources to support several statements about snakebite incidence.

Chippaux (1998) attempted to update the study by Swaroop and Grab, but he also relied on limited epidemiological data in arriving at estimates. According to his survey, Asia had in the 1990s about 100 000 deaths per year, Central and South America 5000, USA and Canada 15, Europe 15, the Middle East 100 and finally Oceania 200. Altogether Chippaux's total figure for snakebite deaths was 125 000 per year. Swaroop and Grab's figures, according to Chippaux, were greatly underestimated. But it is also hard to authenticate Chippaux's high death rates as his study is mostly based on uncertain assumptions and literature reviews.

In the meantime, many countries have taken measures to reduce snakebite incidence by building better houses, using shoes and boots while walking or working in the fields etc. The most successful effort to reduce the number of fatalities, although not in all countries, is the widespread use of antivenom. In many countries this treatment has drastically reduced the number of deaths caused by snakebites.

The southeast Asia context

Southeast Asia harbours one of the richest snake faunas in the world, which can be exemplified by Malaysia. According to Tweedie (1961), the snake fauna comprises 137 species of land and seasnakes in peninsular Malaysia. The Malaysian region, including Sabah and Sarawak, has a combined total of 192 species of snakes which are found in all manner of habitats (Lim & Lee, 1989). The number of snake species in East Malaysia (Sabah and Sarawak) is probably lower than in peninsular Malaysia.

The first epidemiology of snakebites in Malaysia was reported by Reid *et al.* (1963). This report stated that of the 2114 cases in 1958 and 1959 in the states of Perlis, Kedah and Penang, most of the snakebites were inflicted by the marbled pit viper, also named Malayan pit viper (*Calloselasma rhodostoma*, previously known as *Agkistrodon rhodostoma*). The mortality rate was 1.6 %.

A report by Lim & Abu Bakar (1970) comprising 15 919 cases of snakebites, mainly in northwestern parts of Malaysia (Perlis, Kedah, Penang and Perak) during the period between 1960 and 1968, found a general mortality rate of 0.8 %. An updated report comprising cases from 1960 to 1979 (Lim, 1982) throughout 11 states of West Malaysia (peninsular Malaysia) referred to a total of 53 216 snakebites inflicted by both venomous and harmless snakes. From these, 249 deaths occurred giving a total mortality rate of 0.46 %.

The analysis, based on these 11 states, shows that the higest incidence of snakebites was from the states of Perlis and Kedah with 3.1 and 15 bites per 1000 population as compared to 0.5 bites in Penang and much lower rates in all other states (0.02 to 0.23 per 1000 population).

Between 1960 and 1973 there was a consistent increase in snake bite cases at an average of 12.9 % per year. The six-year period from 1974 to 1979 showed an average annual increase of 0.56 %. In contrast, the mortality rate was the highest in 1961 and 1962 with a steady decline over the years to 0.27 % in 1979. The consistent increase in snakebite cases throughout the period was to be attributed to factors such as the increased speed of deforestation which forces snakes out from their natural niches to seek new environments near and around human habitation, implying that the serpents come closer to houses and gardens in search of prey. The decline of the mortality rate may be due to the availability of antivenom for treatment and perhaps most bites were inflicted by harmless snakes or by defensive biting.

A hospital-based retrospective study of the prevalence of snakebite cases at Hospital Kuala Lumpur (Jamaiah *et al.*, 2006) was carried out over a five-year period from 1999 to 2003. A total of 126 snakebite cases were recorded. Most of the cases were reported in the 11–30 year age group and the male/female ratio was 3:1. About 25 per cent of the cases (both suspected and confirmed) were inflicted by cobras, 10 per cent by vipers, 4 per cent by pythons and 1 per cent of the bites were inflicted by seasnakes. In 60 per cent of the cases the snake could not be identified. There were no fatal cases among the patients.

Thailand's snake fauna is as rich as that of Malaysia. According to Queen Saovabha Memorial Institute and Snake Farm, Thailand is the home of more than 180 snake species. The various zoogeographic regions have important influences on the composition of the herpetofauna. Within Thailand, distinct distribution boundaries are recognizable. The Isthmus of Kra, the narrowest part of the Thai/Malayan peninsula, represents such a significant natural boundary. Many species south of this fauna shed do not occur north of it (Chan-Ard *et al.*, 1999). A large portion of the species inhabiting the central and northern parts of continental Thailand, on the other hand, shares traits with the herpetofauna of Indochina and Myanmar (*ibid.*).

Sawai *et al.* (1972) reported a total of 15 292 snake bite cases from 68 provincial hospitals between 1965 and 1969. The identified cases were 4851 or 31.7 per cent, whereas 9728 or 63.6 per cent were unidentified and 713 or 4.6 per cent were bites by non-poisonous snakes. Of the identified cases, 34 per cent came from the Malaysian viper (*Calloselasma rhodostoma*), 29.6 per cent by green vipers (*Trimeresurus*), 25.2 per cent by cobras (*Naja sp.*), 8.3 per cent by Russell's viper (*Daboia siamensis*, previously grouped with *Daboia russelii*; Thorpe *et al.*, 2007) and 2.9 per cent by other venomous snakes. The mortality rate of the Malayan pit viper was 1.6 per cent and a majority of all cases were found in the southern parts of Thailand. The mortality rate of cobra was 6.5 per cent, with the majority found in central and western parts of the country. Green pitviper bites were most frequent around Bangkok, while cases from Russell's viper were mainly recorded in central parts of Thailand. Despite some small errors in the statistical data, the study shows a mean number of deaths of about 75 persons per year (author's comment). Thailand has developed a rather good system with access to antivenom in medical clinics throughout the country.

A study (Meemano *et al.*, 1987) which stresses the prominence of green pitviper cases in and around Bangkok, shows that their share in this region is more than 90 per cent of total bites. Another study (Rojnuckarin *et al.*, 1998) deals with 278 patients attacked by green pitvipers admitted to Chulalongkorn Hospital from 1987 to 1995. No deaths due to bites by green vipers were reported at the hospital since the development and use of the specific antivenom.

The small country of Singapore, located roughly 130 km north of the equator, has a total land area (including the smaller islands) of 682 square kilometres. Since British colonization in 1819 most of the dense lowland tropical rainforest has disappeared with other terrestrial and freshwater habitats. This has drastically reduced the number of animal species, including snakes. Singapore is a very densely populated (4 million people) city state, albeit with some 2000 hectares of protected nature reserves. Of 55 different snake species historically found in Singapore, most are now threatened by extinction. Encounters with snakes and incidence of snakebites still occur. Snakes are not solely confined to the natural habitats but can also be found in built-up areas.

In 1984, a total of 50 snakebite patients were admitted for treatment in hospitals of the Ministry of Health. Most of the patients were not bitten in forests but at places of work, schools and recreational areas (Gopalakrishnakone *et al.*, 1990). According to Lim & Lee (1989), snakebites are uncommon, with an estimated 40 cases treated at hospitals each year. The mortality rate is low with only one death in the past three years (*ibid.*). A case of morbidity from the bite of a red-necked keelback snake (*Rhabdophis subminiatus*) was reported in 2000 (Seow *et al.*, 2000). This so-called non-venomous snake was kept as a pet. The patient recovered after hospital treatment.

Spread across more than 14000 islands, Indonesia's large population is dispersed and clustered on islands, large and small. On a geographical basis, Indonesia is conveniently, but informally, divided into the Greater Sunda Islands, including the Indonesian part of Borneo, Java, Sulawesi and Sumatra, and the Lesser Sunda Islands, which include, among other islands, Bali, Flores, Lombok, Sumbawa and Timor. In recent decades Indonesia has gone through dramatic environmental changes with areas of primary forest disappearing. According to Groombridge (1992), Indonesia loses annually between 6000 and 9000 km^2 of closed tropical wet forest. Indonesia is very rich in snake species, with about 240 land species recorded in the country. The figure excludes sea snakes and taxa restricted to the Malaysian part of Borneo, but includes those from Irian Jaya (David & Vogel, 1996).

The only report published on snakebites in Indonesia was carried out by Kawamura *et.al* (1975). The authors visited hospitals and health services in Java, Bali, Sumatra, Sulawesi, Kalimantan and Timor and collected historical records of patients and information on snakebites. The total number of cases were not available. About 50 % were due to green vipers (*Trimeresurus*), probably most by *Cryptelytrops albolabris* (formerly *T. albolabris*), with a mortality rate of 2.4 %. Thirty-three per cent of the bites were caused by the Malayan pit viper (*C. rhodostoma*) with a fatality rate of 3.5 per cent.

The most eastern part of Indonesia, Papua Barat/West Papua (formerly Irian Jaya), which is the western part of New Guinea, has not been subject to any snakebite study. The eastern part of the island, Papua New Guinea, has been studied by Campbell (1969), Currie *et al.* (1991) and Lalloo *et al.* (1995). As the whole island of New Guinea is located far east of the Wallace Line, the fauna differs much from that of the Sunda Islands and the rest of southeast Asia. New Guinea's snake fauna thus more resembles that of Australia where the elapids constitute the greater majority of snake species and the family Viperidae is not present.

In their study Swaroop & Grab (p. 74) state that in the Philippine Islands ”relatively few poisonous reptiles are found and mortality from snakebite is therefore negligable. However, two coral snakes – *Doliophis bilineatus and D. philippinus* – are known to occur” [this should be Oriental coral snakes; the species are now considered subspecies of *Calliophis intestinalis*]. No source of data to support this statement is given. Although venomous, most of coral snakes are relatively small serpents, with small mouths, and generally considered incapable of inflicting an effective bite on an adult human, unless roughly handled (author's comment).

It is correct that the Philippines are inhabited by far less poisonous snakes species compared with continental parts of southeast Asia, but among scientists it has been known for a long time that the country is inhabited by the King cobra (*Ophiophagus hannah*), Wagler's pitviper (*Trimeresurus wagleri*, renamed *Tropidolaemus wagleri*) and three cobra species (*Naja*); *N.*

philippinensis, in the north, *N. samarensis* in the south and *N. sumatrana* on Palawan. The cobras can be considered the most serious snakes in the islands with respect to snake bite incidence and deaths.

Reyes and Lamanna (1955) reported a snakebite mortality rate of 1.26 per 100 000 population between 1928 and 1939, with most cases reported from the rice and sugar-growing regions of Luzon. During this period an average of 183 deaths were reported. The Diseases Intelligence Center of the Philippine Government reported that 294 died from snakebites in 1968, 237 or 81 per cent of the deaths occurred in Luzon and 36 or 12 per cent of fatal cases were reported in Mindanao (Sawai *et al.*, 1972).

Watt *et al.* (1987) confirmed in a study based on interviews with villagers in three agricultural areas, that cobra bite (*N. naja philippinensis*) was an important factor of deaths among rice farmers in the area studied. The death rate from cobra bite was estimated as high as 107.1 per 100 000 each year at one site. The confirmed death rate averaged 53.8 per 100 000 for the three villages.

The actual figures from Burma are very uncertain, but the country has a large number of venomous snakes species; cobras (*Naja* spp.), King cobra (*Ophiophagus hannah*), kraits (*Bungarus* spp.), vipers, especially Russells viper (*Daboia russelii*) and pit vipers (*Trimeresurus* sp. complex).

Swaroop & Grab (p. 63) states the following,

”*As compared with other countries of the world, the incidence of snakebite in Burma is very high, the average being 15.4 per 100,000 population, with the district Sagaing recording as high a rate as 36.8 per 100,000. Of a total of 30 districts, 15 have snakebite death rates as high as 15.0 per 100,000 or over*.”

The average number of deaths for each year from 1935 to 1937 were 2072, according to Swaroop & Grab. Minton and Minton (1969) mentioned similar numbers and incidence, but their data were unsourced. When comparing these figures, it appears that Minton and Minton relied on Swaroop and Grab for data. In Burma, which seems to have the highest snakebite mortality in Asia, many serious cases are apparently caused by the *Daboia russelii* (Aung-Khin, 1980; Myint-Lwin *et al.*, 1985; Naing, 1985). No data are available for Cambodia and Laos.

Published data available on the snakebite issue in Vietnam are outdated. From 1948 to 1952, 124 cases of cobra bites were treated in the Institut Pasteur, Saigon; of these two died. The Province of Cantho registered four deaths from snakebites in the period from 1948 to 1950 (Swaroop & Grab, 1954). Michael Barme, former Director of the Pasteur Institute Laboratory in Saigon reported a high incidence of fatal cases from seasnake bites. However, the exact number of cases cannot be confirmed due to the spread of superstitions about snakebite in many villages situated in areas far away from urban centres (Barme, 1963).

Information from the Ministry of Health (April, 2004) stated that some hospitals and research institutes in Vietnam have collected information about snakebite victims and their treatment for several years, but this information/statistics has not been published. Information by a doctor (April 2004) at the large Bach Mai Hospital in Hanoi revealed that about 70–100 snake bite patients in northern Vietnam and about 200–300 patients in southern parts of Vietnam. are treated at large hospitals each year,

The empirical parts of this paper is a field study to examine the snakebite incidence in the Cho Don district in the Bac Can province in northern Vietnam. This is the first field study of the snakebite problem in Vietnam.

THE FIELD STUDY

During the second part of September 2003 a field study was carried out in the Cho Don district (47 000 inhabitants, 2000) in the Bac Can province (280 700 inhabitants, 2000) in northern Vietnam. The field trip was carefully planned so that meetings with responsible medical staff could take place at all administrative levels in the areas investigated. To facilitate obtaining more reliable knowledge of the real snakebite situation, interviews and discussions took place with snakebite victims, their relatives and other community members.

The Cho Don district is located in a mountainous area of northern Vietnam. Most of the district is located at an altitude of 400–900 m. above sea level, with mountains reaching above 1000 m. The district has a large cover of primary moist tropical rain forest and secondary forest after exploitation, intersected by river valleys and wet rice fields. Yearly rainfall is about 1800 mm concentrated during summer. The district is located around the 22nd parallel. The annual mean temperature is about 23° C, with an average high of 28 + C and an average low of 17°C.

The vegetation reflects the burn-beating that is practised in the area and is a mixture of moist tropical evergreen forest, different species of bamboo, woody brush, grasses and wet rice fields.

The first visit was made to the districts main clinic. Then visits were made to two communes (Nam Chuong and Bang Lang) in the Cho Don district. Nam Cuong commune is located about 60 km north of the district town Cho Don, and is reachable by a rudimentary road, using a 4WD jeep. The Bang Lang commune is located about 10 km south of Cho Don district town.

Cho Don District Clinic

The district has a total population of about 47 000 people. The clinic mainly serves Cho Don town and the surrounding countryside, but has also the role of assisting patients from the more remote villages in the district. Interviews and discussions took place with 5 doctors working at the clinic. They were responsible for medical treatment at the clinic and each of them had worked for many years at this particular location. In general the Cho Don Clinic received about 3 to 4 cases of snakebites each year. No casebooks were used, except for the king cobra case below, so the estimated 3 to 4 cases a year were based on experience.

At the clinic only one death owing to snakebite had happened since the year 2000. That year a 30-year old man had arrived at the clinic at 11 p.m., bitten by a king cobra, and had deceased 8 hours later at 7 a.m. Although this is a district clinic with a staff close to 20 doctors, there was no antivenom available and the only treatment possible was life-supporting treatment such as respiratory support. The medical staff at the clinic had no special training to deal with snakebite poisoning and consequently very limited resources to treat serious snakebite cases. During the interviews and discussions, a few of the doctors also expressed the opinion that traditional healers probably were better to deal with snakebite patients than their own clinic! They also said that a majority of all snakebite cases were treated by healers rather than at the medical clinic.

According to the doctors at the clinic, there are three main causes of people being bitten by snakes: people walking in a forest searching for firewood, people working in ricefields and people searching for snakes, i.e. snake handlers or snake traders. The most common snake species involved are kraits, cobras and green vipers.

Nam Cuong Commune (Figure 1)

At the time of the visit, the Nam Cuong rural district had 3027 inhabitants distributed among 11 villages. The field visit took place in one village with roughly 300 inhabitants served by a small clinic headed by a nurse. The medical resources at this level are extremely limited and there are no possibilities to deal with snakebites. There are a few (3–4) cases in the village each year, but nearly all visit traditional healers. Since 2000 she (the nurse) had received three patients (1 in 2000, 2 in 2001), of which one died in 2001. No casebook was used, so this was a recollection. The two cases which survived were, according to the nurse, caused by cobras.

The fatal case took place in September 2001. Early in the evening a male, 30 years of age, went out fishing after a rain had ceased. He put a bait (a piece of meat) in a net and then placed the net just below the water surface in the dam, located in the village. When he returned late in the evening, he noticed an object floundering in the net where he had placed the bait. He assumed it was a fish and grasping it he was immediately bitten. He killed the snake, then went home, but because he did not feel any symptoms he went back fishing. After a few hours he felt difficulties in breathing and returned home (interview with his wife). A few hours later he died, mainly due to respiratory failure. Based on the description of the snake, it was probably a krait (*Bungarus fasciatus* or *B. multicinctus*).

From interviews in the village, it is clear that most cases of snakebites are dealt with by traditional healers still practising their ancient medicine in the area. Another snakebite case in the same village took place in 1998. A girl of 18 was

Figure 1. The dam in Nam Cuong Commune. © S. Eriksson.

resting in her bed. At 3 p.m. she stepped down directly on a cobra lying on the floor and was bitten in a foot. She suffered immediate effects from the bite and became unconscious after about one hour. The victim was sent to a traditional healer and then brought back to her home where she slowly recovered. She suffered from necrosis in her foot and went through surgery at the district clinic. Altogether the community has an annual snakebite incidence of about 10 bites per 1000 population, which is a high figure.

Bang Lang Commune (Figure 2)

This district had 1453 inhabitants, distributed among 9 villages, with one common health clinic. According to the medical staff about 3–4 snakebite victims visit the clinic each year. No medical casebooks are used, so these figures are based on memory. In 2002 there were 3 cases. The victims were working in the forest looking for firewood or animals. According to the doctors most cases are dealt with by traditional healers. None of the cases in recent years had been fatal. The medical staff told of a case in the late 1990s or early 2000s: A woman had been bitten at about 8 p.m. while searching for firewood. According to the doctors, the offending snake was a krait (no particular species identified) and the patient died eight hours later.

Visits were also made to two villages in the Bang Lang commune. The first village had about 200 inhabitants. The author interviewed a man who was 46 years old at the time of the bite (spring 2002). He was bitten by a snake at 6.30 p.m. while walking in the ricefield on his way home. He stepped on the snake and experienced an intense pain shortly after the bite. His foot and leg swelled and began bleeding from the punctures, which are typical symptoms of viper bites. According to the victim, the snake had a length of about 60 to 70 cm, was greyish and had a triangular head which was broader than the body. This description matches that of a viper.

In this case the man first went to the rural clinic, where he received a tourniquet around his leg and cleaning of the wound. Later he went to a traditional healer to be treated with customary herbs. After about one week the patient recovered. He estimated that two or three persons in the village were bitten by snakes each year and recalled that one person in a neighbouring village had died from a snakebite a few years ago but said it was not the woman searching for firewood earlier mentioned. The medical staff at the commune clinic had no knowledge of the case. According to this man most snakebites were caused by cobras, kraits and green vipers.

The author visited another village in Bang Lang rural district. The village had about 150 inhabitants. An interview was made with a woman (41 years old in 2001) who had suffered from a snakebite in August 2001. At lunchtime she went out in the forest close to the village in search of firewood. She was bitten in the foot and felt intense pain and the wound began bleeding. In a short time the leg became very swollen. She went to a traditional healer who treated her with herbs and some kind of drinkable fluid.

Regarding the offending snake, the woman said it was a krait. She said she knew nothing about snakes, but a neighbour had told her that it probably was such a snake. However, the symptoms do not support a bite from krait. They are typical of vipera envenomation. Kraits are usually very timid during daytime and very inclined to bite during the night (author's comment). At the interview she said that the snake was yellow or brown, about 80 cm in length, and had a broad triangular head. This description indicates that the snake was a viper. The patient recovered after a month, although she still had scars on her foot.

The woman knew at least 3 other snakebite cases in the village during the previous two years, all had recovered. None had been in contact with the clinic. Throughout the years she was not aware of anyone bitten by snake having sought treatment at the clinic.

Figure 2. Typical environment at Bang Lang Commune. © S. Eriksson.

Both villages seem to have a snakebite incidence of about 10 bites per 1000 population, which is similar to the rate estimated for the village in Nam Cuong commune.

DISCUSSION

This case study investigates snakebite incidence in two communes in the Bac Can province in northern Vietnam. The investigation indicates a relatively high snakebite incidence, which can partly be explained by a completely rural population working in an environment dominated by agriculture and outdoor activities. Another factor explaining the high incidence is this study's reliance on interviews rather than clinical data, thus incorporating snakebite cases not known to clinics. In the three villages investigated there was one known death in the period 2000–2002. The three other deaths were from villages not included in this study.

In Vietnam there are no snakebite data collected, neither on a local nor on any other administrative level, except unpublished data from a few hospitals and institutes. In the investigated communities no medical casebooks were used, except in one case. Another important factor behind inadequate knowledge about snakebite incidence is the victims' decisions to visit traditional healers instead of seeing a medical clinic. From this field study there are no data showing the share of people visiting traditional healers, but a rough estimate is that less than 20 per cent of the snake-bite victims visit a clinic. Those visiting the healers include victims with mild cases as well as more serious ones.

With their limited resources the clinics have very little to offer. Their capacity to treat serious cases is curtailed as they lack antivenoms. The field study also revealed that some of the doctors interviewed expressed the opinion that traditional healers were better at dealing with snakebite cases than modern medicine! This also implies another serious medical as well as structural problem when dealing with these issues. In the light of the scanty clinical data available and the interviews with the villagers, most serious snakebite cases take place in the evenings and nights. People are bitten in the forest while collecting firewood or walking along small paths. People working in ricefields are also prone to snakebites and according to staff at the clinics it is not uncommon for snakebites to occur among persons deliberately handling venomous snakes, i.e. mainly snake collectors. Most serious cases seem to be caused by cobras and kraits.

But there are some sources of error in making such a statement. During the evening and night it can be difficult to identify snake species and many people have a very limited knowledge of snakes. If a correct identification of the snake cannot be made, the symptoms are usually a good guidance.

Venoms of elapids (cobras, kraits, etc) generally produce neurotoxic symptoms, causing respiratory paralysis, acute heart failure etc. Bites by some kraits causes no local pain or swelling and the effect can be delayed for some hours, such as the case from Nam Cuong. Otherwise the symptoms are similar to those of cobra bite. Most bites from elapids can be avoided by wearing protective boots when walking in fields and forests. Other cases reported in the study and oral information received during the field trip reveal that vipers are an important source of snakebites. Mostly referred to are green tree vipers but these snakes are seldom the cause of serious problems. However, their bite incapacitates the patient for some days or a week. In this study there were also two suspected bites from terrestrial vipers, although the species were not identified.

There are clear indications that the snakebite problem in Vietnam is more serious than in many other southeast Asian countries. Vietnam has a large rural population, limited medical resources at rural and district clinics and lack of antivenom treatment. In more economically developed countries, such as Malaysia and Thailand, better medical resources are available, including general access to antivenom.

Based on this pilot project there are a number of reasons to learn more about humans and snakebites in Vietnam:

* There is a need to know more about the extent and structure of snakebites in Vietnam's provinces. Additional information obtained after the field study (during 2004–2005) reveals that antivenom is not deployed in provincial hospitals and is also lacking in most city hospitals. This implies that a large number of snakebite victims in Vietnam do not receive antivenom treatment.

* Consideration should also be given to the situation in other parts of Vietnam, with divergent geographical characteristics such as altitude, vegetation, population density and occupation patterns. There are also some differences in the number and composition of snake species between northern and southern Vietnam.

* It is also important to reflect on what appropriate measures could be taken for the future.

ACKNOWLEDGEMENTS

Many thanks to faculty at the Center of Environmental Economics and Regional Development at NEU, Hanoi, who assisted me in planning and conducting the field trip. Special thanks to Dr Le Thu Hoa at NEU, who also assisted with information from the Ministry of Health and Bach Mai Hospital, Hanoi. Thanks are also due to Dr Le Van Hoi (MD, MSc) who prepared the visits to the clinics and translated the conversations throughout the field trip.

REFERENCES

Aung-Khin, M. (1980). The problem of snake bites in Burma. *The Snake* **12**, 125–127.

Barme, M. (1963). Venomous Sea Snakes of Vietnam and Their Venoms. In: *Venomous and Poisonous Animals and Noxious Plants of the Pacific Region*. Keegan, H. L.& Macfarlane, W. V. (Eds). Oxford: Pergamon Press,

Campbell, C. H. (1969). *A clincial study of venomous snake bite in Papua*. MD Thesis, Sydney University.

Chan-Ard, T., Grossman, W., Gumprecht, A. & Schulz, K.-D. (1999). *Amphibians and Reptiles of Peninsular Malaysia and Thailand – An illustrated checklist*. Wuerselen, Germany: Bushmaster Publications.

Chippaux, J-P. (1998) Snake-bites: appraisal of the global situation. *Bull. Wld. Hlth. Org.* **76**, 515–524.

Currie, B. J., Sutherland, S. K., Hudson, B. J. & Smith, A. M. A. (1991). An epidemiological study of snake bite envenomation in Papua New Guinea. *Med. J. Austr.* **154**, 266–268.

David, P. & Vogel, G. (1996). *The Snakes of Sumatra: An annoted checklist and key with natural history notes*. Frankfurt am Main, Germany: Edition Chimara.

Gopalakrishnakone, P., Chou, L. M., Aye, M. M., Lim, F. L. K., Cheng, C. T., Keng, L. S., Anantharaman, S. (1990). *Snake Bites and Their Treatment*. Singapore: Ridge Books, Singapore University Press.

Groombridge, B. (Ed.) (1992). *Global biodiversity. Status of the earth's living* *resources. A report compiled by the World Conservation Monitoring Centre*. London: Chapman & Hall.

Jamaiah, I., Rohela, M., Ng, T. K., Ch'ng, K. B., Teh, Y. S., Nurulhuda, A. L., & Suhaili, N. (2006). Retrospective prevalence of snakebites from Hospital Kuala Lumpur (HLK) (1999–2003). *SE. Asian J. trop. Med. publ. Hlth.* **37**, 200–205.

Kawamura, Y., Chinzei, H. & Sawai, Y. (1975). Snakebites in Indonesia. *The Snake* **7**, 73–78.

Lalloo, D. G., Trevett, A. J., Saweri, A., Naraqi, S., Theakston, R. D. G. & Warell, D. A. (1995). The epidemiology of snake bite in Central Province and National Capital District, Papua New Guinea, *Trans. R.. Soc. trop. Med.. Hyg.* **89**, 178–182.

Lim, B. L. & Abu Bakar, B. I. (1970). Bites and stings by venomous animals with special reference to snake bites in West Malaysia. *Med. J. Malaya* **25**, 128–141.

Lim, B. L. (1982). *Poisonous Snakes of Peninsular Malaysia*. Kuala Lumpur: Malayan Nature Society/Institute for Medical Research

Lim, F. L. K. & Lee. M. T-M. (1989). *Fascinating Snakes of Southeast Asia; An introduction*. Kuala Lumpur: Tropical Press Sdn, Bhd.

Meemano, K., Pochanugool, C. & Limthongkul, S. (1987). Incidence of snake bite at Chulalongkorn Hospital. In: *Progress in Venom and Toxic Research*, pp. 36–40. Gopalakrishnakone, P. & Tan, C. K. (Eds). Singapore: National University of Singapore.

Minton, S. A. & Minton, M. R. (1969). *Venomous Reptiles*. New York: Charles Schribner's Sons,

Myint-Lwin, Warrrell, D. A., Phillips, R. E., Tin-Nu-Swe, Tun-Pe & Maung-Maung Lay (1985) Bites by Russell's viper (*Vipera russelli siamensis*) in Burma: haemostatic, vascular, and renal disturbances and response to treatment. *Lancet* **2**, 1259–1264.

Naing, S. (1985). Clinical profile of viper bite cases, Divison Hospital, Magwe (1981–82). *Burm. Med. J.* **31**, 195–203.

Reid, H. A., Thean, P. C. & Martin, W. J. (1963). Epidemiology of snake bite in north Malaya. *Br. Med. J.* **1**, 992–997.

Reyes, A. & Lamanna, C. (1955). Snakebite mortality in the Philippines. *Philippine J. Sci.* **LXXXIV**, 189–194.

Rojnuckarin, P., Mahasandana, S., Intragumthornchai, T., Sutcharitchan, P. & Swasdikul, D. (1998.) Prognostic factors of green pit viper bites. *Am. J. Trop. Med. Hyg*. **58**, 22–25.

Sawai, Y., Koba, K., Okonogi, T., Mishima, S., Kawamura, Y., Chinzei, H., Abu Bakar, b. I., Devaraj, T., Phong-Aksara, S., Puranananda, C., Salafranca, E.S., Sumpaico, J.S., Tseng, C.-S., Taylor, J.F., Wu, C.-S., & Kuo, T.-P. (1972). An epidemiological study of snakebites in the Southeast Asia. *Japan. J. Exp. Med.* **42**, 283–307.

Seow, E., Kuperan, P. Goh, S. K. & Gopalakrishnakone, P. (2000). Morbidity after a bite from a "non-venomous" pet snake. *Singapore Med. J.* **41**, 34–35.

Swaroop, S. & Grab, B. (1954) Snakebite mortality in the world. *Bull. Wld. Hlth. Org.* **10**, 35–76

Thorpe, R. S., Pook, C. E. & Malhotra, A. (2007). Phylogeography of the Russell's viper (*Daboia russelii*) complex in relation to variation in the colour pattern and symptoms of envenoming. *Herpetol. J.* **17**, 209–218.

Tweedie, M. W. F. (1961). *The Snakes of Malaya*. 2nd edition. Singapore: Government Printing Office.

Watt, G., Padre, L., Tuazon, M.L. & Hayes, C.G. (1987). Bites by the Philippine cobra (*Naja naja philippinensis*): an Important Cause of Death among Rice Farmers. *Am. J. Trop. Med. Hyg.* **37**, 636–639.

Nesting ecology of the Eastern box turtle (*Terrapene carolina carolina*) in central Virginia, USA

GORDON L. WILSON[1] and CARL H. ERNST[2]

[1] *New Saint Andrews College, 405 South Main Street, Moscow, Idaho 83843, USA.* gwilson@nsa.edu

[2] Division of *Amphibians & Reptiles, MRC 162, Smithsonian Institution, P.O. Box 37012, Washington, D.C., 20013-7012, USA.* chernst@frontiernet.net

ABSTRACT — The Eastern box turtle, *Terrapene carolina carolina*, was studied in an 11 ha woods in Lynchburg, Virginia, USA. There was evidence that moderate to heavy precipitation in June-July induced nesting behaviour by gravid females. We found that 86–92% of telemetered, gravid females oriented toward open areas (fields, road/trail borders, and yards) to oviposit. Of the observed 13 nestings, 11 (85%) occurred between 17:00 and 01:00 h. Forty-seven percent of eggs hatched in enclosed, predator-proof nest enclosures. Because of migration to and from nesting sites, gravid females had a mean bivariate normal activity range almost five times greater than that of nongravid females. This finding has negative implications regarding the conservation of the species in road-fragmented habitats due to the potential for increased road mortality or other human disturbance of the wider ranging gravid females.

TERRAPENE carolina carolina (Testudines: Emydidae) ranges in the eastern USA from southern Maine south to Georgia and west to Michigan, Illinois, and Tennessee (Ernst *et al*., 1994). The species occurs predominately in mixed oak-pine forests, pine flatwoods, marshy meadows, maritime oak forests, hardwood swamps, and agricultural areas. Moreover, it is frequently found in residential areas and upland forests of the Appalachian Mountains.

Because *T. c. carolina* is the most common terrestrial turtle within its geographic range, it is a convenient subject for research (see Ernst *et al*., 1994; and Dodd, 2001; for reviews of previous studies); however, a disproportionate amount of data is anecdotal. Consequently, there is still need for more information on the turtle's nesting ecology. Previous studies with data, some anecdotal or incidental, on nesting include Ewing (1933), Allard (1935), Stickel (1950), Congello (1978), Boucher (1999), and Wilson & Ernst (2005). Because of the lack of quantitative analysis on several aspects of the turtle's nesting ecology, we decided to explore them more thoroughly, particularly the relationships between nesting and time of day, precipitation, relative humidity, and nest site habitat.

MATERIALS AND METHODS

Field-site description

All data were collected in an approximately 20 ha, undisturbed, oak-pine (*Quercus-Pinus*) woodlot adjacent to the Blackwater Creek Natural Area in the city of Lynchburg, Virginia, USA. The area used for most studies was a flagged area of approximately 11 ha. The habitat ranged from predominately open deciduous woods to dense thickets of brush (mostly raspberry, *Rubus* sp.) and a mowed grassy field. The study area was bordered by the Odd Fellows/Rebekah Nursing Home of Virginia to the northeast and east, the Blackwater Creek bike path to the south and west, and residential homes to the north. To the southeast and northwest, the boundaries were marked with flags based on the relative ease in which the area could be surveyed. The woodland is the property of the Odd Fellows Home, and is within the Blackwater Creek watershed.

Field materials and methods

Virginia *T. c. carolina* may emerge from hibernation as early as late February (Boucher, 1999; Wilson, pers. obs.), but significant activity does not usually begin until April, so studies were begun in that month and extended into the fall during the years 2000–2002. Microenvironmental variables such as air temperature (AT, dial Enviro-Safe Thermometers), surface litter temperature (LT) and soil temperature (ST) (both taken with Taylor soil thermometers), local daily weather conditions (including precipitation data obtained from the United States National Oceanic and Atmospheric Administration [NOAA] website), relative humidity (sling psychrometer), location description (i.e., canopy cover, microhabitat, and landmarks), time and date were recorded at the location of each capture. Each capture point was marked with a flag on which the individual turtle's number, date, and time of capture were recorded. These flags were relocated during the winter and their positions (UTM coordinates) recorded using a Garmin GPS unit. These data were analyzed using Calhome Software (Kie *et al.*, 1996) to calculate home ranges for each female using several different methods: minimum convex polygon (MCP), adaptive kernal (AK), harmonic mean (HM), and bivariate normal (BVN). Results from these methods were compared to ascertain which was the least sensitive to sample size and which was most useful for the objectives of this study (Warkentien, 2001).

The turtle's straight-line carapace length (CL), carapace width (CW), and carapace height (CH) were recorded with dial calipers accurate to 0.5 mm, and mass (BM) to the nearest g with a Pesola spring scale. Each turtle was shell notched for future identification using the coding system of Ernst *et al.* (1974).

Twelve reproductive age females captured during the springs of 2000–2002 were equipped with SOPB-2190 radio-transmitters (Wildlife Materials, Inc.; see Wilson and Ernst, 2005, for attachment procedure), and were tracked for approximately the same annual length of time during the study. Three size categories, usually with four females per category, were captured to span a range of CLs of mature turtles (small, 10.0–11.5 cm; medium, 11.6–12.5 cm; large, 12.6 cm or larger). The females were released at the place of capture, and then radio-located every few days.

Belzer (1999a) and Congello (1978) reported that Pennsylvania *T. c. carolina* generally oviposit in the late afternoon and into the night on overcast or stormy days. We located our females daily, or on every other day, during 16:00 to 20:00 h, especially those females that were determined to contain shelled oviductal eggs through palpation or X-radiographs. If a female was observed nesting, her behaviour was recorded during nest excavation, oviposition, and placement of the eggs within the nest cavity. Once oviposition was completed, she was weighed and set aside. The eggs were then carefully retrieved; their lengths (EL), widths (EW) and masses (EM) recorded (data analyzed in Wilson & Ernst, 2005); they were replaced in the nest as closely as possible to their original positions. The female was then set back in her nesting position to allow her to finish filling and tamping the nest cavity so the soil was compacted in the normal way. Once she finished and moved away, a plywood enclosure 45 cm x 45 cm x 15 cm) with a screen top was placed over the nest to prevent nest predation during the incubation period of approximately 70–80 days (Ernst *et al.*, 1994). The base of the enclosure was partially buried to retain the neonates upon hatching. Also, the enclosure was secured by tent stakes to prevent disturbance by predators or harsh weather conditions. Hatchling retention was brief, as the site was checked daily when the estimated hatching date approached. Once the eggs hatched, the nest enclosure was removed, the hatchlings were measured (CL, CW, BM), and notched. The fate of each egg was recorded (hatched, desiccated, rotted, etc.). By monitoring the 12 females, it was determined if any had laid more than one clutch per year. Nest characteristics were also described (mowed lawn, trail or dirt road border, open, or woodland, etc.), and nest site locations (UTM coordinates) were recorded. Since nesting migrations are not considered part of an animal's home range by most investigators (Burt, 1943; Brown & Orians, 1970), we have combined locational data of both home range and nesting excursions and will refer to this as activity range. Combining all locational data for each female allows us to demonstrate if any temporal differences exist in the mean activity range of females of different reproductive statuses.

Data analysis

Data gathered were used to determine relationships between nestings (date, time, precipitation, relative humidity, and habitat). The

Open area nesters	Forest nesters
#107	#51
#112	
#37	
#53	
#6 (aborted)	
#108 (aborted)	
Probably open area nesters	
#19 (3 years)	
#77	
#67	
#60	

Table 1. Nest site selection of *Terrapene c. carolina* at Lynchburg, Virginia: open area nesters verses forest nesters.

activity range method that was least sample dependent was determined using Calhome Software (see above; Kie *et al.*, 1996). Seven females were chosen (with relatively large UTM data sets), and randomly generated subsets of data points were taken from the total UTM data set of each turtle. Activity range calculations were performed using subset sample sizes of N = 5, 10, and 15 (Warkentien, 2001). BVN was the calculation method that best suited the study. Although BVN is not sample size dependent, each BVN activity range was calculated using females that had UTM sample sizes of at least 10. Once it was chosen, *t*-test comparisons were made between the means of female activity range size depending on reproductive status (gravid or nongravid). Gravid female BVN activity ranges were calculated using location data from home range plus nesting migration movements. Nongravid female BVN activity ranges were calculated using location data from home range movements. Activity range data gathered from radio-tracked females and other individuals encountered on multiple years were averaged.

RESULTS AND DISCUSSION

Nesting, incubation period, and hatching

During 2000 (1), 2001 (7), and 2002 (6), data was gathered from14 nestings during 15th June–3rd July (12) and 18th July (2). The times of nesting were 07:45 (1), 1130 (1), and 17:30–01:00 (12) h. Clutch size averaged 3.1 (1–5) eggs. Of the 49 eggs, 47 (95.9%) were known or assumed to be fertile and two (4.1%) were extremely small and infertile. Twenty-two (47%) of the 47 fertile eggs hatched; known causes of egg destruction were: desiccation (4); plant penetration (1); predation, probably by ants (2); torn egg shell (investigator error) resulting in embryo death (1); fungal rot (5); and causes unknown (8). Another clutch of four eggs perished with a road-killed female. Hatching occurred between 30th August and 24th September; duration of incubation was 64–94 days.

Our results suggest that most gravid females about to oviposit orient toward open areas, corroborating the observations of Allard (1935), Belzer (1999a), Congello (1978), Ernst *et al*. (1994), and Messinger and Patten (1995). From confirmed nestings, 86% of radio-monitored females selected open areas for nesting (Table 1). This percentage was even higher (92%) if all monitored females that most likely nested in an open area were included. Even the nest found in the woods suggests a preference for solar exposure, having been dug in an open patch. However, it should be noted that there were no successful hatchings from this clutch.

There are several possible advantages of females choosing open areas for nesting. Open areas receive more solar radiation, and have a higher ST, which speeds up embryonic development and shortens the incubation period (Dodge *et al*., 1978) This may enable the hatchlings to find suitable overwintering sites before cold weather becomes a threat. Although this may seem advantageous, differential survivorship of short verses long incubation times has not been determined in *T. c. carolina*. Also, the females may seek a ST that straddles the temperature threshold at which the hatchling's sex is determined (temperature sex determination, TSD), somewhere between 27°C and 28.5°C (Dimond, 1983; Ewert & Nelson, 1991), assuring a close to 1:1 male to female ratio.

Precipitation and nesting

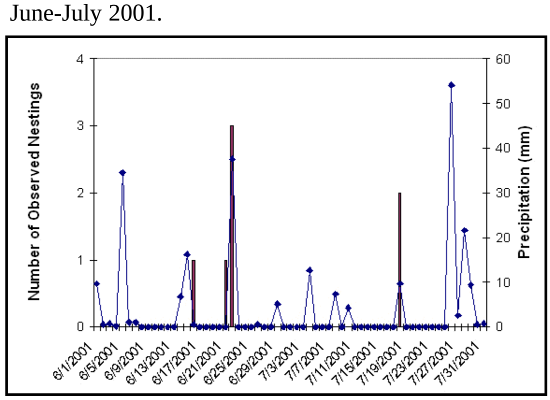
It has been reported that *T. c. carolina* nesting behaviour is evoked by rainfall (Congello, 1978; Belzer, 1999; pers. obs.), but such observations

Figure 1. Female #53 ovipositing in Odd Fellows field the evening of 18th July 2001. © G. Wilson.

have not been quantified or analyzed. It has also been noted that heavy midday rainfall stimulates nesting activity in the semi-terrestrial wood turtle, *Glyptemys insculpta* (Walde *et al.*, 2007). When the Odd Fellows/ Rebekah field and nearby yards were discovered to be hot spots for nesting *T. c. carolina*, surveys were focused there when it had rained or was raining, usually in the late afternoon or evening. When it was dry or experienced only a light, short-lived sprinkle, females did not migrate to nest, even in the peak of the nesting season. In the summer of 2000, one nesting was observed on 16th June after a heavy afternoon thunderstorm. On 5th June 2001, a heavy rainfall of 34.5 mm apparently did not evoke a surge of nesting, possibly it was too early in the season. None of the radio-equipped, gravid females moved toward their nesting areas until mid- to late June. The first good rain during the typical nesting season was on 14th June (6.8 mm) and female 51 was found excavating a nest, but she abandoned the site. Whether our presence disturbed her or she was merely digging a trial cavity, could not be determined. She was monitored again the following evening after a heavier rain, but showed no nesting behaviour. However, female 9 was observed that evening apparently searching for a suitable nest site in the Odd Fellows/Rebekah field. Also, female 112 was digging a trial nest there, which she aborted after investing considerable time and effort in soil that was not very moist. Female 51 successfully nested either later that night or on 16th June. The next four nests were found after a rainfall on 21st–22nd June. A nesting by female 107 occurred on 21st June and females 80, 112 and 117 nested on 22nd June, when there was a much heavier rain event (37.6 mm). No other nestings occurred until 18th July (9.7 mm), when female 122a nested in the morning and female 53 nested that night (Figure 1). Periodic rains occurred early in July, but no completed nests were found. Female 53 was seen digging a trial nest on 4th July after a rainfall, but quit after nightfall. Even though nestings did not necessarily follow every precipitation, one or more nesting attempts always occurred on the same day as a rain event or on the following day while the substrate was still moist (Figures 2–3).

There are several possible advantages of nesting after a substantial rainfall. One advantage is that

Figure 2. Number of observed nestings by *Terrapene c. carolina* (bars) relative to daily precipitation (lines) in June-July 2001.



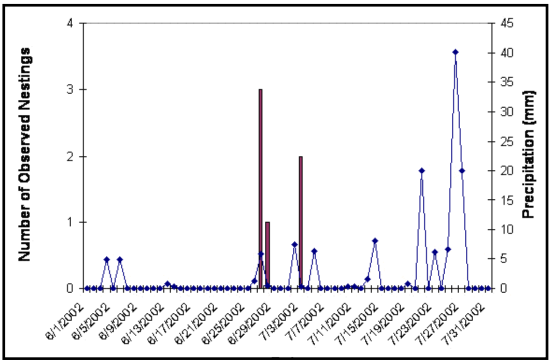


Figure 3. Number of observed nestings by *Terrapene c. carolina* (bars) relative to daily precipitation (lines) in June-July 2002.

rain softens the substrate, making it more friable during the excavation process (Ernst *et al*., 1994). When females were observed digging in dry or only slightly moist ground, the excavation was slow and laborious, and the attempt was usually aborted. Conversely, in well-saturated soils, excavation was more rapid and usually completed (*pers. obs.)*. Moist soil also decreases the chances of egg desiccation (Packard *et al*., 1985); ovipositing in a wet soil allows the eggs to imbibe additional moisture (Lynn & von Brand, 1945). This water would presumably provide a margin of safety against future water loss during drought conditions. Another possible advantage is that of rehydrating the female after water loss during migration and the nesting process. Although striped mud turtles do not require rainfall to nest, Wilson (1998) found that striped mud turtles (*Kinosternon baurii*) select nest sites having higher soil moisture content than randomly selected sites in the same area. This seems to indicate that the females can physically monitor water content in the soil and use it as an indicator for nest site suitability.

Other purported advantages have to do with predator avoidance; predators are not usually as active during rainfall events. However, turtle scent may be more traceable on a moist substrate, due to the cohesiveness of water. Moist soils may also be more impressionable for leaving visible tracks than dry soils. These factors need to be researched to see if they significantly increase predation. Possibly, with regard to predators, nesting in wet conditions may be more of a liability than an advantage.

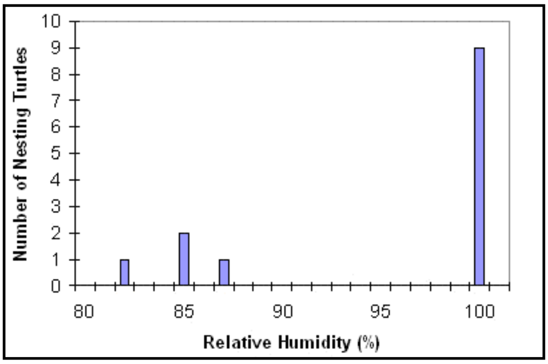
Nesting and relative humidity

Most nestings occurred during or after a significant rain event, so the relative humidity was very high for the majority of them. Nine (64%) of the 14 observed nestings occurred at 100% relative humidity. A relative humidity reading of 87% occurred while female 122a nested. She was found at 07:45 h, which was during a light morning rain but preceding a heavier rainfall later that day. In addition, female 137 nested at 87% relative humidity at 11:30 h on a sunny day after a heavy rainfall the preceding day of 27th June. The nestings by females 37 and 111 took place on 3rd July 2002 after a modest but not soaking rain. Consequently, the humidity was relatively lower compared to those nine nestings that occurred after heavy downpours (Figure 4).

Nest site use

Of the total 15 nests observed, 14 (93%) were in open areas (mowed field, backyards, trail/road borders, woodland clearings). These results could be attributed to a sampling bias because open areas were selectively sampled during optimal egg laying times; however, for all of the gravid and radio-monitored females either found nesting or for which the nest site (7) was found, six (86%) were in open areas with little canopy cover. Two of the six females aborted their attempts at nest excavation, possibly due to the observer's presence. Nevertheless, they had moved to an open area and at least started to excavate a nest. There was also good reason to suspect that four other radio-equipped gravid females nested at

Figure 4. Number of nesting *Terrapene c. carolina* in relation to relative humidity.



open sites; although they were not observed nesting, they engaged in a pre-oviposition migration out of their woodland home ranges toward open areas. Three were found in backyards just prior to oviposition. If these four females are included in the analysis, the open area nestings increased to 92.3% of total nestings of radio-monitored females. The only radio-monitored female that nested in the woods did so about 15–20 m from the edge, and her nest was located in a light gap in the canopy. Overall, six observed nestings (two of which aborted) and six probable nestings occurred in the open, versus only one woodland nesting.

Nesting and time of day

Most observed nestings took place between 17:00 and 01:00 h, but the majority of nesting activity occurred after dusk between 19:00 and 24:00 h. A few females, although they started to dig at a typical time, took longer to excavate their nests and finished after midnight. The only exception to this was the nesting of female 137 at 11:30 h, 28th June. This nesting was unusual in that only one other mid-day nesting has been reported for *T. c. carolina* (Lee, 2002). Figure 5 shows the times that females were first encountered at various points in the nesting process.

The majority of nestings occur at night, probably because most periods of heavy precipitation in this region occur in the afternoon or late afternoon (*pers. obs.*). The gravid female is most likely incited to nest by rainfall (Congello, 1978; Belzer, 1999; pers. obs.), or possibly the drop in barometric pressure that usually accompanies it, rather than simply the onset of darkness. Allard (1948) observed that females generally nest on clear evenings and begin earlier if it is dark and cloudy. He assumed that the key factor was decreased light intensity and not pre- or post rainfall conditions, but mentioned that thunderstorms and showers intervened not infrequently while the females were nesting. He did not indicate, however, whether or not clear-evening nesters excavated prior to or after a rain event.

Until Lee's (2002) report, no mid-day nesting had been previously reported, only early morning (Allard, 1948; Belzer, 1999b; Ernst *et al.*, 1994). The earliest reported afternoon nesting was at

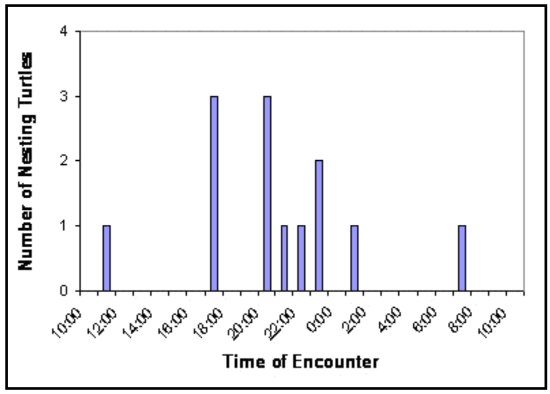


Figure 5. Number of nesting *Terrapene c. carolina* relative to the time initially encountered.

15:45 h (Ewing, 1935). However, Virginia female 137 had an unusual nesting time between 11:30 and 15:00 h; Ernst (unpubl. data) has observed an Alabama *T. carolina major* nesting at 10:30 h. If darkness is an essential factor in box turtle nesting, these records and that of Lee (2002) are inexplicable. However, the mid-day Virginia nesting is understandable, because the soil was still very moist from the heavy rain of the previous day. Unfortunately, Lee (2002) did not mention the weather conditions preceding or following this mid-day nesting. Because darkness without precipitation, or factors associated with it, did not evoke nesting behaviour during our study, it was tentatively concluded that darkness is not the major cue for nesting.

Effects of reproductive status on home range

In a peripheral study on the same population of *T. c. carolina*, Warkentien (2001) calculated the activity ranges using four different methods (see above) of 12 radio-equipped females using UTM data collected in 2000. HM was the most sample size dependent. At a sample size of 15, five of seven turtles had home ranges significantly smaller than the original HM activity ranges calculated from each turtle's entire data set; however, it was not clear whether or not the entire data set was large enough to use this method. The next most sample size dependent method was MCP. The sample size of 15 was almost large enough in that only two out of the seven turtles had significantly smaller activity ranges when compared to their original MCPs. The AK method

Gravid Females		Nongravid Females	
Turtle-year(s)	Activity range size (ha)	Turtle-year(s)	Activity range size (ha)
77-02	48.7	108-02	9.1
112-01	9.8	60-02	2.7
19-00, 01, 02	31.6	59-00, 01, 02	0.6
122-02	6.8	33-00, 01	3.8
51-01	11.7	24-02	5.0
6-02	16.1	125-02	2.1
16-01	6.4	101-01	4.2
107-01	40.2	37-00	2.5
108-01	11.9	38-00	3.9
42-00	15.9	45-00	1.0
60-00	24.6	51-00	12.1
67-00	1.6	53-00	1.1
		65-00	1.6
	Mean = 18.8		Mean = 3.8
	SD = 14.6		SD = 3.3
t-statistic = 3.6	df = 23 p = 0.0015		

Table 2. The effects of reproductive status on home range size in female *Terrapene c. carolina* in Lynchburg, Virginia (Home range calculated using the bivariate normal method).

ranked third in sample size dependency. Only one of seven turtles showed a significantly smaller activity range when compared to the original AK activity ranges. Of the four methods tested, BVN was the least sample size dependent. In spite of the sample size (5, 10, 15), no turtle BVN activity range differed significantly from the original BVN estimation. Thus, BVN was selected for determining the activity range of the radio-equipped females. This method gives a very liberal estimate in that it draws a generous ellipse around the data points and has several assumptions that cannot be met. It is the least sample size dependent because it exaggerates the actual activity range size. Nevertheless, our purpose was to select a method that would be useful in showing relative differences in activity range size between turtles of different reproductive status. BVN activity ranges for radio-monitored females for all three years were categorized according to reproductive status (gravid, nongravid). The mean gravid female activity range was 18.8 ha and the mean nongravid female activity range was 3.8 ha. The difference was significant (*t*-statistic = 3.6, df = 23, $P = 0.0015$, Table 2).

Gravid freshwater turtles and sea turtles migrate outside their home range during the nesting season (Ernst *et al*., 1994). Their home range is mostly aquatic, but, because the eggs must be laid on land to be adequately aerated, gravid females must come ashore to nest, often extending beyond their home range by large distances. Although migration to nesting sites outside of the home range is well documented in aquatic turtles, it is not so understood in *T. c. carolina*. As it lives in the same general habitat as its terrestrial nest site, it could be assumed that females would not necessarily have to relocate far, if at all, to lay eggs. Therefore, migration extending beyond home range would not necessarily be predicted during the nesting season, but in our Virginia population gravid females had a significantly larger mean activity range (18.8 ha) than nongravid females (3.8 ha). Stickel (1950) anecdotally supported these findings in stating that a female may not find a suitable nest site within her home range and may have to make an excursion beyond it to lay her eggs. It was very apparent that our gravid radio-monitored females moved various distances to nest in open areas. The monitored gravid females moved toward open areas to nest, and other gravid nontelemetered females were also observed moving toward or in open areas. As the migration route and nest site are usually outside of the home range, such movement results in a temporal expansion of the female's activity range. The monitored females did not always move to the nearest clearing. Several moved through multiple open areas to reach a distant clearing to nest. After depositing their eggs and subsequently resting a short time, each female returned to her home range.

It can not be assumed that the intervening clearings were marginal nest sites, because other females nested in some of them. Although not conclusive, these excursions possibly indicate movement to a general natal ground. This has been clearly established in several sea turtle species (Ernst *et al*., 1994). Future research should determine if this is true in the genus *Terrapene*. If it is true, the orientational and navigational cues used to find such areas should be investigated. Do particular females use the same nest sites repeatedly (nest site fidelity)? Virginia female 117 was observed nesting about 20 m apart at the same site in two consecutive years, and female 53 searched for a suitable place to excavate in about the same location in which she had nested the year before. However, if nest site fidelity occurs in *T. carolina*, it is not rigid. The general areas chosen by female 19 for three years are known, although she was never observed nesting. All were in different locations within a several hectare area. These areas were well outside and in the same compass direction from her home range.

Gravid females instinctively migrate, not only toward clearings, but also toward areas peripheral to their home ranges. The following are three possible advantages for this behavior which would require further research to be confirmed. 1) Peripheral nesting may promote dispersal of the offspring. This could possibly extend the population's range into other uninhabited suitable areas, thus avoiding or lessening vulnerability to regional perturbations that could cause population decline or extirpation. 2) Peripheral nesting could over time increase gene flow between adjacent populations if the hatchlings take up residence outside of the parental home ranges. Unfortunately, movement or dispersal patterns of Eastern box turtle hatchlings are poorly known. 3) Peripheral nesting may reduce predation on eggs and hatchlings. Nesting outside parental home ranges may make it more difficult for predators to locate them

Conservation implications

Apart from the possible ecological and genetic advantages of nesting outside a home range, there are implications for conservation of *T. c. carolina* occurring in human habitats. The data show that females moved beyond their home ranges to nest in open areas. Since *T. carolina* is the most terrestrial emydid turtle in the USA, its habitat is often shared with humans. The turtle can often be found in residential, suburban, and rural human communities, provided there is adequate woodland nearby. In these shared areas, most open areas that may serve as nesting sites are anthropogenic. Such clearings may be positive for nesting if they are not frequently disturbed. However, as gravid females are drawn into these areas instinctively, they are exposed to a number of threats not usually encountered in their home ranges. These include encountering motorized vehicles while crossing roads, predators hunting along forest edges, and humans who may collect or harass them. One behaviour pattern that mitigates these threats is the temporal separation that usually occurs between turtle nesting times and human activity, as the turtles normally nest at night after or during rainfall. This behavior aids in the avoidance of humans.

Habitats that are fragmented by roads, trails, developments, and other inhospitable tracts create a number of smaller isolated patches of suitable habitat and possibly increase nest site availability (Meffe & Carroll, 1997). In such fragmented habitats, turtles often make road-crossing forays while normally moving about their home ranges, searching for mates, or seeking nest sites, and are at greater risk of being struck by motorized vehicles or disturbed by passing humans. For instance, Dodd *et al*. (1989) observed 160 turtles on northcentral Alabama roads in 1985; 74.4% were dead, and of these, 85% were *T. carolina*. Because the mean BVN activity range of gravid female box turtles in this study is almost five times larger than their mean BVN activity range when not gravid, the chance of crossing roads seeking a nest site is greatly increased in a road-fragmented habitat. It is generally observed that a box turtle population along roads will decline due to unsuccessful road crossings (Anderson, 1965; Klemens, 2000; Mitchell, 1994). Consequently, gene flow is accordingly reduced (Klemens, 2000). If movement patterns between females of different reproductive statuses were the same it could be assumed that road-kills would result in equal numbers of gravid and nongravid females being killed. Even though road-kills are not random and indiscriminate (Ashley *et al.*, 2007) those that do purposefully target turtles are not likely distinguishing between sex or reproductive status in choosing their next victim. Our data suggests that the highly significantly different activity ranges between the two female reproductive classes would result in more gravid females being killed than nongravid ones during the June–July nesting season. Gibbs & Steen (2005) found that there was a trend toward a male-biased sex ratio in areas of increasing road networks since 1930. This trend was apparent in all turtles species surveyed but was the most pronounced in aquatic species and progressively less in semiaquatic and terrestrial species. Steen *et al*.(2006) found that a larger fraction of road-kill turtles were female and concluded that females are indeed more likely to make road-crossing forays. They suggested that their finding may explain the skewed sex ratio toward a male bias. Our study did not radio-monitor male turtles so we could not determine if there was a difference in the activity ranges of male turtles and gravid or nongravid female turtles. Our findings however did suggest that gravid females would be the most likely female reproductive class encountering roads. Our finding that gravid females have a much larger mean activity range corroborates the view of Steen & Gibbs (2004), Gibbs & Steen (2005), and Steen *et al*. (2006) that gravid females are more susceptible to vehicular death due to terrestrial nesting migrations. It appears that those females responsible for the reproductive output of the population have a much greater chance of being killed, thus reducing the population's reproductive effort yearly, and resulting in an eventual decline in numbers. Such selection is opposite of typical selection in that those females that have the highest clutch frequency (not necessarily largest clutch size) are selected against. If the trait of low clutch frequency is heritable, then road fragmentation not only directly accelerates population decline by killing individual turtles, but also by the selection of low clutch frequency females because they are less likely to be road-killed. Wilcove *et al*. (1986), Wilcox (1980), and Wilcox & Murphy (1985) observed that isolated islands of habitat support fewer individuals than expanses of habitat interconnected by habitat corridors. Obviously vehicular traffic kills turtles (Dodd *et al*., 1989; Ashley & Robinson, 1996; Klemens, 2000; Ashley *et al.*, 2007), but we also think the male-biased sex ratios in areas of higher road densities (Steen *et al*., 2006) and widespread box turtle decline in road fragmented habitats (Klemens, 2000) may be amplified by the movement patterns of gravid females.

A holistic approach to the conservation of *T. c. carolina* must be ecologically circumspect. If policy makers are to make informed decisions, they need to have access to pertinent information on the ecology of the box turtle. These include its habitat use and home range characteristics; movement patterns; activity range; population sex ration; age and size structures; range of threats to the population and habitat; spatial arrangement of suitable habitat; and the relationship of these habitats to the landscape. This study has addressed important aspects of the first points, but only regarding adult turtles, especially the activity ranges of gravid and nongravid females in relation to threats encountered along anthropogenic edges.

Important questions answered in this study are the following: the reproductive output of the population (Wilson & Ernst, 2005), nest site selection, environmental conditions for nesting, timing of nesting, and the differential movement of gravid verses nongravid females. However, obvious gaps in our knowledge remain: the fate of unprotected nests, the proportion of hatchlings that survive to reproductive age, and the movement patterns (including home range size) and dispersal behaviour of hatchlings. These poorly understood facets of Eastern box turtle ecology are needed to advance conservation management strategies for populations intimately associated with human development.

Finally, conservation strategies need to consider box turtle management on the broader scale of landscape ecology. Only a few niche requirements of *T. c. carolina* need to be understood and conserved in order to maintain healthy populations. These include the maintenance of quality habitat patches of adequate size, the development or maintenance of corridors that in some way span roads and interconnect such patches, and the creation and maintenance of undisturbed open area buffer zones either external or internal to these patches. The corridors (probably under road culverts, which are used by *T. carolina*; Ernst, *pers. obs*.) would provide pathways for gene flow among adjacent populations and would minimize road kills. To devise and construct effective road crossing corridors for turtles on a large scale will require much creativity if they are to be considered economically feasible. However, even if cost-effective small wildlife culverts (and drift fences directing small animals into them) are designed, they still might not be constructed until the public understands and values the movements of wildlife. Currently, successful road crossings are accomplished by determined lucky turtles that have run the gauntlet of traffic (Steen & Gibbs, 2004) or by concerned citizens providing a temporary shuttle service for other turtles attempting to cross. The open buffer zones will provide gravid females suitable nesting areas relatively free from human threats.

We should continue ecological and behavioural studies to fill in the gaps in our knowledge, not only to satisfy human curiosity but also to fine-tune conservation efforts. We do not, however, have to wait until all these knowledge gaps are filled to formulate an adequate conservation strategy. Innovative and knowledgeable biologists are needed to instill within local citizens an appreciation for *T. c. carolina* and other wildlife, and to also devise feasible conservation strategies that are implemented by the public rather than imposed on them.

ACKNOWLEDGEMENTS

We thank Paul Sattler (Chairman) for allocating Liberty University Biology Funds for the purchase of much of the necessary field equipment. Thanks also go to Thomas Akre for his training in radiotelemetry, and to the Odd Fellows/Rebekah Nursing Home for allowing us to conduct the study on their property. We are grateful to Tyler Warkentien, Seth Anderson, David Perault, and all members of the Wilson family for field assistance. Finally, we are grateful for Norman Reichenbach for his statistical assistance and advice.

REFERENCES

Allard, H. A. (1935). The natural history of the box turtle. *Science Monthly* **41**, 325–338.

Allard, H. A. (1948). The eastern box turtle and its behavior. *J. Tennessee Acad. Sci.* **23**, 307–321.

Anderson, P. (1965). *The Reptiles of Missouri*. Columbia: Univ. Missouri Press.

Ashley, E. P. & Robinson, J. T. (1996). Road mortality of amphibians, reptiles and other wildlife on the Long Point Causeway, Lake Erie, Ontario. *Can.Field-Nat.* **110** (3):403–412.

Ashley, E. P., Kosloski, A., & Petrie, S. A. (2007). Incidence of intentional vehicle-reptile collisions. *Hum. Dimen. Wildl.* **12**:137–143.

Belzer, B. (1999a). Predictor of nesting onset by eastern box turtles. *Box Turtle Conserv. Newsl.* **8**, 11–12.

Belzer, B. (1999b). Morning nesting by *Terrapene carolina carolina*. *Box Turtle Conserv. Newsl.* **8**, 12–13.

Boucher, T. P. (1999). Population, growth and thermal ecology of the eastern box turtle, *Terrapene carolina carolina* (L.), in Fairfax County, Virginia. *Ph.D. Dissertation*. Fairfax, Virginia: George Mason University.

Brown, J. L. & Orians, G. H. (1970). Spacing patterns in mobile animals. *Ann. Rev. Ecol. Syst.* **1**, 239–262.

Burt, W. H. (1943). Territoriality and home range concepts as applied to mammals. *J. Mammal.* **24**, 346–352.

Congello, K. (1978). Nesting and egg laying behavior in *Terrapene carolina* in Pennsylvania. *Proc. Pa. Acad. Sci.* **52**, 51–56.

Dimond, M. T. (1983). Sex of turtle hatchlings as related to incubation temperature. *Proc. 6th Reptile Symp. Captive Prop. Husbandry*, pp. 88–101. Thurmont, Maryland: Zoology Conservation.

Dodd, C. K., Jr. (2001). *North American Box Turtles: A Natural History.* Norman: Univ. Oklahoma Press.

Dodd, C. K., Jr, Enge, K, M., & Stuart, J. N. (1989). Reptiles on highways in north-central Alabama. *J. Herpetol.* **23**, 197–200.

Dodge, C. H., Dimond, M. T., & Wunder, C. C. (1978). Effect of temperature on the incubation time of eggs of the eastern box turtle (*Terrapene carolina carolina* Linné). *Florida Mar. Res. Publ.* **33**, 8–11.

Ernst, C. H., Lovich, J. E. & Barbour, R. W. (1994). *Turtles of the United States and Canada*. Washington, DC: Smithsonian Inst. Press.

Ernst, C. H., Hershey, M. F. & Barbour, R. W. (1974). A new coding system for hardshelled turtles. *Trans. Kentucky Acad. Sci*. **35**, 27–28.

Ewert, M. A. & Nelson, C. E. (1991). Sex determination in turtles: diverse patterns and some possible adaptive values. *Copeia* **1991**, 50–69.

Ewing, H. E. (1933). Reproduction in the eastern box turtle *Terrapene carolina carolina* (Linné). *Copeia* **1933**, 95–96.

Ewing, H. E. (1935). Further notes on the reproduction of the eastern box turtle, *Terrapene carolina* (Linne'). *Copeia* **1935**, 102.

Gibbs, J. P. & Steen, D. A. (2005).Trends in sex ratios of turtles in the United States: implications of road mortality. *Conserv. Biol.* **19**, 552–556.

Kie, J. G., Baldwin, J. A. & Evans, C. J. (1996). CALHOME: a program for estimating animal home ranges. *Wildl. Soc. Bull.* **24**, 342–344.

Klemens, M. W. (Ed.). (2000). *Turtle conservation*. Washington, DC: Smithsonian Inst. Press.

Lee, D. S. (2002). A note on box turtle reproduction. *Turtle Tortoise Newsl.* **6**, 27.

Lynn, W. G. & von Brand, T. (1945). Studies on the oxygen consumption and water metabolism of turtle embryos. *Biol. Bull*. **88**, 112–125.

Meffee, G. K. & Carroll C. R. (Eds.). (1997). *Principles of Conservation Biology*. 2nd. ed. Sunderland, Massachusetts: Sinauer.

Messinger, M. A. & Patton, G. M. 1995. Five year study of nesting of captive *Terrapene carolina triunguis*. *Herpetol. Rev*. **26**, 193–195.

Mitchell, J. C. (1994). *The Reptiles of Virginia*. Washington, DC: Smithsonian Inst. Press.

Packard, G. C., Packard, M.J. & Gutzke, W.H.N. (1985). Influence of hydration of the environment on eggs and embryos of the terrestrial turtle *Terrapene ornata*. *Physiol. Zool*. **58**, 564–575.

Steen, D. A. & Gibbs, J. P. (2004). Effects of roads on the structure of freshwater turtle populations. *Conservation Biol.* **18**, 1143–1148.

Steen, D. A., Aresco, M. J., Beilke, S. G., Compton, B. W., Condon, E. P., Dodd, C. K. Jr., Forrester, H., Gibbons, J. W., Greene, J. L., Johnson, G., Langen, T. A., Oldham, M. J., Oxier, D. N., Saumure, R. A., Schueler, F. W., Sleeman, J. M., Smith, L. L., Tucker, J. K., & Gibbs, J. P. (2006). Relative vulnerability of female turtles to road mortality. *Anim Conserv.* **9**, 269–273,.

Stickel, L. F. (1950). Populations and home range relationships of the box turtle *Terrapene c. carolina* (Linnaeus). *Ecol. Monogr*. **20**, 351–378.

Walde, A. D., Bider, J. R. Masse, D., Saumure, R. A., & Titman, R. D. (2007) Nesting ecology and hatching success of the wood turtle, *Glyptemys insculpta*, in Quebec. *Herpetol. Conserv. Biol.* **2**, 49–60.

Warkentien, T. E. (2001). A comparison of home range estimation techniques using the eastern box turtle, *Terrapene carolina*. *Honors Thesis*. Lynchburg, Virginia: Liberty University.

Wilcove, D. S., McLellan, C. H. & Dobson, A. P. (1986). Habitat fragmentation in the temperate zone. In: *Conservation Biology: The Science of Scarcity and Diversity*, pp. 237–256. Soule, M. E. (Ed.). Sunderland, Massachusetts: Sinauer.

Wilcox, B. A. (1980). Insular ecology and conservation. In: *Conservation Biology: An Evolutionary-ecological Perspective*, pp. 95–117. Soule, M. E. & Wilcox, B. A. (Eds.). Sunderland, Massachusetts: Sinauer.

Wilcox, B. A. & Murphy, D. D. 1985. Conservation strategy: the effects of fragmentation on extinction. *Amer. Midl. Nat.* **125**, 879–887.

Wilson, D.S. (1998). Nest-site selection: microhabitat variation and its effects on the survival of turtle embryos. *Ecology* **79**, 1884–1892

Wilson, G .L. & Ernst, C. H. (2005). Reproductive ecology of *Terrapene carolina carolina* (eastern box turtle) in central Virginia. *Southeast. Nat.* **4**, 689–702.

Notes on reproduction in three species of *Sphenomorphus* Squamata: Scincidae) from Papua New Guinea

STEPHEN R. GOLDBERG[1] and FRED KRAUS[2]

[1]*Department of Biology, Whittier College, Whittier, California 90608 USA*. sgoldberg@whittier.edu [corresponding author]

[2]*Bishop Museum, Department of Natural Sciences, Honolulu, Hawaii 96817 USA*. fkraus@hawaii.edu

SPHENOMORPHUS is a large genus of skinks ranging across much of southeastern Asia and the Papuan region, comprising New Guinea, Bismarck Archipelago, Solomon Islands, and adjacent smaller islands. Lizards referred to the same genus are also present in Central America (Savage, 2002). Approximately 45 species are known from the Papuan region (Papuan Herpetofauna, 2007) and dozens more await formal description. Of these species, *S. granulatus* ranges throughout the Southeast Peninsula from Milne Bay Province to the Huon Peninsula and also occurs on the adjacent D'Entrecasteaux Islands (Zweifel, 1980; Mys, 1988; Kraus & Allison, 2004). *Sphenomorphus jobiensis* (the largest species we studied) ranges widely across most of New Guinea and also occurs on New Britain, New Ireland and the Admirality, D'Entrecasteaux and Louisiade Islands (Mys, 1988; Kraus & Allison, 2004). It is known to be a complex of closely related species (Donnellan & Aplin, 1989) that is currently undergoing revision (G. Shea pers. comm.), but an updated taxonomy is not currently available. *Sphenomorphus minutus* (the smallest species we studied) has a spotty distribution across the northern versant and central mountains of New Guinea (Mys, 1988) and also occurs in the D'Entrecasteaux and Louisiade islands of Misima and Sudest (Kraus & Allison, 2004; Kraus & Shea, 2005). To our knowledge, there are no published accounts regarding reproduction in these species and little reproductive information exists for any other Papuan *Sphenomorphus*. The purpose of this paper is to report information on the reproductive cycle of the three species listed above from a histological examination of museum specimens collected by FK. This is part of an ongoing series of studies on the reproduction of lizards from Papua New Guinea.

METHODS

Sphenomorphus skinks from Milne Bay Province, Papua New Guinea were examined from the herpetology collection housed at the Bernice P. Bishop Museum (BPBM), Honolulu, Hawaii (see Appendix). Skinks were collected from 2002 to 2004 and were studied from a geographically constrained region so as to allow for examination of seasonal reproductivity without inadvertently introducing confounding geographic variation. The left testis or ovary was removed, processed by standard histological techniques and stained with Harris' hematoxylin followed by eosin counterstain (Presnell & Schreibman 1997). Male maturity was established via evidence of spermiogenesis in progress. Female maturity was recognized via evidence of yolk deposition. Female clutch size was determined by counting enlarging follicles (> 4 mm) or oviductal eggs. Lizard snout-vent length (SVL) was measured to the nearest millimeter after euthanization, just prior to preservation.

RESULTS AND DISCUSSION

The only stage observed in the testicular cycle was spermiogenesis, during which seminiferous tubules are lined by spermatozoa and clusters of metamorphosing spermatids are present.

Sphenomorphus granulatus: The sample (n = 14) consisted of 6 females with mean SVL = 52.2 mm ± 4.5 SD, range = 45–58 mm; 6 males with mean SVL = 50.7 mm ± 8.2 SD, range = 35–58 mm; and 2 individuals that were presumed to be neonates with mean SVL = 21.0 mm ± 3.5 SD, range = 18–23 mm. Males undergoing spermiogenesis were collected from the months of April (n = 4), May (n = 1), and August (n = 1). The smallest reproductively active male (BPBM 16010) measured 35 mm SVL and was taken August 2002. Three females from April 2002 were not reproductively active. One female taken in August 2002 contained 2 enlarged follicles > 4 mm. Of two females taken in September 2002, one contained 2 oviductal eggs, and one contained 2 enlarged follicles > 4 mm. Mean clutch size for these females was 2.0 ± 0.0 SD. The smallest reproductively active female (2 enlarged follicles > 4 mm) measured 45 mm SVL (BPBM 16014) and was taken in September 2002. The two remaining individuals, one taken in April 2002 and one in August 2002 were presumed to be neonates.

Sphenomorphus jobiensis: The sample (*n* = 36) consisted of 12 females with mean SVL = 87.4 mm ± 7.5 SD, range = 78–98 mm; and 24 males with mean SVL = 88.2 mm ± 8.1 SD, range = 73–102 mm. Males undergoing spermiogenesis were collected from February (*n* =12), April (*n* = 6), August (*n* = 4), and September (*n* = 2). The smallest reproductively active males measured 73 mm SVL (BPBM 19010 and 19013) and were taken in April 2002. Two of six females collected in February were reproductively active (one each with 2 and 3 oviductal eggs, four inactive). Both females from April were reproductively active (one with 2 oviductal eggs, the other with corpora lutea). Two of three May females were reproductively active (one undergoing yolk deposition, the other with 2 enlarged ovarian follicles > 4 mm). One August female was reproductively active (3 oviductal eggs). Mean clutch size for 5 females (4 with oviductal eggs, 1 with enlarged follicles) was 2.4 ± 0.55 SD, range = 2–3. The smallest reproductively active female (BPBM 19014), (corpora lutea present) measured 78 mm SVL and was collected in April 2002.

Sphenomorphus minutus: The sample (*n* = 18) consisted of 8 females with mean SVL = 33.1 mm ± 2.9 SD, range = 29–39 mm; 8 males with mean SVL = 34.3 mm ± 4.4 SD, range = 27–39 mm; and 2 individuals that were presumed to be neonates, mean SVL = 17.5 mm ± 2.1 SD, range = 16–19 mm. Reproductively active males were collected in January (*n* = 1), April (*n* = 3), June (*n* = 1), August (*n* =1), and September (*n* = 2). The smallest reproductive male (BPBM 16040) measured 27 mm SVL and was taken in September 2002. All females were reproductively active: January (1 with an enlarged follicle > 4 mm, 2 each with 1 oviductal egg,) and August (2 undergoing yolk deposition, 1 with an enlarged follicle > 4 mm, 2 each with 1 oviductal egg). Mean clutch size for six females was 1.0 ± 0.0 SD. The smallest reproductively active female (BPBM 16033) measured 29 mm SVL and was taken in August 2002. Both presumed neonates were collected in August 2002.

There is little information currently available regarding reproduction in *Sphenomorphus*. In the Solomon Islands, *Sphenomorphus solomonis* produces clutches of up to 3 eggs and *Sphenomorphus tanneri* lays 2 eggs (McCoy, 2006). In Papua New Guinea, *Sphenomorphus pratti* has been reported to contain three oviductal eggs (Loveridge 1948). *Sphenomorphus tagapayo* from the Phillippine Islands has a brood size of two (Brown *et al.*, 1999). Huang (1997) reported that females of *Sphenomorphus taiwanensis* from a montane habitat (2360 m) in Hualien County, Taiwan, followed a seasonal ovarian cycle in which reproduction was restricted to May–July.

Fitch (1982) reported that for tropical lygosomine skinks from aseasonal rainforests, reproduction generally occurs year-round but is subject to changing levels resulting from variations in temperature and moisture. Our samples confirm extended reproduction for these three species of *Sphenomorphus*: *S. granulatus, S. jobiensis* and *S. minutus*. However our samples were too small to identify a peak of activity, if one exists.

We do not know of prior histological investigations into the testicular cycles of Papuan *Sphenomorphus* lizards. However, for other lygosomine skinks from that general region, Zug et al. (1982) reported year-round spermatogenesis in the skink *Carlia bicarinata* at Port Moresby, Papua New Guinea, with peaks during March to April and August to October. Wilhoft (1963) reported *Carlia* (as *Leiolopisma*) *rhomboidalis* underwent spermiogenesis throughout the year in tropical Australia. Goldberg & Kraus (2008) reported extended periods of reproduction in five species of *Emoia* from Papua New Guinea. The extended reproductive activity of our three species of *Sphenomorphus*, all derived from low- to mid-elevation rainforest habitats of relatively constant annual mean temperatures, are consistent with this pattern.

In contrast, Huang (1997) reported that *Sphenomorphus taiwanensis* from high-elevation, subtropical Taiwan (2360 m elevation) underwent a seasonal testicular cycle in which maximum spermiogenesis occurred in September and October, with regressed testes observed in November. This suggests that *Sphenomorphus* testicular cycles vary in response to differing environmental parameters. Whether a similar pattern exists in high-elevation *Sphenomorphus* from New Guinea remains to be seen.

Subsequent investigations on additional species of *Sphenomorphus* will be needed to expand our understanding of variability in the reproductive cycles (clutch sizes, number of clutches and duration of spermiogenesis) exhibited by members of this genus. Of especial interest is whether such variation might correlate to elevation and to identified species groups within this large genus.

ACKNOWLEDGEMENTS

We thank Jessica Carlson for assistance with histology and P. Banige, I. Bigilale, F. Francisco, P. Lagalaga, F. Malesa, D. Salepuna, M. Samson, J. Tekwae, B. Uruwa, J. Volo, Allen, Dage, Don, Genta Sr., Genta Jr., James, Johan, Koko, Lawasi, Munda, Pipi, Saina, Suki, and Tannu for field assistance; and S. Andrew, Aussiya, N. Doni, C. Graham, H. Korage, D. Libai, B. Libasi, D. Mitchell, P. Robert, B. Salepuna, B. Seta, B. Yawai, and Conservation International for logistical field assistance. We thank the many landowners who kindly granted us permission to survey on their lands; the PNG National Museum and Art Gallery for providing in-country collaborative assistance; and the Department of Environment and Conservation, National Research Institute, and Milne Bay Provincial Government for permission to conduct this research. This research was supported by NSF grant DEB-0103794 and is contribution 2008–02 from the Pacific Biological Survey at the Bishop Museum.

REFERENCES

Brown, R. M., McGuire, J. A., Ferner, J. W., & Alcala, A. C. (1999). New species of diminutive scincid lizard (Squamata; Lygosominae: *Sphenomorphus*) from Luzon Island, Republic of the Philippines. *Copeia* **1999,** 362–370.

Donnellan, S. C. & Aplin, K. P. (1989). Resolution of cryptic species in the New Guinean lizard, *Sphenomorphus jobiensis* (Scincidae) by electrophoresis. *Copeia* **1989,** 81–88.

Fitch. H. S. (1982). Reproductive cycles in tropical reptiles. *Occas. Pap. Mus. Nat. Hist., Univ. Kansas* **96,** 1–53.

Goldberg, S. R., & Kraus, F. (2008). Notes on reproduction in five species of *Emoia* (Squamata: Scincidae) from Papua New Guinea. *Salamandra* **44,** 54–58.

Huang, W. (1997). Reproductive cycle of the skink, *Sphenomorphus taiwanensis,* in Central Taiwan. *J. Herpetol.* **31,** 287–290.

Kraus, F., & Allison, A. (2004). New records for reptiles and amphibians from Milne Bay Province, Papua New Guinea. *Herpetol. Rev.* **35,** 413–418.

Kraus, F. & Shea, G. (2005). Additional reptile and amphibian range extensions for Milne Bay Province, Papua New Guinea. *Herpetol. Rev.* **36,** 471–473.

Loveridge, A. (1948). New Guinean reptiles and amphibians in the Museum of Comparative Zoology and the United States National Museum. *Bull. Mus. Comp. Zool.* **101,** 305–430.

McCoy, M. (2006). *Reptiles of the Solomon Islands.* Sofia: Pensoft Publishers.

Mys, B. (1988). The zoogeography of the scincid lizards from North Papua New Guinea (Reptilia: Scincidae). I. The distribution of the species. *Bull. Inst. r. Sci. nat. Belg., Bioloy Ser.* **58,** 127–183.

Papuan Herpetofauna. (2007). http://www.bishopmuseum.org/research/pbs/pngherps/. Downloaded 27th April 2007.

Presnell, J. K., & Schreibman, M. P. (1997). *Humason's Animal Tissue Techniques,* 5th Ed. Baltimore: The Johns Hopkins Press.

Savage, J. M. (2002). *The Amphibians and Reptiles of Costa Rica: A Herpetofauna Between Two Continents Between Two Seas*. Chicago: The University of Chicago Press.

Wilhoft, D. C. (1963). Gonadal histology and seasonal changes in the tropical Australian lizard, *Leiolopisma rhomboidalis*. *J. Morphol*. **113,** 185–204.

Zug, G. R., Barber, M. M., & Dudley, J. C. (1982). Gonadal histology and reproduction in *Carlia bicarinata* (Scincidae, Sauria, Reptilia) of the Port Moresby Area, Papua, New Guinea. *Herpetologica* **38,** 418–425.

Zweifel, R. G. (1980). Results of the Archibold expeditions. No. 103. Frogs and Lizards from the Huon Peninsula, Papua New Guinea. *Bull. Amer. Mus. Nat. Hist.* **165,** 387–434.

Appendix

Specimens of *Sphenomorphus* from Milne Bay Province, Papua New Guinea examined from BPBM.

Sphenomorphus granulatus (*n* = 14) Cloudy Mountains, along Upaelisafupi Stream, April 2002: BPBM 15617, 15618, 15620-15625; Owen Stanley Mountains, Mt. Pekopekowana, Wailahabahaba Creek, May 2002: 15628, Fergusson Island, Oya Tabu, August 2002: BPBM 16007, 16010; Fergusson Island, Oya Waka, September BPBM 2002: 16013-16015.

Sphenomorphus jobiensis (*n* = 36) Cloudy Mountains, along Upaelisafupi Stream, April 2002: BPBM 15645, 16909-16911, 19006, 19009-19014; May 2002: BPBM 15650-15652, Fergusson Island, August 2002: BPBM 16017, 16020, 16022; Fergusson Island, Oya Waka, September 2002: BPBM 16025; Fergusson Island, Oya Tabu, August 2002: BPBM 19016, 19017; September 2002: BPBM 19019; Siyomu Village, February 2003: BPBM 19025-19027, 16906, 16907, 16918, 16920-16922; Bunisi Village, February 2003: BPBM 16905, 16914-16916, 16923; Gasu Village, February 2003: BPBM 16917.

Sphenomorphus minutus (*n* = 18) Cloudy Mountains, along Upaelisafupi stream, April BPBM 2002: 15655, 15657; Fergusson Island, Oya Tabu August 2002: BPBM 16031-16036; Fergusson Island, Ova Tabu, August 2002:16037; Fergusson Island, August 2002, BPBM 16038; Fergusson Island, Oya Waka, September 2002: BPBM 16039; Normanby Island, Samoau, September 2002: BPBM 16040; Misima Island, January 2003: BPBM 16840-16842; Normanby Island, Saidowai. January 2003: BPBM 16843, 16844; Sudest Island, SW slope Mt. Rio, April 2004: BPBM 20057.

Ecogeographical notes on a rare species of false coral snake, *Oxyrhopus doliatus* Duméril, Bibron & Duméril, 1854

LUIS FELIPE ESQUEDA [1,5], MARCO NATERA-MUMA [2], SANTOS BAZÓ [3] and ENRIQUE LA MARCA [4]

[1,5] *Investigador Asociado, Laboratorio de Biogeografía, Escuela de Geografía, Facultad de Ciencias Forestales y Ambientales, Universidad de Los Andes, Mérida 5101, Venezuela.* luisfesqueda@gmail.com [corresponding author]

[2] *Museo de Vertebrados, Centro de Estudios del Llano, Universidad Rómulo Gallegos. Apartado 205, San Juan de Los Morros 2301, estado Guárico, Venezuela*. mnateram@yahoo.com

[3] *Investigador Asociado, Laboratorio de Biogeografía, Escuela de Geografía, Facultad de Ciencias Forestales y Ambientales, Universidad de Los Andes, Mérida 5101, Venezuela*. cocodriloextremo@hotmail.com

[4] *Laboratorio de Biogeografía, Escuela de Geografía, Facultad de Ciencias Forestales y Ambientales. Universidad de Los Andes, Mérida 5101, Venezuela*. enrique.lamarca@gmail.com

PREVIOUSLY known as *Oxyrhopus venezuelanus* Shreve, 1947, this snake is a colubrid species belonging to the subfamily Xenodontinae, originally described on the basis of a single specimen from the population 'El Paují', Acosta municipality, Falcón State, Venezuela. A recent revision revealed that this name is a junior synonym of *Oxyrhopus doliatus* Duméril, Bibron & Duméril, 1854 (Zaher & Caramaschi, 2000); however, these authors did not specify the type locality of the species, which will be necessary to ascertain in the future, although Brazil is assumed to be the locality. The taxon is known from the Aragua, Carabo, Miranda, Vargas and Yaracuy States, and Capital District (Roze, 1966; Peters & Orejas-Miranda, 1970; Manzanilla *et al*., 1996; Kornacker, 1999; Rivas, 2002). Until the present time, its known distribution was restricted exclusively to the premontane forest, between 10–500 m asl, in the Coastal Range and Serranía of San Luis, respectively. The species was reported for first time in the Venezuelan Andes, specifically in the region of Escuque, Trujillo State, by Esqueda *et al*. (2007:92). Seven

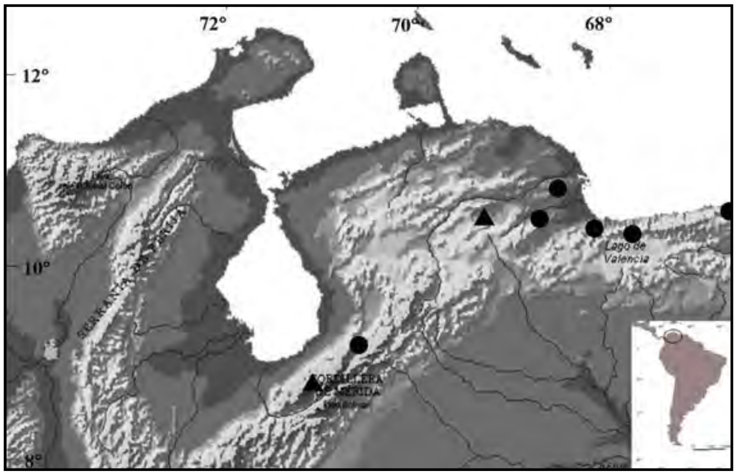


Figure 1. Distribution ranges of *Oxyrhopus doliatus* Duméril, Bibron & Duméril, 1854. Black circles are literature records (Roze 1966, Rivas 2002, Esqueda *et al*., 2007) and black triangles are examined museum records (EBRG and CVULA).

additional specimens previously catalogued confirm its presence in the Mérida, Lara and Trujillo states, as follows: EBRG 4383, coming from El Guape, Crespo municipality, Lara State, 10°17’N, 69°08’W, approx., 715 m; CVULA 3150, La Azulita, 2000 m, Andrés Bello municipality, Mérida State; CVULA 2426, 9 Km SW Quebrada Azul (road La Azulita), 1000 m asl; CVULA 3661, La Azulita, Cuchilla de San Rafael, 1400 m asl; ULABG 2952, La Azulita, 915 m asl; ULABG 6827, Candelitas, road Escuque, Escuque municipality, Trujillo State; ULABG 5694, between Escuque and Las Palmas, 1436 m, Escuque municipality, Trujillo State (Figure 1).

Unlike the Andean populations, where the species occur at higher elevations in environments corresponding to cloud forests and montane semicaducifolious forest, snakes from northern Venezuela occur at lower elevations. This taxon is ecologically sympatric with other false coral snakes that exhibits a mimetic coloration (batesian mimicry), such as *Erythrolamprus bizona* Jan, 1863, *Erythrolamprus pseudocorallus* Roze, 1959, *Oxyrhopus petola* (Linnaeus, 1758) and *Lampropeltis triangulum andesiana* Williams, 1978 (Roze, 1966, 1996; Barrios & Navarrete, 1999; Esqueda & La Marca 1999; Mijares-Urrutia & Arends, 2000; Navarrete & Rodríguez, 2003; Campbell & Lamar, 2004; La Marca & Soriano, 2004; Lotzkat, 2006). Nonetheless, *Oxyrhopus doliatus* is easily distinguished from its congeners by having a color pattern with bands clearly arranged in two designs (Figure 2). The anterior third of the body has black bands wider than white bands, similar to the pattern exhibited by *Micrurus mipartitus* (Duméril, Bibron & Duméril, 1854). The remaining portion of the body has red bands wider than black bands, these limited to both sides by narrow white bands, similar to that exhibited by *Micrurus dumerilii* (Jan, 1858). Both of these venomous species are sympatric with *O. doliatus* throughout its distributional range.

This is the third species of false coral snake known to occur at elevations above 1800 m asl; only *E. pseudocorallus* and *L. triangulum andesiana* reach similar altitudes (Roze, 1966; La Marca & Soriano, 2004; Navarrete & Rodríguez, 2003). As other auhtors have already indicated

Figure 2. *Oxyrhopus doliatus* Duméril, Bibron & Duméril, 1854, from Lara State, Venezuela (EBRG 3150). © Marco Natera.

(Manzanilla *et al*., 1996; Mijares-Urrutia & Arends, 2000), the species is uncommon. Actually our Andean environments are being subjected to strong impacts from human activities, principally on forested ecosystems. In consideration of its apparent scarcity, mimetic coloration, and the threats that exist to its habitats, we recommend including this species on the red list of Venezuela as an endangered species.

ACKNOWLEDGEMENTS

Our thanks to Amelia Díaz de Pascual (Colección de Vertebrados, Universidad de Los Andes), Francisco Bisbal and Ramón Rivero (Estación Biológica Rancho Grande), for allow LFE and MNM to examine the specimens under their care. Ramón Santos, Jaime Péfaur for their assistance in field as collectors. Carlos Navas recommended valuable improvements to the paper. Finally, we thank to Abraham Mijares Urrutia and Fernando Rojas Runjaic for comments on the manuscript.

REFERENCES

Barrios. C & Navarrete, L. F. (1999). Geographic distribution of *Lampropeltis triamgulum andesiana*, Mérida, Venezuela. *Herpetol. Rev*. **30**, 174–175.

Campbell J.A. & Lamar, W. W (2004). *The Venomous Reptiles of the Western Hemisphere*. Comstock Publishing Associates, Cornell University Press, Ithaca and London. 870 pp.

Esqueda, L. F. & La Marca, E. (1999). New reptilian species records from the Cordillera de Mérida, Andes of Venezuela. *Herpetol. Rev*. **30**, 238–240.

Kornacker, P. M. (1999). Checklist and Key to the Snakes of Venezuela. Lista Sistemática y Clave para las Serpientes de Venezuela. PaKo-Verlag ed. Rheinbach, Germany. 270 pp.

Esqueda, L., La Marca, E. & Bazó, S. (2007) ("2005"). Un nuevo colúbrido semifosorial del género *Atractus* (Dipsadinae) de la vertiente lacustre de los Andes de Venezuela. *Herpetotropicos* **2**, 87–93.

La Marca, E. & Soriano, P. J. (2004). *Reptiles de Los Andes de Venezuela*. Fundación Polar, Conservación Internacional, CODEPRE-ULA, Fundacite-Mérida, BIOGEOS, Mérida, Venezuela.173 pp.

Lotzkat, S. (2006). Taxonomie und Zoogeographie der Herpetofauna der Nirgua-Massivs, Venezuela. Diplomarbert im Fachberich Biowissenschaften der Johann Wolfang Goethe-Univesitat. Frankfur am Main. 160 p.

Manzanilla, J., Fernández-Badillo, A. & Visbal, R. (1996). Fauna del Parque Nacional Henry Pittier, Venezuela. Composición y distribución de los reptiles. *Acta Cient. Venezol.* **46**, 1–19.

Mijares-Urrutia, A. & Arends R., A. (2000). Herpetofauna of Estado Falcón northwestern Venezuela: a checklist with geographical and ecological data. Smithsonian Herpetological Information Service 123. 30 pp.

Navarrete, L.F. & Rodríguez-Acosta, A. (2003). Notes on the natural history of the milknake *Lampropeltis triangulum andesiana* Williams, 1978 in Venezuela. *Carib. J. Sci.* **39**, 235–236.

Peters, J. A. & Orejas–Miranda, B. (1970). Catalogue of the Neotropical Squamata. Part I: Snake. *U.S. Natl. Mus. Bull.* **297**, 1–247.

Rivas, F. G. (2002). Geographic distribution *Oxyrhopus doliatus*. *Herpetol. Rev*. **33**, 150.

Roze, J. A. (1966). *La Taxonomía y Zoogeografía de Los Ofidios de Venezuela*. Univ. Central de Venezuela, edit. Biblioteca. Caracas. 362 pp.

Roze, J. A. 1996. *Coral Snakes of the Americas: Biology, Identification and Venoms*. Malabar, Florida: Krieger Publ. Co. 328 pp.

Zaher, H. & Caramaschi, U. (2000). Synonymization of *Oxyrhopus venezuelanus* Shreve, 1947, with *Oxyrhopus doliatus*, Duméril, Bibron & Duméril, 1854, and revalidation of *Oxyrhopus erdisii* (Barbour, 1913) (Serpentes, Colubridae). *Dumerilia* **4**, 113–122.

***SALVADORA MEXICANA* (Mexican patchnose snake): COMBAT BEHAVIOR**. The difficulties in monitoring much of the natural history in secretive snake species warrants the documenting of snake behavior when it is observed (Gillingham *et al*., 1977). Male combat has been documented in many species of snakes (Gillingham, 1987), however the full extent to which male combat occurs among most snake species likely remains unknown or undocumented (Shine, 1994).

Although seven species make up the genus *Salvadora* (*bairdi*, *deserticola*, *grahamiae*, *hexalepis*, *intermedia*, *lemniscata*, and *mexicana*) much of the basic natural history for the genus is lacking (Ernst & Ernst, 2003). Some reproductive data have been collected for species within *Salvadora* (Vitt, 1978; Stebbins, 1985; Goldberg, 1995; Werler & Dixon, 2000; Ernst & Ernst, 2003) but to our knowledge male combat behavior has not been reported for the genus.

On 9th June 2007 (15:19 h) we observed two male *Salvadora mexicana* during a combat session in a tropical deciduous forest just west of Ostuta in Michoacán, México (18.51394N, 103.46616W, WGS84; 171 m elev.). The combatants (Figure 1) had begun their bout on a hill near the side of the road before we first observed them. These individuals were intertwined with one another in stereotypical combat behavior (Lowe, 1948) without indication of biting or serious aggression between them. This combat bout took place over a period of ca. 3 min and five photographs were taken of the account (UTA digital images 1078–1082), during which time they were either oblivious to or undaunted by our movements. Both males appeared similar in length and mass. They quickly separated as we rushed towards them and one of the two individuals was collected (UTA R-55373). This adult male (SVL 85.7 cm, TBL 104.8 cm) was of reproductive age and possibly fighting for territorial dominance (see Lowe & Norris, 1950), however Gillingham (1987) states that there is little evidence for territoriality in snakes. This documents the first observation reported of male combat in *S. mexicana* and the genus *Salvadora*. These observations suggest that other species in the genus may conduct similar male combat as well.

ACKNOWLEDGEMENTS

Financial support for this trip was provided by grants to E. N. Smith from Bioclon and the National Science Foundation (DEB-0416160). We thank C. M. Sheehy, III and S. A. Orlofske for providing helpful comments to the manuscript.

REFERENCES

Ernst, C. H. & Ernst, E. M. (2003). Snakes of the United States and Canada. Smithsonian Institution Press.

Gillingham, J. C. (1987). Social behavior. In: *Snakes: Ecology and Evolutionary Biology*, pp. 184–209. Siegel, R. A., Collins, J. T., & Novak, S. S. (Eds.). Macmillan Publishing Company.

Gillingham, J. C., Carpenter, C. C., Brecke, B. J. & Murphy, J. B. (1977). Courtship and copulatory behavior of the Mexican milk snake, *Lampropeltis triangulum sinaloae* (Colubridae). *Southwest. Nat.* **22**, 187–194.

Goldberg, S. R. (1995). Reproduction in the western patchnose snake, *Salvadora hexalepis*, and the mountain patchnose snake, *Salvadora grahamiae* (Colubridae), from Arizona. *Southwest. Nat.* **40**, 119–120.

Lowe, C. H. (1948). Territorial behavior in snakes and the so-called courtship dance. *Herpetologica* **4**, 129–135.

Lowe, C. H. & Norris, K. S. (1950). Aggression behavior in male sidewinders, *Crotalus cerestes*, with a discussion of aggressive behavior and territoriality in snakes. *Nat. Hist. Misc. Chic. Acad. Sci.* **66**, 1–13.

Shine, R. (1994). Sexual size dimorphism in snakes revisited. *Copeia* **1994**, 326–346.

Stebbins, R. A. (1985). field guide to the amphibians and Reptiles of Western North America. Houghton Mifflin.

Vitt, L. J. (1978). Caloric content of lizard and snake (Reptilia) eggs and bodies nad the conversion of weight to caloric data. *J. Herpetol.* **12**, 65–72.

Werler, J. E. & Dixon, J. R. (2000). Texas Snakes: Identification, Distribution, and Natural History. University of Texas Press.

ROBERT C. JADIN[1] and URI OMAR GARCÍA-VÁZQUEZ[2]

[1]*Amphibian and Reptile Diversity Research Center, Department of Biology, University of Texas at Arlington, Arlington, Texas, 76019, USA.* snakeman1982@hotmail.com

[2]*Museo de Zoología, Facultad de Ciencias, Universidad Nacional Autónoma de México, A.P. 70-399, C.P. 04510, México D.F.*

Figure 1. Two combatant male *Salvadora mexicana* in Michoacán, México (UTA digital image 1082). © U. García-Vázquez.

OXYRHOPUS RHOMBIFER INAEQUIFASCIATUS **(Flame snake): HABITS AND REPRODUCTION**. The Flame snake is a Neotropical species that occurs in central South America (Cei, 1993) with a colour pattern resembling that of the true coral snakes of genus *Micrurus* (Scrocchi *et al*., 2006). Data on natural history are scarce and only refer to two of the three subspecies that inhabit Argentina (*O. r. bachmanni* and *O. r. rhombifer*). These are characterized as oviparous terrestrial snakes that live in open areas such as grasslands and low hills (Cei, 1993; Giraudo, 2001; Cabrera, 2004; Scrocchi *et al*., 2006). The less studied subspecies, *O. r. inaequifasciatus*, occurs in the Pantanal (Brasil and Paraguay) and Great Chaco (Bolivia, Paraguay, and northern Argentina) regions (Cei, 1993; Kacoliris *et al*., 2006).

Between 2005 and 2006, we monitored 124 tree hollows used by parrots for nesting, as part of a research project on nesting ecology of the Blue-fronted parrot (*Amazona aestiva*). The survey was carried out at Loro Hablador Provincial Park (25º48´00´´S, 61º70´00´´W), located in the 'Impenetrable' (Great Chaco Region), a flood plain characterized by continuous seasonal dry forest dominated by white and red quebracho trees (*Aspidosperma quebracho-blanco* and *Schinopsis lorentzii* respectively); and by an absence of permanent wetlands or streams (Cabrera, 1976).

We found 4 hollows occupied by Flame snakes; all of them located in white quebrachos. The high of cavity-entrance varied from 3.5 m to 6.8 m and cavity depth varied from 0.6 m to 2.5 m. We found four adult individuals of *O. r. inaequifasciatus* in separate cavities. One of these individuals was observed twice (in the same cavity), on 29th October 2005 and 18th January 2006 (81 days later). On this second encounter the adult Flame snake was found along with three new-borns of the same species (Figure 1). Digital photographs of these specimens were deposited at Museo de La Plata (ref: MLP cf 0050-0054). The other tree hollows were also reinspected, but no other snakes were found.

We consider that the most probable explanation for one adult and three neonate Flame snakes sharing a single tree hollow is that the adult had laid its eggs at the bottom of the cavity, and we found it with recently hatched neonates. In our opinion, this is more likely than the rare coincidence of four individuals separately climbing the same tree and occupying the hollow. However, the possibility that tree cavities could act as pit-fall traps cannot be dismissed; in the latter case, the adult specimen would have been trapped.

Figure 1. Flame snake adult and neonates within a hollow in a White quebracho tree. © I. Berkunsky.

While terrestrial habits have been reported for *O. r. bachmanni* and *O. r. rhombifer*, our field observations suggest that *O. r. inaequifasciatus* possesses also arboreal habits. Snakes visit tree-hollows in order to obtain food and refuge (Fitzgerald *et al*., 2002; Fokidis & Risch, 2005); and it is possible that Flame snakes use tree hollows as nesting sites.

REFERENCES

Cabrera, A. L. (1976). *Regiones Fitogeográficas Argentinas*. Enciclopedia Argentina de Agricultura y Jardinería. Buenos Aires. Editorial ACME. T. II. 85 pp.

Cabrera, M. R. (2004). *Las serpientes de Argentina central*. UNC, Córdoba, Argentina. 109 pp.

Cei, J. M. (1993). Reptiles del noroeste, nordeste y este de la Argentina: Herpetofauna de las selvas subtropicales, Puna y Pampas. Mus. Reg. Sci. Nat. Torino, Monog. XIV, 1–950.

Fitzgerald, M., Shine, R. & Lemckert, F. (2002). Radiotelemetric study of habitat use by the arboreal snake *Hoplocephalus stephensii* (Elapidae) in Eastern Australia. *Copeia* **2**, 321–332.

Fokidis, B. H. & Risch, T. S. (2005). The use of nest boxes to sample arboreal vertebrates. *Southeast. Nat.* **4**, 447–458.

Giraudo, A. R. (2001). Serpientes de la selva Paranaense y del Chaco húmedo. L.O.L.A., Buenos Aires, Argentina. 328 pp.

Kacoliris, F. P., Berkunsky, I. & Williams, J. (2006). Herpetofauna of the Argentinean impenetrable

Great Chaco. *Phyllomedusa* **5**, 149–157.
Morello, J. & Adámoli, J. (1974). *Vegetación y ambiente de la Provincia del Chaco*. INTA. Serie Fitogeográfica 13. 130 pp.
Scrocchi, G.J., Moreta J.C & Kretzchmar, S. (2006). *Serpientes del Noroeste Argentino*. Tucumán, Argentina: Fundación Miguel Lillo. 176 pp.

IGOR BERKUNSKY[1] and FEDERICO P. KACOLIRIS[2]

[1] *Laboratorio de Ecología y Comportamiento Animal. Facultad de Ciencias Exactas y Naturales. Universidad de Buenos Aires. Pabellón II. Ciudad Universitaria (C1428EHA), Ciudad Autónoma de Buenos Aires. Argentina.*

[2] *Laboratorio de Herpetología, Departamento de Vertebrados. Facultad de Ciencias Naturales y Museo. Universidad Nacional de La Plata. Paseo del Bosque s/n. (B1900FWA), La Plata. Buenos Aires. Argentina.*

***NATRIX MAURA* (Viperine snake): DEFENCE BEHAVIOUR**. The ways in which animals respond to a perceived threat are varied and depend on many factors, for example the size of the predator, its body temperature, its size or sex or the nature of the terrain where the encounter takes place. Snakes employ a variety of defence behaviours in response to predators. Included in this array is 'balling', a behaviour that is perhaps most commonly seen in the small boid *Python regius*, but this has also been observed in the viperine snake *Natrix maura* in Spain (Hailey & Davies, 1986). The present note describes the behaviour in *N. maura* in France and gives a photographic example. On June 23rd 2007 at the southern end of the village of Chasnais in the Vendee region of western France, a male *N. maura* (s.v. length 37cm) was captured whilst basking next to a drainage ditch. The snake was in the process of ecdysis (Figure 1) and this probably enabled the close approach and relatively easy capture as usually the snakes rapidly flee into water when approached. The weather was sunny at the time with an air temperature 23°C. After a few minutes handling, to enable the taking of photographs, the snake adopted the behaviour shown in Figure 2. As can be seen, the head is hidden and in the centre of the 'ball' with the tail raised above, which could represent a tail lure where a less valuable part of the body is offered as a diversionary tactic. According to Arnold & Ovenden (2002), *N. maura* may attain total lengths of 100cm

Figure 1. *Natrix maura*, just after capture. As can be seen the snake was in the process of ecdysis, as indicated by the cloudy eye condition. © R. Meek.

Figure 2. *Natrix maura* employing 'balling' behaviour.

and hence this individual was at the smaller end of the size range. Hailey & Davies (1986) found that the behaviour was more frequently employed by smaller *V. maura* due perhaps to their lower endurance and suggested that static defence may reduce the feeding stimulus of a predator and adopted when fasting or where performance capacity was reduced, for example low body temperature. It may be that in the present instance ecdysis was also a contributing factor. However, it should be noted that here the behaviour was apparently used as a last resort and adopted after flight and then musk release had failed. Biting has also been cited as a defence response in *N. maura* (Arnold & Ovenden, 2002) but was not observed in this snake nor in any of the *N. maura* captured in this area – perhaps there are regional differences. Roth & Johnson (2004) attribute an absence of biting in certain snakes to the potential danger of reducing the distance between predator and snake and hence the vulnerability of the head and neck region to injury.

REFERENCES

Arnold, E. N. & Ovenden, D. W. (2002). *A Field Guide to the Reptiles and Amphibians of Britain and Europe*. HarperCollins, London.

Hailey, A. & Davies, P. M. C. (1986). Effects of size, sex, temperature and condition on activity metabolism and defence behaviour of the viperine snake, *Natrix maura*. *J. Zool., Lond*. **208**, 541–558.

Roth, D. R. & Johnson, J. A. (2004). Size based variation in antipredator behaviour within a snake (*Agkistrodon piscivorous*) population. *Behav. Ecol*. **15**, 365–370.

ROGER MEEK. *7 Rue Georges Clemenceau, Chasnais 85400, France*. Rogermeek85@aol.com

BUFO BUFO **(Common toad): BREEDING PHENOLOGY**. The Common toad (*Bufo bufo*) is a cosmopolitan species occupying a variety of terrestrial habitats all over Europe. As the species has a wide distribution it seems logical that there will be different reproductive patterns across its distribution.

The breeding season of this species is highly variable, influenced by altitudinal and climate gradients. In Spain, *B. bufo* is supposed to have a highly synchronized reproductive period (Richter-Boix *et al*., 2006) but with regional differences due to latitude. In Doñana National Park (SW Spain), the breeding season begins in January-February (Diaz-Paniagua et al., 2005); in mountanous populations from Madrid, reproduction occurs in June (Martinez-Solano *et al*., 2006). In Cataluña, in the east of Spain, breeding onset ranges between January and March (Salvador & Garcia-Paris, 2001).

During the monitoring of Gandaras de Budiño e Ribeiras do Louro wetland, Porriño, NW Spain (29TNG36), some strings of *B.bufo* eggs were detected on 6th December 2006. This is the earliest record of toad egg-laying recorded during the last 10 years of monitoring there. This fact was also coincident with the early metamorphosis of toadlets at that site, these being found during the first week of March 2007.The breeding season in Galicia starts in March according to published data about B.bufo in our region (Galan & Fernandez Arias, 1993; Galan, pers. comm.) but it seems that there is a trend towards earlier breeding (Ayres & Garcia, 2007; Ayres, 2008).

The temporal spacing of the toad breeding season is not well known, it would be interesting to obtain more information about reproductive differences due to altitudinal and hydroperiod gradients (Hartel *et al*., 2007). Also, climate change could modify the breeding phenology of temperate amphibians and is known to affect reproduction and survival (Tryjanowski *et al*., 2003; Reading, 2007; Sparks *et al*., 2007). This could be the reason for these early spawn strings, as Galicia sometimes suffers in this decade severe drought during summer-autumm, with the driest period in the last 60 years recorded in 2006-2007. Daily maximum temperature was also high, reaching 20ºC on some days. It seems that a combination of rainfall and high temperature could be the driving factor that led *B.bufo* to start the breeding season earlier than in previous years.

REFERENCES

Ayres, C. (2008). Post-mortem amplexus in marauded *Bufo bufo* (Linnaeus, 1758). *Podarcis* **9** (In press).

Ayres, C. & Garcia, P. (2007). Depredación de nutria *Lutra lutra* (Linnaeus, 1758) sobre sapo común Bufo bufo (Linnaeus, 1758) en el lic Gándaras de Budiño (Galicia). *Galemys* **19**, 45–50.

Díaz-Paniagua, C., Rodríguez, C., Portheault, A. & de Vries, W. (2005). Los anfibios de Doñana. Organismo Autónomo de Parques Nacionales, Madrid.

Galán, P. & Fernández-Arias, G. (1993). Anfibios y réptiles de Galicia. Edicions Xerais de Galicia, Vigo.

Martínez-Solano, I., García-París, M. & Bosch, J. (2006). Anfibios de Peñalara, Identificación y Conservacion. Direccion General de Promocion y Disciplina Ambiental. Comunidad de Madrid.

Hartel, T., Sas, I.; Pernetta, A.P. & Geltsch, I.C. (2007). The reproductive dynamics of temperate amphibians: A review. *North-Western J. Zool*. **3**, 127–145.

Richter-Boix, A., Llorente, G. A.& Montori, A. (2006). Breeding phenology of an amphibian community in a Mediterranean area. *Amphibia-Reptilia* **27**, 549–559.

Reading, C. J. (2007). Linking global warming to amphibian declines through its effects on female body condition and survivorship. *Oecologia* **151**, 125–131.

Salvador, A. & García-París, M. (2001). Anfibios Españoles. Identificación, historia natural y distribución. Canseco Editores, Talavera de la Reina.

Sparks, T., Tryjanowski, P., Cooke, A., Crick, H. & Kuzniak, S. (2007). Vertebrate phenology at similar latitudes: temperature responses differ between Poland and the United Kingdom. *Clim. Res.* **34**, 93–98.

Tryjanowski, P., Mariusz, R. & Sparks, T. (2003). Changes in spawning dates of common frogs and common toads in western Poland in 1978–2002. *Annals. Zool. Fenn.***40**, 459–464.

CESAR AYRES. *ROAGA. Centro de Investigación e Información Ambiental -Estrada PO-546 Pontevedra-Marín, km. 4 Apdo. 127- C.P. 36080. Lourizán - Pontevedra-Spain.* cesar@herpetologica.org

Book Reviews

Biology of the Boas and Pythons

Robert W. Henderson and Robert Powell (Editors)

Eagle Mountain Publishing
ISBN 978-0-9720154-3-4
Hardcover; 448 pages; US$100

Biology of the Boas and Pythons is the product of an international symposium – Biology of Boas, Pythons, and Related Taxa – held in 2005 in Tampa, Florida. With contributions from 79 authors, it brings together in one stunning volume a collection of 30 original research papers on the natural history of this fascinating group of snakes. The main focus of the book is on the larger boids and pythonids, with some species represented more frequently than others; six papers for example are devoted to studies of *Boa constrictor*, and *Python molurus* is featured in five. A number of papers are included, however, which deal specifically with smaller members of these groups.

Following a preface (Richard Shine), and introduction by the editors ('The biology of boas and pythons: a retrospective look to the future'), the content of the book is divided into four main sections – Ecology, Natural History, and Evolution; Behavior; Physiology, Neurology, and Reproductive Biology; and Conservation. Space prevents discussion of these sections in any great detail, but their various component papers are listed as follows:

Ecology, Natural history, and Evolution (10) – the higher-level relationships of alethophidians as inferred from nuclear and mitochondrial genes; the ecomorphology of boines, with emphasis on South American forms; the thermal biology of *Python natalensis*; reproduction and thermoregulation in *Boa constrictor occidentalis* in relation to habitat use; comparative ecology of *Python reguis* and *P. sebae*; body size and head shape of island *Boa constrictor* in Belize; habitat use by *Epicrates monensis* on Isla Mona; natural history of *Eunectes murinus* in the Venezuelan Llanos; foraging ecology of the Green tree python; and the use of roadkill and incidental data as indicators of habitat use in *Morelia kinghorni* and *M. spilota*.

Behaviour (5) – motor recruitment patterns during striking; reponse of *Eunectes notaeus* to aquatic acoustic stimuli; constricting strength in snakes; courtship, mating and alternative reproduction tactics in *Ungaliophis continentalis*; geographic variation in pheremone trailing behaviors of *Liasis mackloti*.

Physiology, Neurology, and Reproductive Biology (6) – the thermal physiology and thermoregulatory behavoir of Rubber boas; adaptive correlation between feeding habits and digestive physiology for boas and pythons; vision and infrared imaging in boas and pythons; the infrared sight of boas and pythons; the specific dynamic-action in boas and pythons; and sexual size dimorphism and the mating system of Green anacondas.

Conservation (7) – effects of habitat loss on the genetic structure of populations of *Boa constrictor occidentalis*; conservation biology of the Yellow anaconda in northern Argentina; spatial ecology of resident and displaced *Boa constrictor imperator* on Ometep Island, Nicaragua; responses of *Corallus coooki* and *C. grenadensis* to distrubed habits; ecology and conservation of *Boa constrictor* on the Cayos Cochinos, Honduras; genetic population structure of the Yellow anaconda in northern Argentina; and introduced populations of *Boa constrictor* and *Python molurus bivittatus* in southern Florida.

Reproduced throughout in colour, *Biology of the Boas and Pythons* contains more than 200 photographs, maps, and other illustrations. Most of the images are of excellent quality, and some of those taken of snakes in their natural environment are spectacular; take a look at the huge *Python natalensis* photographed from a helicopter as it basks near a porcupine burrow (p. 70), and the *Python molurus bivittatus* in an Everglades swamp killed after it had consumed an overs-sized American alligator (p. 426). The magnificent colour painting on the dust jacket deserves special mention; produced by renowned wildlife artist Carel Pieter Brest Van Kempen, it is a striking composition of a Reticulated python striking at prey from its ambush site on a river bank. At the beginning of the book is a photograph of the symposium participants, at least some of whom are presumably also the authors, but who they are is not exactly clear; no names are given in the caption beneath.

Biology of the Boas and Pythons is an outstanding book of high scholarship, and I have no doubt will receive broad acclaim not only within the herpetological research community, but among snake enthusiasts in general. In their opening chapter, Henderson and Powell express the hope that 'it will inspire both seasoned and novice snake biologists to explore the potential for conducting field-driven projects with these amazing animals'. Given that we know so little about the natural history of many species, and that some are among the most exploited of all reptiles, there is quite clearly an urgent need for such work.

Peter Stafford. *The Natural History Musuem, London.*

BRITISH HERPETOLOGICAL SOCIETY COUNCIL 2007/2008

Society address: c/o Zoological Society of London, Regent's Park, London NW1 4RY

Website: http://www.thebhs.org

President:	Prof. T.J.C. Beebee	Dept. of Biochemistry, School of Life Sciences, University of Sussex, Falmer, Brighton BN1 9QG. *E-mail: t.j.c.beebee@sussex.ac.uk*
Chairman:	Mr. J. Coote	*E-mail: chair@thebhs.org*
Treasurer:	Mrs. P. Pomfret	15 Esk Way, Bletchley, Milton Keynes MK3 7PW. *E-mail: treasurer@thebhs.org*
Membership Secretary:	Mr. T. Rose	11 Strathmore Place, Montrose, Angus DD10 8LQ. Tel: +44 (0)1674 671676; Mob: 07778 830192. *E-mail: baankulab@yahoo.co.uk*
The Herpetological Journal		
Receiving Editor:	Dr. W. Wüster	School of Biological Sciences, University of Wales, Bangor LL57 2UW. *E-mail: herpjournal@thebhs.org*
Managing Editor:	Dr. E. Price	International Training Centre, Durrell Wildlife Conservation Trust, Les Augrès Manor, La Profonde Rue, Trinity, Jersey JE3 5BP. *E-mail: eldom@jerseymail.co.uk*
The Herpetological Bulletin		
Editor:	Dr. P. Stafford	Dept. of Botany, The Natural History Museum, Cromwell Road, London SW7 5BD. *E-mail: herpbulletin@thebhs.org*
Reviews Editor:	Mr. N. D'Cruze	The World Society for the Protection of Animals, 89 Albert Embankment, London SE1 7TP. *E-mail: neildcruze@wspa.org.uk*
The NatterJack		
Editor:	Ms. M. Lock	262 Lyall Place, Farnham, Surrey GU9 0EQ. *E-mail: natterjack@thebhs.org*
Co-editor:	Mr. T. Rose	See Membership Secretary above.
Librarian:	Mr. D. Bird	Jacaranda Cottage, New Buildings, Spetisbury, Blandford Forum, Dorset DT11 9EE. *E-mail: drbird.herp1@virgin.net*
Development Officer:	Mr. M. Hollowell	*E-mail: markh22@btinternet.com*
Webmaster:	Mr. P. Pote	262 Lyall Place, Farnham, Surrey GU9 0EQ. *E-mail: webmaster@thebhs.org*
Conservation Officer:	Mrs. J. Clemons	34 Montalt Road, Cheylesmore, Coventry CV3 5LU. *Email: janice.clemons@virgin.net*
Trade Officer:	Mr. P. Curry	90 Brook Crescent, Chingford, London E4 9ET. *E-mail: peter.curry@eurorep.co.uk*
Captive Breeding Committee *Chairman:*	Dr. S. Townson	103 Chancellors Road, Stevenage Old Town, Hertfordshire SG1 4TZ. *E-mail: simon.townson@ntlworld.com*
Education Committee *Chairman:*	Mr. D. Freeman	272 Whaddon Way, Bletchley, Milton Keynes MK3 7JP.
Research Committee *Chairman:*	Dr. C. Gleed-Owen	c/o The Herpetological Conservation Trust, 655A Christchurch Road, Boscombe, Bournemouth, Dorset BH1 4AP. *E-mail: research@thebhs.org*
North-West England Group Representative:	Mr. R. Parkinson	317 Ormskirk Road, Upholland, Skelmersdale, Lancashire. *E-mail: northwest@thebhs.org*
Scottish Groups Liaison Officer:	Mr. F. Bowles	37 Albany Terrace, Dundee DD3 6HS. *E-mail: frankdbowles@hotmail.com*

Ordinary Members

Mr. D. Willis	*E-mail: davewillisbhs@yahoo.co.uk*	(3rd year)
Ms. E. Daw	Strathmore Veterinary Clinic, 6 London Road, Andover, Hampshire SP10 2PH. *E-mail*: *reptilevn@yahoo.co.uk*	(3rd year)
Mr. N. D'Cruze	WSPA, 89 Albert Embankment, London SE1 7TP. *E-mail: neildcruze@wspa.org.uk*	(1st year)

Past Presidents (retiring date)

Dr. M.A. Smith (1956), Dr. J.F.D. Frazer (1981), The Earl of Cranbrook (1990), Prof. J.L. Cloudsley-Thompson (1996), Dr. R. Avery (1997), Dr. H. Robert Bustard (2005)

THE HERPETOLOGICAL BULLETIN

Contents

- Registered Charity No. 205666 -