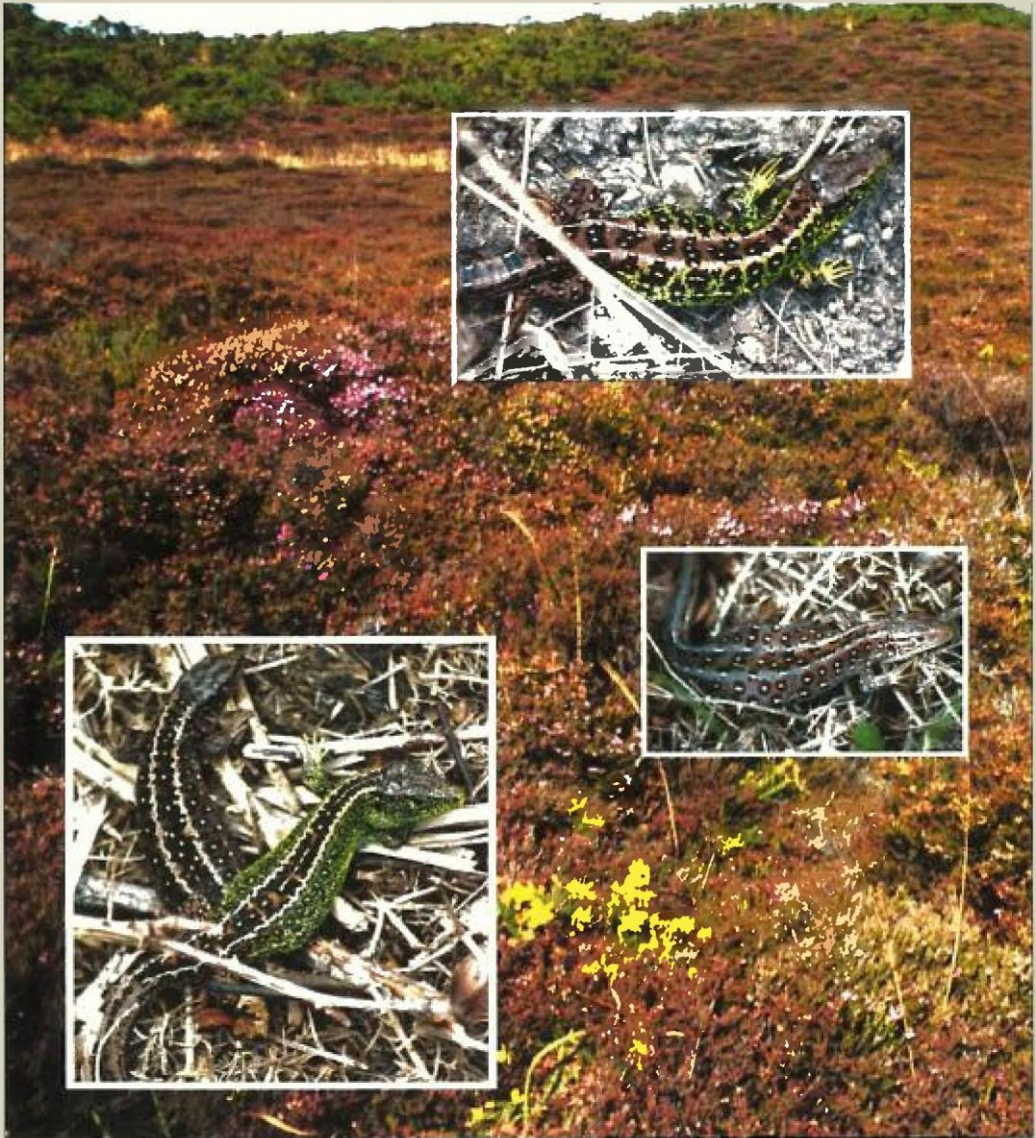


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The **Herpetological Bulletin** is produced quarterly and publishes, in English, a range of articles concerned with herpetology. These include full-length papers of mostly a semi-technical nature, book reviews, letters from readers, society news, and 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).

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Front cover illustration

Male and female Sand Lizards, *Lacerta agilis*, photographed on a Dorset nature reserve. Photograph by Rachel Fearnley. See article on page 10.

EDITORIAL

Letter to the Editor

Dear Sir,

On the cover of the latest *Bulletin* [Number 80, Summer 2002] is a good photograph of a Black Mamba, *Dendroaspis polylepis*. On second glance I saw two loreal scales between the preocular and nasal scales and thought *this is not a mamba*. The only elapids known to have loreal scales are the two species of *Pseudohaje*, *P. goldii* and *P. nigra*; these look different and are not known to occur in the area. At the end of Tony Phelps' interesting article on the Black Mamba in KwaZulu-Natal is a list of other snakes seen in the area. The only one of roughly the same size and general appearance as a Black Mamba is the Boomslang, *Dispholidus typus*. On checking a few specimens it is clearly not a Boomslang. However, apart from the loreal scales, its squamation fits that of a Black Mamba. I conclude that there was no mix up between legend and photograph but that it shows a Black Mamba with a highly unusual variation in the head squamation.

Received from Garth Underwood, 6th September.

Editor's comment: Tony's photograph is actually of a captive in the collection of the Liverpool School of Tropical Medicine – its precise locality is unknown, but I am informed (courtesy of Paul Rowley) that it originally came from the Transvaal Snake Park via London Zoo.

In memoriam – Garth Underwood

Shortly after receiving the above note from Garth I received the sad news of his death. Even during his last weeks it seems he retained his sharp eye for detail. He was 83. A full tribute to Garth's life and work will be appearing in the *Herpetological Journal*, and another by his close colleague at The Natural History Museum, Colin McCarthy, is to be published in the American journal *Copeia*, but in this opening section of the *Bulletin* I thought I'd also record a few personal recollections of a man I consider myself privileged to have known, albeit for only the last few years of his life, and who was a founding member of the BHS.



Garth, photographed in the Natural History Museum's old Spirit Building; May 1966.

Garth was known throughout the herpetological world for his many outstanding contributions to reptilian biology, and he was a recognised major authority on snakes. A number of taxa have been named specifically in his honour, and he himself was the describing author of several new species, perhaps the most extraordinary being a mussurana from St. Lucia, *Clelia errabunda*, which appears to have been extinct for the last 100+ years. The only known specimens – believed previously to have represented the widely distributed mainland species (*C. clelia*) – were collected in the 1880s. He was a modest man who always showed interest in what others were doing and gave freely of his time and experience. This was demonstrated quite clearly to me only a few months ago when I decided to seek his help on an aberrant museum specimen of the colubrid snake *Symphimus mayae*. Not wanting to impose too much on his time (although long retired he still came in regularly to continue his work at the NHM) I went over to see him one morning and explained what the problem was – as always he agreed without hesitation and suggested I leave the specimen with him for an hour or two. When I returned later around 5 he had been called away and I assumed he had not had the chance to even look at it. In a large jar on his desk, however,

I found the specimen, neatly pinned out and dissected, to the side of which lay several sheets of notes describing his observations in meticulous detail. He had quite clearly devoted the entire day to the task.

After delving into the Society's records, Monica Green (Secretary) informs me that Garth first joined the BHS in September 1947 (at the grand annual subscription rate of 10 shillings!). Over the intervening 50+ years he regularly attended its meetings in London and during the time I have known him cannot remember an occasion when he missed an AGM. His staunch support for the BHS is further reflected in a substantial donation he once made to the Land Fund.

Garth had many friends and colleagues the world over and will be greatly missed. The Society has also lost one of its most distinguished, long-standing, and generous members, whose work has furthered our knowledge of reptiles enormously, and whose contribution to herpetology in its broader sense must surely qualify as being nothing short of profound. *Ed.*

Meet the Council.....

Frank D. Bowles, Scottish Groups Liaison Officer.

Frank was born in Middlesex in 1931. He has been fascinated by reptiles and amphibians from a very early age, and had found all the common British herpetofauna, as well as Green Frogs, by the age of 11. Although he studied Art and went into education as a career, he managed to bring herpetology into his field of scientific illustration, both in the content of HNC exams for which he was the examiner, and in the 1995 unitised Graphic Design HND into which he introduced a Herpetological Illustration unit.

He has recorded the herpetofauna of countries in many parts of the world and is at present trying to initiate a thorough survey of Scotland, where he has lived since 1944, a country three-fifths the size of England with a population of only five million, and hundreds of square miles of unrecorded or misrecorded wild habitat. He attempts to do this by acting as a contact for both Scottish Amphibian and Reptile Groups and individuals interested in any aspect of herpetology. New records, both of Scotland's three reptile species, and rarer,



protected amphibians, are constantly coming in. Of particular significance are the number of Great Crested Newt sites recently discovered by the Clyde group and Adder sites by that of Lothian.

Frank has been a member of the BHS since 1985, and has contributed to the *Bulletin* since 1988. In 1992 he addressed the VI Congreso Espanol de Herpetologica on the reptiles of north Portugal. He has also spoken at several Herpetofauna Workers meetings and helped organise Scottish groups. He also continues to prepare illustrations of both reptiles and amphibians which he uses to raise their profile with the general public, and has been involved with Tayside Biodiversity projects such as the Garden Pond Frog survey initiated by Dundee Museum, which used one of his illustrations in their display.

Peter Stafford, Editor, *The Herpetological Bulletin*.

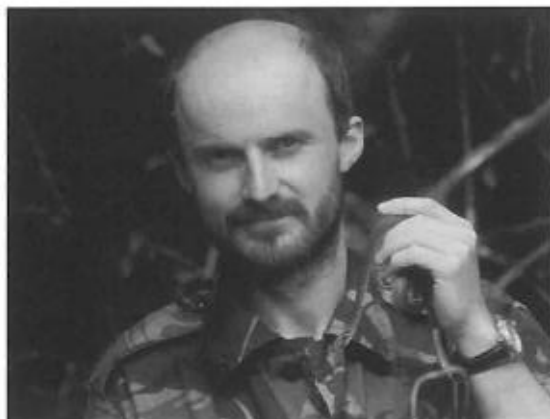
I joined the BHS in 1983 and — no doubt like many others reading this — have had an interest in herpetology for as long as I can remember. My first introduction to 'exotics' came at the age of nine when my parents agreed that I could keep a pair of skinks I had seen for sale in a local pet shop. I was immensely proud of these lizards and would sit for hours on end watching them scramble around in their vivarium, imagining what it would be like to see such wonderful-looking creatures (one was an exquisite blue-tailed *Mabuya*) in the wild. But it was when I was 14 that I began to take a serious interest in the subject. I was in Zambia at the time (1975) and on one particularly memorable occasion visiting a small zoo-park near

the capital, Lusaka. Inside an open pit in the middle of the park was a man giving a talk about the local snakes, and after having asked him several questions he plucked a large, slender green one from a branch next to him and handed it up for me to hold. From that moment I became hooked and have always considered myself somewhat indebted to this 'snake-man' — though years later when I dug out an old photo of myself with the animal coiled around my arms it quite clearly depicted a Boomsnang!

Over the last 30 years I have kept and bred many species of reptiles — from skinks I moved on to snakes and for a long time was especially fascinated with 'boids'. My principal interest nowadays, however, lies in field research. Since joining the staff of The Natural History Museum in 1983 I have been fortunate to be involved with expeditions to various parts of the tropics, mostly Central America; eleven of these have been to Belize, and as I write this (August) I am again packing my bags for a trip to this corner of the Caribbean, where for the next few weeks we (a collaborative project with colleagues from Texas Tech University) will be investigating the status of Morelet's Crocodile (*C. moreletii*) in a little known mountain river system.

Much of my published work on herpetology has concerned the specific area of Belize and adjacent parts of Central America. These include a co-authored book (Academic Press, 2000) and a dozen or so scientific papers, the most recent focusing on Coral Snakes (*Micrurus*) and Neotropical Forest Racers (*Dendrophidion*). I have written or co-authored several other books and about 30 general articles on reptiles, mostly snakes, and in my capacity as research biologist in the Department of Botany have also published widely on the subject of palynology — the study of pollen grains and spores. Presently, I am working on my dissertation, which concerns the ecology of a little known invertebrate-eating snake endemic to the Yucatán Peninsula, *Symphimus mayae*.

I am a member of several other herpetological societies, and in the early 1980s served for a time on the council of the International Herpetological Society, of which I have been a member off and on since 1978.



The purpose of these short profiles is to introduce ourselves as Council officers and give some idea of our particular herpetological interests (see first in series, *Bulletin* 79). In finishing this one of myself, however, I'd like to also take the opportunity to thank those who assist me with production of the *Bulletin*, not least my wife Marian, who readily steps in when needed to help with proof-reading and other tasks, and the many colleagues who willingly (and in some cases regularly) set aside their time to help with the reviewing of articles. Without this support I would find it difficult to continue and at times unable to produce some issues of the *Bulletin* at all. For their help in reviewing articles during this last year, or assistance with other *Bulletin*-related matters, I would like to extend particular thanks to the following:

Franco Andreone
 Roger Avery
 David Bird
 Bill Branch
 Robert Bustard
 Keith Corbett
 Richard Griffiths
 Clive Cummins
 Barry Hughes
 Pat Manly
 Colin McCarthy
 Tony Phelps
 Simon Townson
 Stephen Von Peltz
 John Wilkinson
 Wolfgang Wüster

**The Status of the Common Lizard
(*Zootoca vivipara*)
in the West of Scotland**

J.A. GIBSON

Scottish Natural History Library, Foremount House, Kilbarchan, Renfrewshire PA10 2EZ.

AS the author of the standard works on the Reptiles and amphibians of the Clyde area, I was naturally interested in Mr. Frank Bolwes' queries about the status of the Common Lizard, *Zootoca vivipara*, in Scotland (*Herpetological Bulletin* 80, 4-6; 2002). Unfortunately any suggestion that the lizard may be increasing is very wide of the mark, at least in the West of Scotland. Indeed the reverse is now sadly very much the position.

If Mr. Bowles, during his short stay as a boy in Renfrewshire in the 1940s, had contacted the old-established (1847) and distinguished Renfrewshire Natural History Society, always so glad to assist young naturalists, the Society would readily have shown him the lizards, which at that time were quite common and well distributed throughout most suitable parts of the county, and had always been recorded as such in the Society's publications. Unfortunately this is no longer the case.

Whatever the position may be in other parts of Scotland, in the Clyde Faunal Area (lowland Clyde, the Loch Lomond area, South Argyll, and the Clyde Islands) the lizard is one of the species which has markedly decreased in population density over the past twenty-odd years. Although still fairly widely distributed, lizards, apart from a few select areas, are now distinctly thin on the ground, a situation which is naturally causing some concern. I have been recording reptiles and amphibians in the West of Scotland for the past sixty years, but nowadays in many parts of the Clyde area I can hardly find a single lizard where over a decade ago I could easily see many in an afternoon's walk. The reasons for this worrying decrease are not yet clear.

With regard to Renfrewshire, it is perhaps worth noting that, as far as reptiles and amphibians are concerned, the county is one of the most intensely recorded parts of the British Isles. The Renfrewshire Natural History Society (the oldest natural history society in the West of Scotland) has published several written accounts of the county's reptiles and amphibians over the past ninety years; founded the Renfrewshire Biological Records Centre, the first-ever local biological records centre to be established in Scotland, forty years ago; and since then has published two comprehensive distribution Atlases (1970 and 1983), the first of which was apparently the first complete Vertebrate Atlas of an entire county ever to be published in Great Britain. Moreover in 1997, as part of its 150th anniversary celebrations, the Renfrewshire Society decided to produce an updated edition of the county Vertebrate Atlas, which is now nearing completion.

Additional comments: The author of the article to which this note refers informs me that his only experience of rural Renfrewshire was between 1944-1948, during which time he saw no reptiles. His queries about the status of lizards nationally in Scotland were based on an increase in his own sightings here, in the east of the country, the north, and also the west in Mull and Galloway. Recent work with other naturalists in Fife indicates that lizards there, far from being extinct as was generally thought, are still thriving in the vicinity of Kincardine Bridge.

ORIGINAL ARTICLES

Husbandry of captive Bearded Dragons (*Pogona vitticeps*); does handling influence thermoregulation?

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ABSTRACT. — The behaviour and body temperatures of the Bearded Dragon (*Pogona vitticeps*) were recorded during periods with handling and non-handling intervals. Differences in perching and hiding were observed after the animals were handled but basking and locomotory activity remained almost constant. The observed differences in behaviour appeared to have no influence on either set point or variance in body temperatures.

THE thermal dependence of reptilian physiology and the behavioural mechanisms employed to achieve target body temperatures are now well understood (Huey, 1982). Changes in the body temperature of ectotherms have been shown to influence, among others, growth rates, reproduction and general health. Therefore in respect to husbandry, it is important that reptiles should be given the opportunity to display natural behaviour and attain appropriate body temperature levels through the provision of housing that resembles as closely as possible a species natural habitat (Avery, 1985). However there are other husbandry factors to consider, stress for instance, which in reptiles may disrupt behaviour and induce sub-optimal body temperatures (Arena & Warwick, 1995). The discovery of elevated body temperatures in the teiid lizard *Callopiastes maculatus* in response to being handled — defined as emotional fever (Cabanac & Gosselin, 1993), gave rise to a series of questions regarding lizard biology, not the least being, what are the long term implications of persistent handling and how widespread are handling effects on the body temperatures of different species? This paper gives details of a study of thermoregulatory behaviour in the Australian Bearded Dragon (*Pogona vitticeps*). The aim was to determine whether handling would

disrupt behaviour patterns to the extent that thermal set points and thermoregulatory precision would be affected. The work was part of a second year Higher National Diploma research project undertaken by K.C., M.H. & T.W under the supervision of R.M. at Huddersfield Technical College.

METHOD

All work was carried out at the Herpetological Unit at Huddersfield Technical College between September 2001 and June 2002. Observations were made usually once per week between 13:00 hrs and 15:20 hrs on 9 lizards from two enclosures of 2.1x1.1m and 0.5x1.2m in ground measurement. Both enclosures had perching, basking and hiding areas available. The enclosures were glass covered units and hence the lizards were subject to natural light at all times although UV lamps and infrared heaters were also installed. The latter produced thermal gradients from around 15-55°C. A non-invasive Omega OS204 Digital Thermometer was used to record skin surface temperature of each dragon which corresponds fairly closely to core body temperature in lizards (Meek, 1999). Four types of behaviour were identified 1) Basking, positioned under a heat lamp, 2) Perching, positioned remotely from a heat source in an

elevated location either on a rock or branch, 3) Locomotory activity, which is self explanatory and 4) Hiding, inside a hide box or down a tunnel. The results of this study are based on a total of 1170 behaviour records and 1170 body temperature measurements.

The lizards were all adults, captive bred at the college, and aged between 2 and 3 years. They were exposed to both people passing and actually entering (walk-in) their enclosures on a daily basis. Each cage had only one resident male, although as many as 6 females could be present in a cage but only 3 lizards were identified and used from each cage at any given time (1 male and 2 females). No physical interactions were observed during the study between individuals other than mating.

Procedures

The behaviour of three animals was observed for one hour during which time the lizards body temperatures and behaviour were recorded every five minutes. All animals were then removed from the enclosure and held and manipulated for a period of twenty minutes before being returned to the cage. They were observed for a further hour, recording temperatures and behaviour as before.

Independently on other weeks a control was set up where the procedure was repeated except the animals were left in their enclosures for the twenty minute interval without being handled or measured in any way. Both groups of lizards were employed as control and manipulated treatments.

RESULTS

Behaviour. Table 1 shows the pooled behaviour of the Bearded Dragons during the one hour periods before and after the handling and non-handling intervals. Differences in behaviour between

	Basking	Perching	Hiding	Locomotory activity
A) Before non-handling	67	16	1	16
B) After non -handling	69	11	3	17
C) Before handling	29	31	26	14
D) After handling	31	38	18	13

Table 1. Behaviour of *Pogona vitticeps* during the study period. The results show the different levels of behaviour expressed as percentages of total behaviour within each one hourly sampling period before and after handling and non-handling intervals. Percentage values have been rounded to the nearest integer and the results are based on pooled samples for each observational period. Sample sizes are for non-handling observations (A and B) $n = 234$ for each sampling hour and for handling (C and D) $n = 351$ for each sampling hour.

	Mean	±Std. Dev.	Min.	Max.	n	p
A) Before non handling	34.4	2.2	24.7	39.8	234	
B) After non handling	34.5	1.9	25.5	38.7	234	0.52 (n.s.)
C) Before handling	33.3	3.3	23.9	41.0	351	
D) After handling	33.5	2.8	26.0	41.7	351	0.35 (n.s.)

Table 2. Body temperatures ($^{\circ}\text{C}$) of *Pogona vitticeps* before and after non-handling and handling intervals. The p values are based on comparison of means of pooled data sets (ANOVA) between A and B and between C and D. Mean body temperatures are given with one standard deviation along with minimum and maximum body temperatures recorded. The number of observations (n) during each observation period is also given.

observational conditions were apparent. Basking intensity was 67% for the 1 hour before and 69% for the 1 hour after the 20 minute non-handling interval; this compared to 29% of basking before and 31% basking after the handling interval. However we considered the general differences between the handling and non-handling sessions less important than the relative changes in behaviour (the differences between A and B compared to the differences between C and D). Examined from this perspective it would appear that there were no shifts in basking duration after handling or non-handling (2% increase in both instances) and only a 1% decrease after handling and 1% increase without handling in locomotory activity (all $P > 0.05$ using a percentage

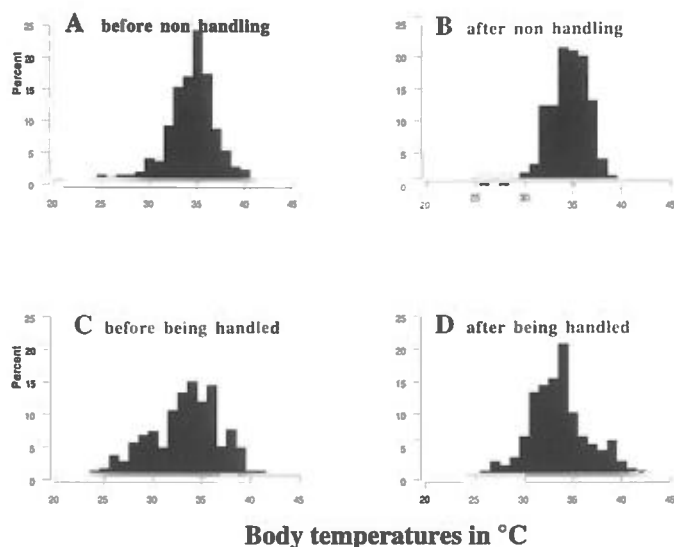


Figure 1. Frequency distributions of *P. vitticeps* body temperature before (A) and after (B) the non-handling interval and before (C) and after (D) the handling interval. The data are shown as percent frequencies of the total number of observations within each hourly period. Sample sizes are given in Table 2.

comparison test with the h-distribution at $d.f. = 234$ for non handling and $d.f. = 351$ for handling). Perching increased from 31 to 38% after the lizards were handled but decreased by 5% - from 16 to 11% during non-handling sessions but neither of these behaviours shifts were found to be significant (handling ($d.f. = 351$) and non-handling ($d.f. = 234$) both gave $h = 0.147$, $P > 0.05$). The only significant shift in behaviour was the 8% decrease in hiding after being handled ($h = 0.194$, $d.f. = 351$, $P < 0.05$); this increased non-significantly by 2% after the 20-minute non-handling period.

Body temperatures. Table 2 shows the statistics relating to pooled body temperature measurements; Fig. 1 shows histograms of the overall body temperature distributions before and after the handling or non-handling intervals in more detail. The data were examined for relative shifts in the patterns of body temperatures that could be identified as due to handling influences, which is

again between A and B compared to differences between C and D in either Table 2 or Fig 1. This is: 1) adjustments in set point temperatures, here determined as the arithmetic mean body temperatures; and 2) changes in thermoregulatory precision, defined as the variances in body temperatures around the means. As can be seen from Table 2 the changes in mean body temperatures were minor either from before to after handling (0.1°C) or between before to after non-handling (0.2°C). The

differences were tested using ANOVA which showed that they were not significant; non-handling, $F(1,466) = 0.4$, $P > 0.05$; handling, $F(1,700) = 0.87$, $P > 0.05$.

The variances in lizard body temperatures were greater before the 20-minute intervals whether handled $s^2 = 10.9$ versus $s^2 = 7.9$ or not handled, $s^2 = 4.79$ versus $s^2 = 3.53$. A Levene's test set at the 95% interval was unable to reject a null hypotheses of equal variances in the corresponding data sets; variances did not change significantly either after the lizards were handled or in the absence of handling. The Levene's value for not handled variances (A versus B) was 0.74, $P = 0.89$, and when the lizards were handled (C versus D) 0.87, $P = 0.74$. Therefore no significant changes in either set point temperatures or degree of thermoregulatory precision could be found in the body temperature data.

DISCUSSION

The results of this study were unable to show conclusive evidence that handling influenced *P. vitticeps* body temperature levels despite the mainly minor behavioural differences. The results were not unexpectedly different from Cabanac & Gosselin's (1993) study on handling effects in *C.*

maculatus since the reaction of a reptile to being handled may be dependent on its natural escape behaviour. Consider flight as the method of escape, here increases in body temperature and the subsequent Q_{10} effects would be beneficial increasing, critically, muscular energy. This is indeed the method employed by many of the smaller teiid lizards (including *C. maculatus*) that are often quick moving highly mobile animals. In contrast, passive defence as seen in certain glass lizards (e.g. Hailey & Theophilidis, 1987), death shamming (Carpenter & Ferguson, 1977) and the cryptic behaviour frequently observed in agamids (e.g. Hennig, 1979) including *P. vitticeps*, require that the animal remains immobile. Increases in body temperatures and metabolic rates in response to predators may not be adaptive in this escape tactic since movement would render them conspicuous. The perching recorded in captive *P. vitticeps* appears to be analogous to the crypsis observed under natural conditions.

A second and perhaps just as obvious possibility is that, as captive bred animals, the lizards had become habituated to the presence of humans. Habituation has been observed in other lizards e.g. *Lacerta*, *Amphibolurus*, *Uta* (Greenberg, 2001) and *Anolis* (Sugarman, 1990). A good example is in *Anolis carolinensis* where the defensive immobility response diminishes with increasing exposure to human observers (McNight, 1978) and may vary with environmental conditions (Hennig, 1979). Bearded Dragons may also be in this category, since they are comparably easy to maintain in captivity in the sense that they are 'placid' i.e. subjectively they appear to tolerate disturbance and low levels of stress and this could result in a lack of effects on behavioural thermoregulation. It is also possible of course that the dragons were affected by handling but not in the ways measured here. The problem of measuring stress or other physiological disturbances in reptiles is that the only direct way is through measuring hormone levels, but the act of removing a blood sample may in itself be a stressful experience (Avery, 1999). In this respect the lizards could even have been influenced in some way by measurement,

irrespective of the use of non-invasive infrared detectors to record body temperatures, although it might then be expected that if they were sensitive to this degree, they would react in some significant way to handling.

Behaviour alone may not necessarily provide a useful indication of stress in reptiles. In lizards behaviour is not always homogenous and may adjust to subtle background environmental conditions, differences between individuals, physical condition and, on occasion in *P. vitticeps*, the selection of temporary semi-dormant periods to low body temperatures – possibly a form of metabolic resting? However, the ranges and means of body temperature recorded in captive *P. vitticeps* were in close agreement with field body temperatures (several references reviewed in Heatwole & Taylor, 1987) indicating no evidence for any 'low temperature preference' in captive reptiles suggested by Warwick (1990). The present approach was based on the assumption that if a handled lizard is stressed, normal behaviour will be abandoned to the extent that this will influence thermoregulatory precision or shifts in thermal set points; there was no evidence for this in the present study. Future studies could provide useful information in this area of interest by investigating shifts in respiration rates (Avery, 1999) and comparative growth rates between handled and non-handled animals.

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A photographic study of reproductive behaviour in the Sand Lizard, *Lacerta agilis*, on a Dorset nature reserve

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THIS report presents the results of extensive behavioural monitoring of populations and individuals of *Lacerta agilis* on a Dorset nature reserve during the spring, summer and autumn of 2001. The objective of the study was to provide a detailed photographic record of breeding behaviour for one of Britain's rarest reptiles.

Lacerta agilis is the largest of the United Kingdom's two native lacertids. At present the species persists only in Surrey, Dorset and Merseyside (Corbett, 1988), although introduced populations may also survive in Sussex, Devon and Wales following a program of recovery. Dorset is undoubtedly the stronghold and the overwhelming majority are to be found on the remaining heathlands within this county (Beebee & Griffiths, 2000). The continued destruction and fragmentation of Dorset's heaths combined with the effects of uncontrolled fires has resulted in the extinction of many local populations. Currently, *L. agilis* is an endangered species and is nationally protected under schedule 2 of the UK Conservation (Natural Habitats etc.) Regulations 1992, and internationally protected under the Council of Europe's Convention of European Wildlife and Natural Habitats and Species Directive (1992).

Lacerta agilis has a wide European range extending from western France across the European continent and into central Asia. In Britain, it is an animal of lowland heaths and occasionally of coastal sand dunes and thrives only where there is dense dwarf-shrub or similar vegetation at ground level. They also require areas of open exposed sand in which to lay their eggs. Optimum Sand Lizard habitat is a southern heathland with a south-facing sandy bank and extensive stands of mature ling or bell heathers, interspersed with open patches of track or sand (Beebee & Griffiths, 2000).

Lacerta agilis in Britain emerge from hibernation during February and March, though the males in general appear a couple of weeks before the females. As the sun strengthens, activity increases and after a spring moult males begin to acquire their greenish breeding colours. By mid to late April the time spent basking declines and the lizards become preoccupied with mating and feeding. In the summer when the sun is at its height, the lizards are seldom seen and much of their time is spent underground or foraging in vegetation (Beebee & Griffiths, 2000). *Lacerta agilis* mate between April and early May (mating was observed on the Dorset site in early May), lay their eggs between late May and June, which then hatch between August and September. The lizards then return to hibernation late September to October (although the exact time is dependent on the weather).

The diet of *L. agilis* consists of a wide range of invertebrates and they can be seen chasing bumble bees, butterflies and moths, spiders, crickets, harvestmen, flying ants and beetles (Beebee & Griffiths, 2000). The intelligence of *L. agilis* has been documented and recognised notably by Rollinat over a century ago (Smith, 1951).

Site Description

The lizards were observed at a small 5 ha Local Nature Reserve, which has been designated as a Site of Special Scientific Interest (SSSI) in Dorset, managed and maintained by Poole Borough Council. It is a mosaic of several habitats including secondary woodland with stands of willow, birch and oak, scrub areas dominated by gorse and bramble, acidic grassland varying in maritime influence and wetness, remnant heath, reed-bed, ditches, banks and ponds. The site is



Plate 1. Area of site in which the lizards were observed basking and displaying territorial behaviour for the 2001 season. The habitat here is characterised by reed, bramble, silt, bare ground and gorse.

adjacent to urban areas on three sides with a golf course containing heathland to the North. Approximately 0.5 ha of the site is occupied by the lizards.

The lizards observed prior to 1996 have been present on only two areas of the site, and it is believed that at this time the populations were isolated. Habitats in these areas differ significantly from one another and from the expected and typical Sand Lizard habitat. The areas that are known to contain historical populations of lizards consist of gorse, bramble, scrub and silt banks, and the other of low mixed vegetation, reeds, bramble and grasses (Plates 1 and 2).

The majority of the lizard activity observed during this study has occurred on these silt banks or in the low mixed vegetation surrounding them. These habitat types have been encouraged in the management regime of the site by maintaining and providing open sunny areas with low vegetation, areas of open sand and wind breaks of taller scrub.

Population status and response to active management

Sand Lizards have been seen on the site prior to 1996 but not regularly recorded. From 1996 onwards surveys have been conducted each year and the results of these fed back into active management of the site for reptiles. In 1996 only eight individuals were recorded, found on the two



Plate 2. One of the many silty banks created and encouraged by the site managers. This photograph was taken year beginning 2002, after the activity in this study was recorded.

main silt banks and in mixed vegetation to the North of the site, which probably represents an underestimate. From 1997 onwards recording appears to have continued at much the same level. Twenty individuals were recorded in 1997 and this is thought to be a reasonable estimate of the population size at that time. Active management started in 1995 has steadily improved the habitat available. The number of individuals recorded has steadily increased from 30 in 1998, to 48 in 1999, and 55 in 2000. In 2001, 90 individuals were recorded, of which 15 were confirmed new sightings. Few young animals are seen in the open until later in the year unless disturbed by adults and are likely to be very under-recorded.

The total number of Sand Lizards currently present at this site is difficult to determine, but the population appears to be thriving and responding well to active management. The density of individuals appears to be significantly higher than the expected density quoted in recent literature (e.g. Beebee & Griffiths, 2000). It is probable that the populations here are less isolated than they were in 1996. In particular, movement of animals between ancillary colonies at the site may have increased, and movement may have also occurred to and from the adjacent golf course, on which recent management has created additional areas of open heathland.

METHODOLOGY

Lizards at this site were recorded on detailed maps of the reserve with each individual given a number. Each animal was numbered when first observed and its location accurately recorded on a detailed site map. This data was used as a baseline for the survey to determine the expansion of the populations and where possible, to obtain a photographic record of the back pattern for each numbered individual (for future identification purposes). It was important that each individual lizard kept its original number. This was ensured by use of the detailed reserve maps during recording. It should be recognised that surveying for this study started late in the season.

Surveys were conducted by walking a set route through the site and across the occupied bank habitats without interfering with the lizards or degrading the area.

Following several unsuccessful survey days from the end of April, five continuous full days were spent on site when all the observations noted in this study were recorded. These observations were recorded between 10th and 14th May 2001.

When a lizard was observed the following was noted:

- * Date and time of sighting
- * Weather conditions
- * Sex
- * Whether adult or juvenile
- * Location on the site map

- * Presence of other lizards
- * Behaviour at time of sighting (basking/mating)
- * Lizard number
- * Whether a new sighting
- * Where possible a photograph of the back pattern or behavioural activity was taken

FIELD OBSERVATIONS AND RESULTS

It is of great importance to stress that all the behaviour displayed by the lizards was completely natural. There were no human pressures or influences governing the behaviour of the animals during and after this study.

Three distinctive and eventful sequences were chosen from the field observations. Each photograph in this article has been selected as it displays either a typically observed and well documented aspect of behaviour or, more interestingly a type of behaviour not noted or observed in either wild or captive populations of sand lizards. Each sequence is described in its entirety and each interesting observation or aspect of behaviour is cross-referenced to the corresponding photograph.

Sequence 1

Behaviour noted

- Female approaching male
- Biting
- Circling

Date and time

~11:00 hrs, 11th May 2001

Weather conditions

Lots of cloud cover, humid and warm.

Duration of display

~2 minutes.

Size and Age of lizards

Not noted

Notable points

Observations 4 and 6 have not been documented in previously published research.



Plate 3.



Plate 4.



Plate 5.



Plate 6.



Plate 7.

Sequence 1. Summary: male 66 and female 67.

1. Male moves towards female tasting the air as he moves.
2. Male approaches female almost cautiously and makes eye contact; he then begins to circle female (Plate 3).

3. Female changes body posture and her behaviour begins to resemble that of agitation (shaking of front foot, flicking of tail) as male approaches.
4. Female approaches male in an almost aggressive manner and moves forward with mouth slightly open towards his head (Plate 4).
5. Male continues to circle female, then starts to bite her tail (Plate 5).
6. Female maintains eye contact with male and moves towards his head with mouth open (Plate 6).
7. Male and female begin circling each other with female gradually becoming more flattened and widened; the pair are continuously moving closer together (Plate 7).
8. Female leads male into surrounding vegetation.



Plate 8.



Plate 9.

Sequence 2

Behaviour noted

- Guarding
- Biting
- Female agitation
- Territorial

Date and time

~10:00 hrs, 10th May 2001

Weather conditions

Lots of cloud cover, humid and warm.

Approximate age and size of individuals

Age unknown, male ~26cm, female ~26cm.

Duration of sequence

Approximately 30 minutes.

Notable points

This pair of lizards was seen regularly on site in the same area and consequently their behaviour has been extensively documented.

It is not known whether the couple had mated prior to this sequence.

Sequence 2. Summary - male 52 and female 53.

1. Male guards female.
2. Female displays agitation by shaking front foot and flicking tail.
3. Male and female circle each other.
4. Male guards female (Plate 8).
5. Male aligns himself with agitated female where eye contact is made and maintained (Plate 9).

6. Male runs away at speed and begins to circle territory; this lasts approx. 5 minutes (after sequence, male 89 observed nearby, where male 52 was circling territory).

7. During this time female returns to favourite basking spot (identified from previous observations), catches and eats a fly, then continues to bask.

8. Male returns to female, tasting air as he moves.

9. Female responds by displaying agitation.

10. Male guards agitated female.

11. Male and female circle each other.

12. Male bites female; she responds by biting him.

13. Activity in steps 11 and 12 continue for approximately 10 minutes.

14. Site of activity is left for 5 minutes; on return, female is displaying a sizeable mating wound on her right flank. It is not known whether this pair of lizards actually mated.

Sequence 3

Behaviour observed

Mating, territorial and guarding.

Date and time

~12:00 hrs, 11th May 2001

Weather conditions

Lots of cloud cover, humid and warm.

Approximate age and size of individuals

Age unknown, male ~25cm, female ~25cm.

Duration of sequence

Approximately 10 minutes.



Plate 10.



Plate 11.



Plate 12.



Plate 13.

Notable Points

Prior to copulation, the mating pair moved to denser lower vegetation where they were more camouflaged.

Sequence 3. Summary - male 56 and female 63.

1. Male bites female continually, gradually moving up her body.
2. Male curls around female and exhibits guarding behaviour.
3. Male begins biting female directly below her hind legs (Plate 10).
4. Male mates with female (Plate 11).
5. Male circles female post copulation and eye contact is made (Plate 12).
6. Male guards female directly after mating (Plate 13).
7. New male (male 64) approaches mated pair and mated male (male 56) 'tastes' air whilst guarding female.

8. Mated male 56 chases new male 64 off at speed, whilst female remains under cover of vegetation.

9. Female basks.

10. Mated male basks exactly where male 64 was observed after mating.

DISCUSSION

The close monitoring and photography of these lizards has created the opportunity to detail and analyse their movements, postures, interactions and behaviour at a level not previously investigated in wild *L. agilis*. Outlined in this discussion are four main points of interest.

- Timing of activity
- Dorsal pattern Variation
- Behaviour
- Areas for Further Study

The Timing of the Activity Recorded

'The duration of the period of seasonal activity substantially varies among populations of *L. agilis*

... which seems to be primarily a consequence of geographical variation in environmental temperatures (Adolph & Porter, 1993; in Gvozdik, 2000). The timing of the mating behaviour observed this season occurred at the same time of year as previous site records for this behaviour.

During the study period the weather was extremely humid. All aspects of the observed activity were recorded between 10:00 and 19:00 hrs; due to time constraints it was not possible to observe the lizards at other times. Most of the mating activity observed was seen at 11:00, 12:00 and 15:00 hrs, even with the same pairs of lizards, over a couple of days. Generally speaking, each lizard was seen in the same area of the site at roughly the same time each day. To observe as many individuals and mating pairs as possible, areas of the site were visited at different times of the day. This provided time variation and increased the opportunity to see more individuals.

The mating display for male 52 and female 53 was observed and their full sequence is included in the field observations. Their mating display combined with basking time occurred over a period of approximately 2 hours. During this time numerous other lizards were observed in the area.

Dorsal Pattern Variation

As noted previously, the dorsal pattern of the Sand Lizard is unique to each individual. It was observed that in both sexes the colour intensity, markings, spots and the dorsal stripes vary significantly between individuals, aiding recognition.

With male lizards it was evident that not only the markings and spots on their back differ significantly but also the shade, brightness and extent of colouration on their flanks. The dorsal stripes vary in colour (from cream to brown), intensity, continuity and width. The intensity of the male flank colouration increases after emergence from hibernation. This distinctive colouration is visible before the first skin moult. The colouration continues to increase with time and male condition until the males have mated, after which it gradually starts to fade.

Olsson (1993) states that green colouration in males is allometrically related to body size, which suggests that the larger the males the more vibrant the colour. Beebee & Griffiths (2000) concurred with this and further stated that 'the largest males are the greenest', this study found no evidence to support this claim. It appeared that the males frequently observed basking and feeding were notably greener than males which did not display this behaviour. It has been suggested (D. Bird & D. Hurst, pers. comm.) that really bright males appear to be out basking where they can be seen and hence approached by females, whereas the less bright males need to look for females with which to mate. Olsson et. al. (1995) state that a male's mating success depends primarily on his ability to encounter receptive females and achieve mating in competition with other males. The female dorsal pattern is also subject to natural variation. The female back pattern varies between the spots and marking on the back and the shade of brown on the flanks.

There is no evidence to suggest that the male lizard selectively chooses females based solely on their lightness or darkness of their back pattern. Olsson (1993) and Olsson & Madsen (1995), claim that males prefer the larger more fecund females where a choice is available. From the monitoring at this site, our observations indicate that the younger the female the lighter brown the back pattern, and the older the female the darker the back pattern. However, this can not be confirmed as the sample size was too limited. It is expected that this observation is highly site specific and could be partly be explained by inbreeding of the populations.

Behaviour

From the observations recorded it can be concluded that the mating behaviour in this population of *L. agilis* can be divided into the following categories of activity:

- * Agitation of the female
- * 'Circling'
- * Biting
- * Copulation
- * Guarding
- * Basking



Plate 14.

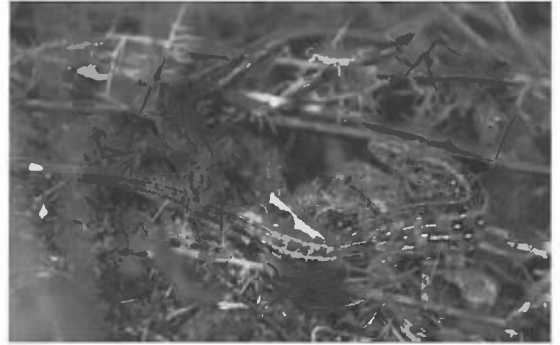


Plate 15.



Plate 16.



Plate 17.



Plate 18.

Agitation of the female

This is the first display in the mating sequence. When a male Sand Lizard approaches a female she appears very agitated. This agitation is displayed by the female shaking vigorously one of her front feet whilst flicking her tail. Eye contact is made and kept with the male throughout (Plate 14; part of sequence 1). This contradicts Beebee & Griffiths (2000), in which it is suggested that the female shakes her front foot to discourage the males.

'Circling'

When the female and male have accepted each other as a mate, and the female has performed her agitation display, the lizards start to circle each other simultaneously (Plate 15). Whilst circling, it appears the lizards gradually move closer together and the female then starts to flatten herself out. Circling was observed in all mating pairs of Sand Lizards during the course of this study.

Biting

The male, after circling the female clamps her tail in his mouth, then gradually in stages moves further up her tail, clamps her upper tail, then above her back legs and then her stomach area. This display occurs very quickly, although the male may hold the female in a clamped position for up to 30 seconds at a time. The lizards may start to circle each other again after completing the biting sequence. This can happen several times before the female and male are ready to mate (Plate 16).

Copulation

The male and female in sequence 3 were photographed during copulation (Plate 11). It appears that when the Sand Lizards decide to mate, they prefer a slightly vegetated area with some cover. No copulating lizards were observed out in the open. It should be noted that there were always 'single' males nearby a mating pair. The 'single' male always approached the mating pair just after copulation and on every occasion was chased off by the newly mated male.

Guarding

At the start of this study the term guarding was used to describe how the male appears to protect/watch over the female after copulation. A year on, different types of 'guarding' behaviour have been demonstrated by males towards females. The subtle differences in behaviour differed between pairs of lizards that were known to have mated and pairs which had not yet mated. Thus, prior to copulation the male and female lizards display pair bonding behaviour and after copulation true 'guarding' behaviour is exhibited (Plate 17). In this article all reference to the term 'guarding' refers to post copulation guarding. Guarding behaviour was observed in all mated pairs of lizards. The amount of time the female was guarded after mating varied between an hour and 5 days.

There is published literature detailing mate guarding post-copulation, both in captive and wild populations. Olsson (1992) commented that 'After mating the male stayed near the female, generally resting his chin and forelimb on top of her. This behaviour is commonly observed in natural conditions'.

Olsson et al. (1995) also comment that 'larger males guarded females longer and were more likely to mate guard a female of a similar age' the observations noted during this season of monitoring found no conclusive evidence to support this statement. However, Olsson (1992), clearly states that mating motivates a male to defend the newly mated female'. This behaviour was frequently observed in several different pairs of mated lizards whereby the guarded female was approached by a 'new male' only to be aggressively chased off by the recently mated male.

One other guarding position that the mated pairs adopted is illustrated in Plate 18.

Basking

After post-copulation guarding, the male and female basked in the area close to where they mated and within close proximity to each other. The female was very flattened and especially well camouflaged.

Areas for future study

This study of one population of Sand Lizards has recorded and briefly discussed three main areas of interest: the timing of activity, dorsal back pattern variation, and mating behaviour. In addition, the results have highlighted some areas requiring further clarification. There is a particular need to evaluate and review the current recommended survey techniques for this species and it is encouraged that the success of recent habitat management on the site is evaluated. Additional proposals for further research ideas are outlined below.

Timing of activity

- Investigation of the emergence of Sand Lizards from hibernation.
- Evaluation of the importance of early emergence from hibernation with respect to creating territories.

Dorsal Back Pattern Variation

- Clarification of the rate of development of greenness in the flanks of the males after emergence from hibernation (currently in progress).

- Determination of the importance of male greenness in mate ranking order.
- Establishment and development of a dorsal back pattern database to enable accurate identification of individuals and to monitor movement and distribution around the site (currently in progress).
- Clarify and further investigate the increasing darkness in colour of females with age.

Behaviour

- Comparison of the mating behaviour of this wild population to that of captive populations.
- Comparison of the behaviour observed with that of published literature.
- Analysis of the decrease in male tolerance level after emergence from hibernation to their tolerance level prior to mating.
- Quantitative analysis of the competition for withholding territories.
- Investigation to determine the extent of male dominance.
- Investigation into the importance in early establishment of territory and mating success.
- Investigation of the displacement of males from territories.
- Investigation of pair bonding behaviour.
- Clarification of the term 'guarding'.

Surveying Techniques

- Critically evaluate the current techniques for surveying this species.
- Accurately establish the male:female ratio at this site.

Habitat management and Population Size

- Investigation into what constitutes a good basking spot.
- Analysis of habitat within which mating occurs.
- Review and evaluation of recent site management.
- Determination of the actual population size and structure based on knowledge of current under recording.
- Review of the 'typical' lizard habitat.
- Impact of amenity use of the reserve on the lizard populations.

Studying this population of Sand Lizards uncovered some new aspects of behaviour not previously documented. To quote Nijam (1996) 'more research into small isolated populations, fragmentation and isolation is needed'. This will at

least help maintain and preserve the current stability of *L. agilis* populations in this area and provide valuable data for optimal habitat management.

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The use of screw pines (*Pandanus* spp.) by amphibians and reptiles in Madagascar

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ABSTRACT. — The importance of plant-held water bodies (phytotelmata) to amphibians and reptiles has been recognised in many tropical environments. However, water-holding plants from Madagascar have not been investigated in this regard. I surveyed screw pine (*Pandanus*) plants at two localities in southeastern Madagascar to document usage of these micro-aquatic habitats by amphibians and reptiles. Twenty species (nine frogs, six geckoes, four snakes, and one skink) were found in these plants (32% of the total estimated herpetofauna of the area). At least five species are obligate *Pandanus*-dwellers, while others facultatively used the water-filled leaf axils of these plants. A literature review indicates that at least twenty-one additional species in Madagascar are commonly or exclusively found in *Pandanus* plants. This information demonstrates the importance of these unique microhabitats to Madagascar's poorly known and highly endemic herpetofauna.

BROMELIADS in the neotropics provide a unique aquatic microhabitat for numerous species of amphibians and reptiles (e.g., Dunn 1937). Some species are specialised bromeliad breeders and are completely dependent on these aquatic environments to complete their lifecycle (Lannoo et al., 1987). Plants from the paleotropics in the genus *Pandanus* (Pandanaeae, 'screw pines') are analogous to bromeliads in many respects. Like bromeliads, many screw pines hold rainwater in their leaf axils (i.e., they are phytotelms) and these micro-aquatic environments are used by a wide assortment of animals, including some reptiles and amphibians (Fish, 1983).

Screw pines are widespread in the paleotropics (approximately 600 *Pandanus* species total, 85 in Madagascar; Schatz 2001) and can be found in many environments. Those *Pandanus* that retain rainwater in their leaf axils can provide an important habitat for reptiles and, especially, amphibians. While Wassersug et al. (1981) stated that tree holes and tree buttresses were the primary phytotelm habitats in tropical Asian forests, several species of anurans are known to breed in water-filled *Pandanus* leaf axils (e.g., *Pelophryne brevipes*, *Philautus lissobranchius*, Alcalá & Brown 1982; *Platymantis vitiensis*, Gibbons & Guinea 1983).

In Madagascar, *Pandanus* plants are utilised by amphibians and reptiles for a variety of activities such as breeding, resting and feeding. Some specialised species are obligate *Pandanus*-dwellers and rely exclusively on these plants throughout their life cycle. However, despite the importance of these microhabitats, there has been no attempt to summarise the available information on the herpetofauna of *Pandanus*. My objective here is to summarise and describe the herpetofauna of *Pandanus* from two localities in southeastern Madagascar, and briefly discuss what is known from the rest of the island from data available in the literature.

MATERIALS AND METHODS

I surveyed six fragments of coastal rainforest at two sites in the Fort-Dauphin (Tolagnaro) region of southeastern Madagascar (Mandena 24°57'S; 47°02'E; Sainte Luce 24°46'S; 47°10'E) for amphibians and reptiles. These surveys were conducted as part of a detailed study of the population ecology of *Pandanus*-dwelling frogs in this area (the details of which will be published elsewhere). *Pandanus* plants were sampled visually by inspecting all leaf axils for the presence of amphibians or reptiles. *Pandanus* that had their crowns more than 2 m but less than 4 m

above the forest floor were sampled using a step ladder 1.5 m high. *Pandanus* greater than 4 m in height were sampled by ascending adjacent trees using tree climbing equipment (Laman, 1995). *Pandanus* sampling occurred during the day and at night with the aid of a headlamp. Combined, over 1700 individual *Pandanus* plants of all sizes were sampled. Each plant was searched from one to nine times over the study period for a total of over 8400 observations. Other habitats in this area (e.g., leaf litter, woody debris, sand-scrub, streams, ponds) were also formally surveyed for amphibians and reptiles during this and previous survey efforts using transects, pitfall traps and opportunistic searching (Ramanamanjato, 2000).

Presence-absence data were compiled from all *Pandanus* observations from Mandena and Sainte Luce (1999 - 2002). Frequency data were obtained from permanent plots at Sainte Luce (2000 - 2002). Facultative and obligate *Pandanus*-dwelling species were differentiated based on survey results from *Pandanus* and non-*Pandanus* habitats. Species found only in *Pandanus* were categorised as obligate, those also found elsewhere were categorised as facultative. Surveys were conducted in 1999 (31st May to 21st June - dry season), 2000 (3rd February to 28th March - wet season) 2001 (14th January to 26th February) and 2002 (24th January to 3rd March). See Ramanamanjato (2000) for more information on the study area.

Reference specimens of all amphibians and reptiles found in *Pandanus* were deposited at the University of Michigan Museum of Zoology and the Departement de Biologie Animale at the Université d'Antananarivo, Madagascar. Other records of amphibians and reptiles in *Pandanus* from Madagascar were collected from the literature and from the observations of other researchers.



Figure 1 (above). Adult *Mantidactylus bicalcaratus* on *Pandanus* leaf, Sainte Luce, Madagascar. © Richard Lehtinen.

Figure 2 (below). Adult female *Phelsuma quadriocellata* immediately after depositing two eggs in a *Pandanus* leaf axil, Sainte Luce, Madagascar. Colour returned to normal within 30 s. © Richard Lehtinen.

RESULTS

Twenty species of amphibians and reptiles were detected in *Pandanus* at Sainte Luce and Mandena (nine frogs, six geckoes, four snakes, and one skink; Table 1). Five of these species were deemed obligate *Pandanus*-dwellers, including three frogs in the genus *Mantidactylus* that complete their entire life cycle in *Pandanus* plants (Fig. 1). The remaining *Pandanus*-obligate species are two

Species	Reproduction in <i>Pandanus</i>	<i>Pandanus</i> Use	Life Stage	Season	Height (m)	Frequency (%)
<i>Boophis madagascariensis</i>	N	Facultative	Adults	Wet season	near ground	< 1
<i>Mantidactylus bicalcaratus</i>	Y	Obligate	All	Year round	7 m	48.1
<i>Mantidactylus boulengeri</i>	N	Facultative	Adults	Year round	near ground	< 1
<i>Mantidactylus depressiceps</i>	N	Facultative	Juveniles, Adults	Dry season	4 m	1.3
<i>Mantidactylus cf. pulcher</i>	Y	Obligate	All	Year round	5 m	1.7
<i>Mantidactylus punctatus</i>	Y	Obligate	All	Year round	11 m	14.4
<i>Mantidactylus cf. wittei</i>	N	Facultative	Adults	Year round	near ground	< 1
<i>Plethodontohyla notosticta</i>	N	Facultative	Adults	Year round	near ground	< 1
<i>Heterixalus boettgeri</i>	N	Facultative	Adults	Dry season	near ground	< 1
<i>Boa manditra*</i>	N	Facultative	Adults	Year round	3 m	< 1
<i>Ithyocyphus oursi</i>	unknown	Facultative	Adults	Year round	5 m	< 1
<i>Liopholidophis cf. stumpffi</i>	N	Facultative	Adults	Wet Season	near ground	< 1
<i>Madagascarophis colubrinus</i>	N	Facultative	Adults	Year round	near ground	< 1
<i>Ebenavia inunguis</i>	unknown	Facultative	Juveniles, Adults	Wet Season	near ground	2.5
<i>Geckolepis maculata</i>	Y	Facultative?	Adults	Year round	7 m	< 1
<i>Hemidactylus mercatorius</i>	N	Facultative	Adults	Dry Season	unknown	< 1
<i>Phelsuma antanosy</i>	Y	Obligate	All	Year round	2 m	NA
<i>Phelsuma quadriocellata</i>	Y	Obligate	All	Year round	3 m	10.9
<i>Phelsuma lineata</i>	unknown	Facultative	All	Year round	3 m	< 1
<i>Amphiglossus punctatus</i>	unknown	Facultative?	Juveniles, Adults	Year round	5 m	< 1

Table 1. Data on amphibians and reptiles found in *Pandanus* at Sainte Luce and Mandena, southeastern Madagascar, 1999-2002. Height (m) is the maximum height at which each species has been found in *Pandanus*. Frequency is the proportion of *Pandanus* occupied by each species in 2001 (unavailable for *P. antanosy* - not present in permanent plots).

* = *Sanzinia madagascariensis*.

geckos in the genus *Phelsuma* (Fig. 2). The remaining species from Sainte Luce and Mandena appear to inhabit *Pandanus* plants facultatively.

Amphibians and reptiles were found in three different species of screw pines (*Pandanus platyphyllus* and two undescribed species). *Mantidactylus cf. wittei* was found only in *P. platyphyllus* (usually at the forest edge or in deforested areas). *Boophis madagascariensis* was found on two occasions on an undescribed stream species of *Pandanus*. *Phelsuma lineata* and *P. quadriocellata* were also found several times on this stream species. All other records of amphibians and reptiles in this study were from an

undescribed species of phytotelmic, terrestrial *Pandanus* (M. Callmander, pers. comm.).

Several species occurred in a relatively high proportion of *Pandanus* in the permanent plots. *Mantidactylus bicalcaratus* (48.1%), *M. punctatus* (14.4%) and *Phelsuma quadriocellata* (10.9%) were the most common. All other species were found in three percent or less of the *Pandanus* in the permanent plots (Table 1). Most species found in *Pandanus* were found only in those plants on or near the forest floor. Several species, however, were found in *Pandanus* as high as 11 m in the canopy. Some species were found in *Pandanus* only in the dry season or wet season, but most were found in *Pandanus* year round (Table 1).

A literature review revealed 21 additional species that are frequently or exclusively found in association with *Pandanus* in Madagascar (Table 2). These include 16 frogs, four geckos and a snake. Several of these also appear to be obligate *Pandanus*-dwellers.

Family	Species	Reproduction in <i>Pandanus</i>	<i>Pandanus</i> Use	Data Source	
Colubridae	<i>Lycodryas</i> (= <i>Stenophis</i>) <i>gaimardi</i>	unknown	Facultative	R. Nussbaum, pers. comm.	
Gekkonidae	<i>Paroedura bastardi</i>	N	Facultative	R. Nussbaum, pers. comm.	
	<i>Phelsuma dubia</i>	unknown	unknown	Glaw & Vences, 1994	
	<i>Phelsuma guttata</i>	unknown	unknown	Raxworthy, 1988	
Hyperoliidae	<i>Heterixalus alboguttatus</i>	N	Facultative	Blommers-Schlösser, 1982	
	<i>Heterixalus tricolor</i>	N	Facultative	Razarihelisoa, 1974	
Mantellidae	<i>Boophis apisthodon</i>	N	Facultative	C. Raxworthy, pers. comm.	
	<i>Boophis tephraeomystax</i>	N	Facultative	C. Raxworthy, pers. comm.	
	<i>Mantella laevigata</i>	N	Facultative	H. Heying, pers. comm.	
	<i>Mantidactylus albolineatus</i>	Y	Obligate	Blommers-Schlösser, 1979	
	<i>Mantidactylus flavobrunneus</i>	Y	Obligate	Blommers-Schlösser, 1979	
	<i>Mantidactylus liber</i>	N	Facultative	Blommers-Schlösser, 1979	
	<i>Mantidactylus peraccae</i>	N	Facultative	Blommers-Schlösser, 1979	
	<i>Mantidactylus tornieri</i>	N	Facultative	Blommers-Schlösser, 1979	
	<i>Mantidactylus webbi</i>	N	Facultative	H. Heying, pers. comm.	
	Microhylidae	<i>Anodonthyla boulengeri</i>	N	Facultative	H. Heying, pers. comm.
		<i>Anodonthyla rouxae</i>	Y	Obligate?	Glaw & Vences, 1994
		<i>Platypelis barbouri</i>	unknown	unknown	Blommers-Schlösser, 1975
<i>Platypelis grandis</i>		unknown	Facultative	R. Nussbaum, pers. comm.	
<i>Platypelis tuberifera</i>		Y	Obligate	Blommers-Schlösser, 1975	
<i>Plethodontohyla inguinalis</i>		N	Facultative	Andreone & Randriamahazo, 1997	

DISCUSSION

A relatively large proportion of the herpetofauna in the study area use *Pandanus* plants for a variety of activities (32% - 20 of an estimated 62 forest species; Ramanamanjato, 2000). Some species are obligate *Pandanus*-dwellers, such as the mantellid frogs *Mantidactylus bicalcaratus*, *M. cf. pulcher* and *M. punctatus*. These frogs lay egg masses on the leaves of phytotelmic *Pandanus* (not in tree holes as reported in Lannoo et al., 1987). After 3-12 d the jelly dissolves and the hatchlings wriggle down the leaf into the water-filled leaf axil to continue their larval development (R. Lehtinen, unpublished data). Unlike many phytotelmic anurans, however, these species also remain exclusively on *Pandanus* plants as juveniles and adults. Twenty or more individuals of these species can be found in large *Pandanus* and all three species can be found in a single plant. Other frogs are also frequently found in *Pandanus*, but are not dependent on these plants to complete their life cycle (Table 1).

Table 2. Other records of amphibians and reptiles from *Pandanus* in Madagascar.

It is not particularly surprising that screw pines are important habitats for frogs in Madagascar. Frogs have been reported from *Pandanus* in the Philippines (Alcala & Brown, 1982; Das & Charles, 1994), New Guinea (Allsion & Kraus, 2000), Fiji (Gibbons & Guinea, 1983), and other localities in the paleotropics. Reptiles, however, have less frequently been reported from *Pandanus*. My observations indicate that screw pines are also important microhabitats for some snakes, skinks, and geckos.

Several geckos use *Pandanus* plants for reproductive activities. The recently discovered day gecko *Phelsuma antanosy* is almost invariably associated with *Pandanus* plants and lays its eggs only in *Pandanus* leaf axils (Raxworthy & Nussbaum, 1993a; J.-B. Ramanamanjato, pers. comm.). This regional endemic is only known from four unprotected sites, one of which has

recently been destroyed (Raxworthy & Nussbaum, 2000). *Phelsuma quadriocellata*, also lays eggs in *Pandanus* leaf axils (Fig. 2). In this species, a single male and female, and sometimes one or more juveniles or egg clutches, are often found on suitable *Pandanus*. Individuals forage widely and are often found on adjacent vegetation (R. Lehtinen, unpublished data). *Phelsuma lineata* was also frequently found on *Pandanus* plants and may reproduce there, but this species also lays its eggs in other habitats. A fish-scale gecko, *Geckolepis maculata*, is frequently found in large *Pandanus* plants and eggs of this species have been found there (R. Nussbaum, pers. comm.).

Other reptiles are more facultative inhabitants of screw pines. The nocturnal snakes *Boa manditra* and *Madagascarophis colubrinus* are often found resting in *Pandanus* during the day, usually in the leaf axils or, less commonly, coiled around the trunk at the base of the plant. *Ithycyphus oursi*, by contrast, is diurnal and frequents *Pandanus* plants to hunt for frogs. At Sainte Luce, I witnessed *I. oursi* hunt and consume adult *Mantidactylus bicalcaratus*, *M. depressiceps* and *M. punctatus*. Geckos may also frequent *Pandanus* plants for feeding, as insects congregate to breed in the water-filled leaf axils. The recently described skink *Amphiglossus punctatus* is an interesting case, as it is found both on the forest floor and in aerial *Pandanus* (up to 5 m high) at Sainte Luce. All other known members of this genus are primarily fossorial or semi-aquatic (Raxworthy & Nussbaum 1993b).

Obligate *Pandanus*-dwelling species are, predictably, found on *Pandanus* year round. Of those species that use *Pandanus* facultatively, most are also found in *Pandanus* year round. However, several species are only found in *Pandanus* during the dry season (*H. boettgeri*, *M. depressiceps*). During the rainy season these species breed in lentic water bodies in (*M. depressiceps*) and out (*H. boettgeri*) of forest (R. Lehtinen, unpublished data). Dry season *Pandanus* use by these species is likely the result of relatively cool, moist conditions in *Pandanus* leaf axils. This suggests these species may use *Pandanus* primarily for thermoregulatory and

water balance functions in the dry season.

Not surprisingly, most species that were deemed obligate *Pandanus*-dwellers are found in a relatively high proportion of the plants sampled and most facultative *Pandanus*-dwellers were found in a relatively low proportion. However, some species, such as *Mantidactylus cf. pulcher* and *Ebenavia inunguis* do not fit this pattern well. (Table 1). This may be due to sampling error or to an incomplete knowledge of the natural history of these species. For example, future research may discover that *Ebenavia inunguis* lays eggs in *Pandanus*. Other phytotelmic plants (particularly *Ravenala madagascariensis* (Strelitziaceae) and *Typhonodorum lindleyanum* (Araceae)) are also sometimes used by amphibians and reptiles in Madagascar but are rare in this particular area.

These data indicate that *Pandanus* are important microhabitats for many species of amphibians and reptiles in Madagascar. This simple fact has not previously been appreciated and these key environments clearly are deserving of further study. In addition to my field data, a literature review indicates that numerous other amphibians and reptiles (particularly frogs and geckos; Table 2) in Madagascar also use *Pandanus*. This list is undoubtedly incomplete and future research will likely reveal many other species that use these micro-aquatic habitats. However, these plants have become rare in some areas. The leaves of *Pandanus* plants are used by villagers to weave baskets, hats, and other products and harvesting these leaves is often done by cutting down the entire plant. Also, *Pandanus* are slow growing and appear to germinate poorly in degraded conditions (R. Lehtinen, unpublished data). While forests in general are in dire need of protection in Madagascar, *Pandanus* plants may merit particular attention as they provide a key resource to many species.

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Herpetofauna of Hog Island, Grenada

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HOG Island is an uninhabited islet (28 ha) with a maximum elevation of 50 m located about 115 m off the southern coast of Grenada (Fig. 1). The mean annual temperature at sea level is 30°C (CCA/IRF, 1991) and the mean annual rainfall for the ten-year period 1992-2001 at Mount Hartman Bay on the adjacent main island was 98.2 ± 13.0 cm. Most of the island is covered by dry forest, which blends into coastal mangrove stands on the leeward shore. A few open fields serve as testament to past use for grazing livestock. A few small, sandy beaches are scattered around the coast. Fishermen and tourists occasionally visit the island.

Neither of the island lists by MacLean et al. (1977) or Corke (1992) included records for Hog Island. In June 2002, we spent 37.5 person hours in two visits (one by day and the other at night) on the island in order to survey the herpetofauna. Voucher specimens are deposited in the Bobby Witcher Memorial Collection (BWMC) at Avila University (06942-7, 07033). All means are presented ± 1 standard error; for all tests, $\alpha = 0.05$.

We found three species of lizards and one frog. *Anolis aeneus* (Polychrotidae) is a xerophilic to mesophilic species of moderate size (Schwartz & Henderson, 1991). Essentially ubiquitous on Grenada, this lizard was common in all but the most open habitats on Hog Island (Plate 1).

Hemidactylus mabouia (Gekkonidae) often is edificarian, but may be found under planks, loose rocks in open areas, and piles of coastal wrack (Schwartz & Henderson, 1991). We found one individual and calcareous eggshells, probably attributable to the species, under rocks in the forest. *Gymnophthalmus underwoodi* (Gymnophthalmidae) is a small, mesophilic parthenogene found in xeric woodlands, leaf litter, and rocks (Schwartz & Henderson, 1991). Although only recently reported from Grenada (Hardy, 1982; Vanzolini, 1990), the species is common in a variety of habitats. Hog Island individuals were found in leaf litter throughout the dry forest. *Eleutherodactylus johnstonei* (Leptodactylidae) is a moderately sized member of the genus that generally occurs in mesic forests (Schwartz & Henderson, 1991). The species is ubiquitous on Grenada, and one is out of earshot of calling males only in the most intensely developed urban center of St. George's. On Hog Island, individuals were heard throughout the forested areas and along the edges of open fields and sandy beaches.

Somewhat surprising was the apparent absence of three species that are widely distributed on Grenada, all of which are typically easy to find when present. *Anolis richardii* is abundant in all Grenadian habitats, where it typically is syntopic with *A. aeneus* (Schoener & Gorman, 1968; pers.

observ.). *Ameiva ameiva* (Teiidae) has a disjunct distribution on Grenada and is common at few sites. The latter situation may be attributed largely to predation by the mongoose (*Herpestes javanicus*) and feral cats (*Felis domesticus*), neither of which we observed on Hog Island. Other species of West Indian *Ameiva* often are abundant on small satellite islands (e.g., Censky & Powell, 2001). Considering the presence of suitable habitat and the proximity of Hog Island to Grenada, the absence of *A. ameiva* is difficult to explain.

Corallus grenadensis (Boidae) occupies all forested habitats on Grenada to elevations of at least 525 m in which canopy (or crown) cover is continuous (Henderson, 2002). Treeboas would seem eminently capable of reaching Hog Island (Henderson & Sajdak, in press), where apparently suitable habitat occurs. Hog Island, however, is smaller than the smallest island known to harbour *C. grenadensis* (70 ha). Also, because of the absence of the mongoose and feral cats, we had hoped to find ground-dwelling snakes that have been extirpated (e.g., *Clelia clelia*) or are, at best, exceedingly rare (e.g., *Mastigodryas bruesi*) on Grenada proper. In similar fashion, *Alsophis antiquae* has been extirpated from Antigua proper (Henderson et al., 1996), but a population of approximately 100 individuals remains on a small satellite (Smith et al., 2002).

When we compared Hog Island to other islands of comparable size (20-35 ha), Hog Island supported more species (Table 1). When we considered distance to the nearest large island (> 3200 ha), a relationship between distance and the number of species appeared to be evident. Hog Island is closest to a major island and supports the most species, whereas Petit Nevis and Kick 'em Jenny are farther from major islands and have fewer species. However,

Table 1. Number of species recorded from Hog Island and islands of comparable size in the Grenadines (Corke, 1992). 'Main' islands have areas > 3,200 ha.

Island	Area (ha)	Distance to nearest main island (km)	Number of species
Hog Island	28	0.11	4
Petit Nevis	20	8.62	1
Frigate Island	30	2.77	2
Palm Island	35	3.66	1
Kick 'em Jenny	20	6.95	2
Petit St. Vincent	35	4.71	1



Figure 1. Grenada, showing position of Hog island.

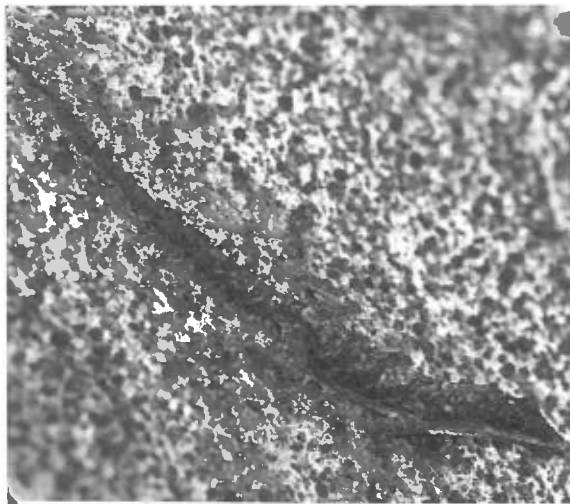
the relationship was not significant (Kendall Rank correlation, $Z = -1.54$, $P = 0.12$). Burns et al. (1992) and Yeska et al. (2000), working on small Hispaniolan satellite islands, reported similar trends, but their data were equally inconclusive.

Hog Island provided an opportunity to observe *Anolis aeneus* in the absence of *A. richardii* to determine if the absence of a potentially competing congener would affect habitat utilization. We collected data on perch height and perch diameter for two size classes of anoles (Table 2). Because perch characters of lizards on large palms appeared to differ from those that

Size Class	Non-palm Height (cm)	Non-palm Diametre (mm)	Palm Height (cm)	Palm Diametre (mm)	All Height (cm)	All Diametre (mm)
Large Males	147.1 ± 13.5 25–30 n = 42	195.2 ± 33.0 10–1000 n = 42	363.3 ± 111.6 30–1000 n = 9	258.9 ± 26.5 180–450 n = 9	185.3 ± 24.5 25–1000 n = 51	206.7 ± 27.6 10–1000 n = 51
Females / Small Males	114.0 ± 10.5 0–300 n = 56	192.1 ± 18.7 15–600 n = 56	297.3 ± 72.7 30–750 n = 11	264.4 ± 13.9 100–350 n = 11	144.1 ± 16.7 0–750 n = 67	201.9 ± 15.7 15–600 n = 67
All	128.2 ± 8.5 0–430 n = 98	193.2 ± 17.9 10–1000 n = 98	327.0 ± 62.8 30–1000 n = 20	252.0 ± 13.8 100–450 n = 20	161.9 ± 14.3 0–1000 n = 118	204.1 ± 15.0 10–1000 n = 118

Table 2. Mean perch heights and perch diametres, ranges, and sample sizes for two size classes of *Anolis aeneus* on Hog Island.

perched on other types of vegetation, we examined data separately for anoles on palms. In fact, both perch heights and diametres of anoles on palms were significantly larger than those on other types of perches (Mann-Whitney U, $Z = -3.21$, $P = 0.001$; $Z = -3.07$, $P = 0.002$; respectively). However, neither perch heights nor diametres of large males differed significantly from those of smaller males and adult females (heights for palms, non-palms, all perches: $Z = -0.42$, $P = 0.68$; $Z = -1.81$, $P = 0.07$; $Z = -1.77$, $P = 0.08$; diametres for palms, non-palms, all perches: $Z = -0.04$, $P = 0.97$; $Z = -1.14$, $P = 0.26$; $Z = -1.01$, $P = 0.31$).



In evaluating the ecomorphology of Lesser Antillean anoles, Losos & de Queiroz (1997) considered *A. aeneus* and *A. gingivinus* (of the Anguilla Bank) to be generalists, although Beuttell & Losos (1999) reported that *A. gingivinus* was most similar to trunk-ground ecomorphs. Mean perch heights of *A. gingivinus* on St. Maarten (Losos & de Queiroz, 1997), where the species coexists with *A. pogus*, and of *A. aeneus* from Grenada (Losos & de Queiroz, 1997) are comparable to those presented here (Contingency test, *A. gingivinus*, $\chi^2 = 0.20$, d.f. = 1, $P = 0.68$; *A. aeneus*, $\chi^2 = 0.03$, d.f. = 1, $P = 0.85$). Mean perch diametre of Hog Island *A. aeneus* differed significantly from that of *A. gingivinus* from St. Maarten ($\chi^2 = 11.8$, d.f. = 1, $P = 0.0006$), but not of *A. aeneus* from Grenada ($\chi^2 = 0.80$, d.f. = 1, $P = 0.37$). Neither perch height nor diametre of Hog Island *A. aeneus* varied from those reported by Eaton et al. (2002) for *A. gingivinus* in the one sampled Anguillian habitat characterised by large trees that presumably would supply an abundance of large height and diametre perches (height, $\chi^2 = 0.10$, d.f. = 1, $P = 0.78$, diametre, $\chi^2 = 0.70$, d.f. = 1, $P = 0.41$). Eaton et al. (2002) had sampled six other habitats and had attributed some of the differences in perch characteristics to the varying availability of perches in different habitats. Our own unpublished data for Grenada also suggest that perch characteristics vary considerably according to habitat. Nevertheless, these

Plate 1. *Anolis aeneus*. Photograph by R. Powell.

ecological data generally support the contention that *A. aeneus* is an ecological generalist (Losos & de Queiroz, 1997; Beuttell & Losos, 1999).

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Oxybelis aeneus (Wagler): an addition to the herpetofauna of Turneffe Atoll, Belize

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TURNEFFE Atoll is the largest of three atolls in Belize, and one of only four atolls in the Western Hemisphere (Stoddart, 1962). Turneffe Atoll is located approximately 35 km from the mainland and consists of a chain of islands partially enclosing a shallow lagoon (Figure 1). The topography, climate, and vegetation of the atoll are fully described by Stoddart (1962, 1963). Recent biodiversity surveys of the Turneffe Atoll documented a herpetofauna consisting of one species of anuran, one species of crocodylian, four species of turtles, five species of lizards, and two species of snakes (Platt et al., 1999a, 1999b; Platt & Thorbjarnarson, 2000). However, Platt et al. (1999b) emphasize that the atoll herpetofauna remains incompletely known and further collecting will likely yield additional records, particularly of cryptic and less common forms such as snakes. We here report the addition of the Neotropical vine snake [*Oxybelis aeneus* (Wagler)] to the herpetofauna of Turneffe Atoll.

Three *O. aeneus* were encountered on Blackbird Cay, Turneffe Atoll during June and July 2002. On 3rd July 2002 we collected an adult *O. aeneus* (total length = 1438 mm; snout-vent length = 860 mm) among ground debris in second-growth littoral forest, approximately 0.25 km north of Blackbird Cay Dive Resort (17° 18.92' N; 87° 47.98' W). This specimen was deposited in the vertebrate collection of the Campbell Museum, Clemson University, Clemson, South Carolina, USA (CUSC 2123). The snake was found as it consumed an adult anole (*Anolis* sp.; probably *A.*

sagrei). Other studies indicate lizards, particularly anoles, are important prey for *O. aeneus* (Keiser, 1967; Henderson, 1982; Wilson & Cruz Díaz, 1993; Lee, 1996). Additional sightings of single *O. aeneus* were made on 11 June and 9 July 2002 in dense grass and scrub along a beach ridge approximately 4 km north of Blackbird Cay Dive Resort (17° 22.41' N; 87° 48.78' W). Our data constitute the first report of *O. aeneus* from any offshore island or atoll in Belize (Lee, 1996; Stafford & Meyer, 2000), and confirm the presence of a third species of snake on Turneffe Atoll.

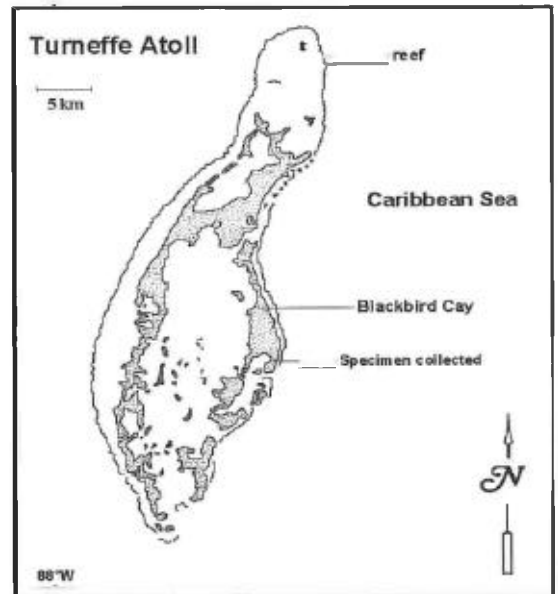


Figure 1.

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NATURAL HISTORY NOTES

Natural History Notes features short articles documenting original observations made of amphibians and reptiles mostly in the field. With few exceptions, an individual 'Note' should concern only one species, and authors are requested to choose a keyword or short phrase which best describes the nature of their observation (e.g. Diet, Reproduction). Format details and other guidelines are available in *Herpetological Bulletin* No. 78, Winter 2001.

TRITURUS MARMORATUS (Marbled newt): POLYMELY. The cases of supernumerary limbs in amphibians are not uncommon (Borkin & Pikulik, 1986; Johnson et al., 2001), but most of the observations have been made in anurans. In the family Salamandridae, natural events of polymely

are reported only rarely. Meyer-Rochow & Asashima (1988) found seven cases of polymely in *Cynops pyrrhogaster* from a sample of 13815 animals examined from Japan. Caetano (1991) cited a case in one *Triturus pygmaeus* among 557 animals from southern Portugal. In *Triturus marmoratus* a case of polymely has been described from Catalonia (Arias et al., 1999). Some cases of regeneration of accessory limbs have been reported also in *Triturus vulgaris* (Griffiths, 1981).

On 3rd May 2002 we found in Carracedelo (Province of León, Spain) a case of polymely in *Triturus marmoratus*. An adult female presented a supernumerary hind limb growing at the left side

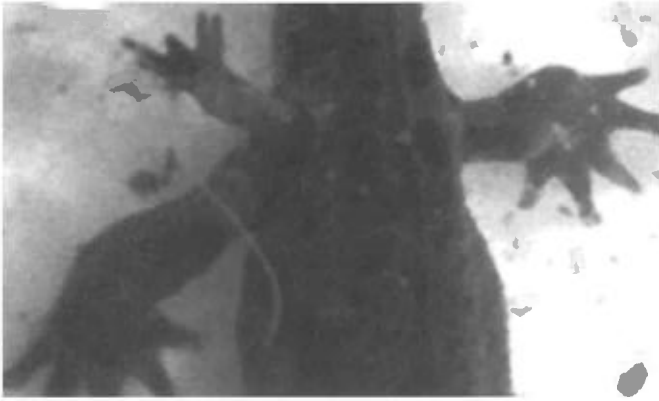


Plate 1.

between the normal limb and the base of the tail (Plate 1). This supernumerary limb was not functional and evidently less developed than the normal limbs. The foot of the limb was subdivided, comprising six well-formed toes.

The animal was otherwise healthy and evidently gravid. It was found in an irrigation ditch with very clean, flowing, half a metre below the surface in deep water with abundant aquatic vegetation. Four males of the same species and several *Triturus boscai* were found at the same site, none of them showing any sign of malformation.

The animal was released again to the water, and thus we have not established the cause(s) of this malformation. The quality of the water makes a chemical explanation improbable. Other possible explanations would be a parasitic (Johnson et al., 2002) or predatory cause (Viertel & Veith, 1992), or alternatively an endogenous cause may be implicated (genetic or metabolic).

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