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THE HERPETOLOGICAL BULLETIN

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

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Seasonal activity, reproductive cycles and growth of the pickerel frog *Lithobates palustris* (LeConte, 1825), from Pennsylvania

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ABSTRACT - Seasonal activity, reproduction and post-metamorphic growth were examined in the pickerel frog *Lithobates palustris* from Pennsylvania using 572 museum specimens collected during 1899-2009 from 66 of 67 counties. Frogs were active from March to November, with a peak in July. Testes were at their maximum dimensions in the fall, and females overwintered with ripened eggs. The greatest frequency of males with enlarged thumbs occurred during March to May, and females were gravid during April to May, indicating early spring breeding, which was typical for populations of the pickerel frog in the middle of its geographic range. Estimated clutch size co-varied positively with female body size and averaged 1,785 eggs. Both sexes reached sexual maturity approximately one year after transformation. Sexual dimorphism in body size was pronounced in this population, with males (mean = 54.9 mm SVL; range = 40.9-66.5) having matured and averaged significantly smaller than females (mean = 67.0 mm SVL; range = 54.1-87.4 mm). Findings from this study corroborate a latitudinal trend in breeding season that followed cool weather and also demonstrated an otherwise inflexible response in other life history traits despite a geographically broad distribution.

HE pickerel frog Lithobates palustris (LeConte, 1825) is an eastern North American ranid found in a wide range of aquatic habitats (Conant & Collins, 1998; Redmer, 2005). Its breeding season is well documented and has been summarised by Redmer (2005). Following a latitudinal cline in breeding season the pickerel frog breeds earliest and over the longest period in the south, and progressively shorter and later in the late spring to early summer in the north of its range (Redmer, 2005). In turn, eggs can hatch between 10-24 days and tadpoles can transform in two to three months (Johnson, 1984; Harding, 1997; Redmer, 2005). Reproductive biology of the pickerel frog, its gonadal cycles and clutch characteristics are less well known (Resetarits & Aldridge, 1988; Trauth et al., 1990). In Pennsylvania little is also known concerning its reproductive characteristics (Hulse et al., 2001). The goal of this study was to clarify aspects of the breeding phenology of the pickerel frog in Pennsylvania and relate our findings to the broader topic of geographic variation in its life history traits.

MATERIALS AND METHODS

We examined 575 pickerel frogs that were collected during 1899-2009 from 66 of the 67 Pennsylvania counties in the holdings of the Carnegie Museum of Natural History in Pittsburgh and the State Museum of Pennsylvania in Harrisburg. Using calipers, the snout-vent length (mm SVL) of all size classes and of tadpoles was measured.

Sexual maturity in males was determined by the presence of enlarged testes and enlarged thumbs. Length and width of the left testis as a percentage of body size was used to measure seasonal differences in testis dimension. Monthly frequencies of enlarged thumbs also served as a measure of seasonal patterns of fertility. Sexually mature females were associated with one of four ovarian stages. In the first stage, oviducts were thin and just beginning to coil, and the ovaries were somewhat opaque. In the second stage, the oviducts were larger and more coiled, and the ovaries contained some pigmented oocytes. In the third stage, oviducts were thick and heavily coiled, and the ovaries were in various stages of clutch development. In the fourth stage, oviducts were thick and heavily coiled, and the ovaries were full of polarized ova with few non-polarized ova, indicating a fully ripened clutch and gravid female (Meshaka, 2001).

Fat body development was scored as absent, intermediate in volume in the body cavity, to extensive development that reached cranially in the body cavity. The latter was used as an estimated monthly incidence of extensive fat relative to all females examined from each month.

A subset of females was examined for clutch characteristics. Ten clutches were removed, patted on a paper towel to remove excess moisture, a subset of ova weighed on an electronic scale, and that mass then extrapolated to estimate clutch size. From each clutch, the diameters of 10 ova were measured using a dissecting scope fitted with an ocular micrometer; the largest ovum was used in comparative relationships with clutch size and female body size.

Tadpole developmental status was scored using Gosner (1960) staging protocol. For practical purposes, tadpoles were assigned to categories of having poorly developed hind legs (less than Gosner stage 37) or well developed hind legs (Gosner stage of at least 37). Metamorphs were distinguished from tadpoles by the presence of forelimbs (Gosner stage 42) and distinguished from juveniles by the presence of a tail. Statistical analysis and graphs were conducted with the use of Microsoft ExcelTM software. Two tailed t-tests were used to compare means between samples and significance was recognised at P < 0.05.

RESULTS

Seasonal Activity

Over a period of 100 years pickerel frogs have been collected during March-November



Figure 1. Seasonal incidence of capture of pickerel frogs *Lithobates palustris* from Pennsylvania. (males n = 121 and females n = 88).



Figure 2. Monthly distribution of testis size of 121 pickerel frogs *Lithobates palustris* from Pennsylvania.

(Fig. 1). An exception to this was a single female individual found in January that was taken from a cave in Indiana County. Commensurate with breeding activities, males outnumbered females in collections during the early part of the year more so than at other times. Peak collections occurred in July, synchronous with the appearance of Metamorphs and perhaps with greater terrestrial activity after breeding. This suggests a need by adults to replenish fat stores before the end of autumn. Metamorphs were apparent from June to August, whereas juveniles were present from March to October. Both life stages were most apparent in August (23/48 and 101/315 individuals respectively).

Seasonal Changes in Testis Size

The monthly distribution of testis length as a percentage of snout-vent length was reduced from March through June and followed by an abrupt increase which peaked soon thereafter (Fig. 2). Seasonal changes in testis width were less apparent but likewise appeared to reach maximum

dimensions by autumn. The seasonal distribution of testis dimensions corroborated spring breeding, as sperm was drained from maximally expanded testis by June and followed by recrudescence thereafter. In this way, enlarged testis toward the end of the year would accompany dormancy so that males would be fertile immediately upon spring emergence.

Male Thumbs

The highest monthly incidences (100%) of enlarged thumbs in males occurred during March to May and again in October. As was the case for the seasonal changes in testis size, enlarged thumbs (a measure of fertility), were highest in frequency at the beginning of dormancy. Enlarged male thumbs lasted through May and were, expectedly, associated with spring breeding. The lowest incidence of enlarged thumbs occurred in June (61.1%) and steadily increased thereafter.

Male Fat and Presence of Food

Extensive fat development was present in males



Figure 3. The annual ovarian cycle of 88 pickerel frogs Lithobates palustris from Pennsylvania.

throughout their active season. However, males emerged with depleted fat stores which, in turn, were at their lowest at the end of breeding in May. Fat development increased monthly, beginning in June until winter dormancy began. At this time all males of the October sample contained extensive fat. Only 25% of males contained food upon emergence in spring. The monthly incidence of males containing food increased rapidly in April (78.9%) while males were breeding. It then continued to increase over the remaining season and peaked in July, sufficient to sequester fat for the winter.

Ovarian Cycle

Having emerged shortly before breeding the majority of females in April were gravid (Fig. 3). The last gravid female of May was collected on 18 May. In June females began the production of clutches as evidenced by a steady decrease in frequencies of stage 1 and 2 females and the steady increase in frequency of stage 3 females during June to September. This trend resulted in the presence of gravid females by August and a full complement of gravid females ready to enter dormancy in preparation for breeding soon after spring emergence.

Clutch Characteristics

Ten females (mean = 74.2 ± 5.01 mm SVL; range = 66.1-79.9 mm) collected during the breeding season produced a mean clutch size of 1,785 eggs (SD = ± 531.4 ; range = 850-2450). A significant and positive relationship existed between clutch size and female SVL (r^2 = 0.7199, P < 0.002) but not between maximum ova size and female SVL (Fig. 4). The relationship between maximum ova diameter and clutch size was positive and significant (r^2 = 0.5116, P < 0.02).

Female Fat and Presence of Food

Eight months of collections had females available for analysis. The frequencies of females with extensive fat development were generally low (< 22.2%) but highest shortly after breeding during June (70.0%) and July (41.7%) and among the 52.9% of females whose clutch development was well underway (stage 3). Only 10.3% of gravid females contained extensive fat. Extensive fat development was also low in stage 1 (25.0%) and stage 2 (11.1%) females. The monthly frequencies of digestive tracts containing food indicated that females were foraging extensively throughout much of the active season. Only in April were frequencies of females having contained food less than 60% of the monthly sample. Between spring emergence and commencement of breeding (after April) food in digestive tracts increased rapidly and then decreased in October as females prepared to enter dormancy. Likewise, food in digestive tracts was present in all four ovarian stages with high frequencies (>80%) found among spent and yolking females while less than one half the frequency (39.7%) was found among gravid females.

Growth and Sexual Maturity

Across Pennsylvania, metamorphs were present

during June to August (Fig. 5), indicating a two to three month larval period after April and May breeding. Body sizes of metamorphs ranged 18.6-31.7 mm SVL (mean = 25.6 ± 3.9 mm; n = 48). The monthly distribution of body sizes suggested that males reached a minimum of 40.9 mm SVL the following spring at 10 months of post-metamorphic age. Mean body size of sexually mature males was 54.9 mm SVL (SD = \pm 5.7 mm; range = 40.9-66.5 mm; n = 121).

The monthly distribution of body sizes (Fig. 5) suggests that although some females could reach maturity of at least 54.1 mm SVL they reached sexual maturity the following summer at approximately 13 months post-metamorphic age. Females appeared to have bred for the first time when they were 22-23 months post-metamorphic age. Mean body size of sexually mature females was 67.0 mm SVL (SD = \pm 8.6 mm; range = 54.1-87 mm; n = 88) (Fig. 5).

Among 88 sexually mature females the mean body size of gravid females ($71.2 \pm 7.6 \text{ mm SVL}$; range = 57.0-86.5 mm; n = 29) was significantly



Figure 4. The relationship between largest ova diameter and body size in mm SVL of 10 female pickerel frogs *Lithobates palustris* from Pennsylvania.



Figure 5. Monthly distribution of body sizes of females (n = 88), juveniles (n = 315), tadpoles with well-developed rear legs (n = 3) and metamorphs (n = 48) of the pickerel frog *Lithobates palustris* from Pennsylvania.

larger (t = -3.383, df = 86, P < 0.001) than that of non-gravid counterparts (65.0 \pm 8.3 mm SVL; range = 54.1-87.4 mm; n = 59). Among all sexually mature adults, mean body size of females was significantly larger (t = -12.274, df = 207, P < 0.001) than that of males.

DISCUSSION

The geographic range of the pickerel frog extends southward from the Canadian Maritime Provinces of New Brunswick and southern Quebec to southern Mississippi (Conant & Collins, 1998), thereby placing Pennsylvania midway across the latitudinal range for the species. This large latitudinal distribution seems to correspond with a cline in the reproductive season of this species, whereby southern populations were typified by December to May breeding, central populations were typified by March to May breeding, and northern populations were typified by May to June breeding (Redmer, 2005). These are broad ranges that are useful within the context of large geographic areas. Within these seasonal ranges can exist shorter seasons but within a broad range. Therefore it is not surprising that within such a large central portion of the pickerel frog's geographic range that breeding seasons may have narrower subsets of the March to May range as in Missouri (Johnson, 1984). For example, in Missouri the breeding season was reported during March to May (Johnson, 1984: Redmer 2005) and that of Wisconsin was April to May (Vogt, 1981; Redmer 2005). The latter season is also true of findings by Hulse et al. (2001), Klemens (1993) for Connecticut and adjacent areas, Great Lakes region (Harding, 2000), and Ithaca, New York (Wright & Wright, 1949). Breeding occurred in April in Indiana (Minton, 2001) and in Pennsylvania Surface (1913) noted egg-laying in May. Our findings are best characterised as that expected for the central portion of the pickerel frog's geographic range having bred during April to May (Redmer, 2005).

The similarity in breeding season between

Pennsylvania and Missouri was reflected in similar gonadal cycles. For example, in Missouri testis mass was lowest in late winter and followed by an increase in mass during April to July (Resetarits & Aldridge, 1988). Similarly, in our study, testis size was smallest in fall and spring and increased in size during May to September.

Two studies, in Missouri (Resetarits & Aldridge, 1988) and our Pennsylvania contribution, show that full complements of eggs were present by the end of summer. Mean clutch size was remarkably stable in the few regions from which such data is available. A mean clutch size of 1,759 eggs was reported for populations in both Missouri (Resetarits & Aldridge, 1988) and adjacent Arkansas (Trauth et al., 1990), similar to the mean values of 1,785 eggs of our study. In all three studies clutch size was positively associated with female body size.

With one difference, the fat cycles of males and females from our study were similar to those from Missouri (Resetarits & Aldridge, 1988). For example, overwintering males initially stored greater amounts of fat than females in Missouri (Resetarits & Aldridge, 1988) and the frequency of males with extensive fat at that time was greater than that of females in Pennsylvania (this study). On the other hand, both sexes entered overwintering with maximum fat stores in Missouri (Resetarits & Aldridge, 1988), whereas in our Pennsylvania study this occurred in males only.

In Missouri, later depletion of fat in males (February) than females (January) was thought to be associated with mobilisation of fat stores by males for breeding activity and to initiate spermiogenesis (Resetarits & Aldridge, 1988). Likewise, fat made in the summer by females in Pennsylvania was possibly converted quickly into clutches for the following season, with less of a requirement for extensive fat storage through the winter than male counterparts. Males, in turn, may possibly have needed more fat through the winter to be used in the spring for calling activity.

Appearance of metamorphs ranged from June in Arkansas (Trauth et al., 1990) and Illinois (Smith, 1961) to June and July in Indiana (Minton, 2001) and Louisiana (Hardy & Raymond, 1991), June to August in Pennsylvania (this study), July to September in Connecticut (Klemens, 1993) and August and September in Pennsylvania (Surface, 1913). A comparison of these emergence dates with respective breeding dates suggests a larval duration of two to three months across populations, although, a four month larval duration may have occurred during one of the breeding seasons studied by Raymond & Hardy (1991). Larval periods of the pickerel frog were noted to be 60 to 80 days in Wisconsin (Vogt, 1981), three months in Missouri (Johnson, 1987), approximately 90 days in West Virginia (Green & Pauley, 1987), three and 1.5 months in Arkansas (Trauth et al., 1990), 60 to 90 days in the Great Lakes Region (Harding, 1997), and 70 to 80 days in the Carolinas and Virginia (Martof et al., 1980). In laboratory conditions, metamorphosis took place 75 to 90 days after hatching (Redmer, 2005). Our data suggest a two, and up to three month, larval period in Pennsylvania, the duration of which was not surprising in light of the frogs known breeding season.

Post-metamorphic growth to sexual maturity was relatively rapid in males (10 months) and females (13 months) from Pennsylvania and most males and all females would reproduce for the first time the breeding season thereafter. Estimated age at sexual maturity of both sexes in our study was earlier than ages noted by others across the region; second spring after transformation in Pennsylvania (Hulse et al., 2001); second spring after hatching in the Great Lakes region (Harding, 1997); three years of age in West Virginia (Green & Pauley, 1987).

The minimum and mean body sizes of adult males (SVL) ranged less so than those of females across the geographic range with no apparent latitudinal trend. Likewise, the degree of sexual size dimorphism was constant across locations whereby males averaged approximately 80% the size of females. The largest adults, however, ranged broadly in both sexes across the range of the species.

CONCLUSION

Pennsylvania populations of the pickerel frog conformed to the latitudinal gradient associated with the breeding season of the species (Redmer, 2005), with Pennsylvania falling midway between northerly and southerly extremes. Concomitant to geographic differences in breeding season, the months in which Pennsylvania pickerel frog metamorphs appeared also differed from other areas of its range, with those of Pennsylvania intermediate between the geographic extremes. Not enough data has yet been collected to determine growth rates beyond age at sexual maturity for the pickerel frog, and to date, the few estimations regarding age at sexual maturity ranged widely. This highlights the requirement for more data before meaningful trends can be proposed. However, despite this, adult body sizes were relatively fixed across its geographic range with a constant ratio of size dimorphism. Mean clutch sizes reported from three states were also similar. Although the larval period of the pickerel frog ranged from one and a half to three and possibly four months, most records noted above were within the two to three month range, which typified Pennsylvania. Thus, Pennsylvania populations of the pickerel frog appear to adhere to the latitudinal pattern associated with cool weather breeding but otherwise exhibit little variability with respect to adult body size and clutch characteristics.

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A hypothesis to explain the distribution of the great crested newt *Triturus cristatus* in the Highlands of Scotland

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ABSTRACT - The great crested newt *Triturus cristatus* is widespread in Britain but rare or absent over much of Scotland. The species is known from a small number of sites in the Scottish Highlands, but these are separated from the rest of the British population by over 80 km of unfavourable habitat, which has given rise to doubts about the origin of great crested newts in the region. The status as native or otherwise has implications for the conservation of the species in the Highlands. This paper looks at new records (since 2000) of *Triturus cristatus* in the Highlands and discusses whether they clarify the status of the species in the area. It describes how great crested newts could have colonised the region naturally. In particular, it considers the importance of climate history in shaping the current distribution of the species.

BRITAIN is a stronghold for the great crested newt *Triturus cristatus*, which has declined throughout most of Europe (Beebee & Griffiths, 2000). Because of its status within Europe it is legally protected and it has also been identified for action under Scotland's Species Action Framework. It is not common anywhere in Scotland, with populations being fragmented and relatively small (Gaywood, 1997). Indeed a recent study by Wilkinson et al. (2011) suggests that less than 1% of Scottish ponds are suitable for the species.

The great crested newt is rare north of the Highland Boundary Fault, with sites near Aviemore and Inverness (Langton & Beckett, 1995; Alexander, 1997). The 80 km gap between the most northerly Lowland site (in Fife) and the most southerly Highland site at Aviemore has not been adequately explained (Beebee & Griffiths, 2000). It is well in excess of any other disjunctions in great crested newt range in Britain and much greater than newts are known to move without assistance (e.g. Kupfer & Kneitz, 2000). This led Langton & Beckett (1995) to conclude that the great crested newt was probably not native to the Highlands. They recommended surveys near to known sites to find "source ponds" (ibid) but additional surveys in 1997 (Alexander, 1997) did not find any new sites.

The Fife site, Turflundie Wood (NO194142), has been described as the most northerly great crested newt metapopulation in the British Isles (JNCC, 2011) with four breeding ponds (McIntyre, 2003) (although the current study has identified pond clusters that may function as metapopulations in the Highlands). Most of the land between Fife and the Highland sites is mountainous and dominated by upland heath; few areas between them appear to be suitable for the species under present vegetation cover. For newts to have reached Inverness, they would either have had to negotiate the Slochd and Drumochter passes, each of which is more than 400 m above sea level, or take the much longer route along the coast, where there are no great crested newt records despite considerable survey effort (Trevor Rose, pers. comm.). The last Scotland-wide survey found no great crested newt more than 290 m above sea level, with 70% of sites being below 124 m (Alexander, 1997).

The earliest records of great crested newts in the Highlands date from 1875 when Wolley reported animals at four sites in Sutherland (Harvie-Brown & Buckley, 1887). They have never been rediscovered at any of these sites despite repeated surveys (HBRG, 2011), and these records may be erroneous (Collier in Langton & Beckett, 1995). Excluding these sites, there are records for ten ponds in the Highlands prior to 2000. The oldest are from 'Abernethy' 1896 (Harvie Brown & Buckley, 1896) and 'Forres' 1914 (HBRG, 2010). There are records for both these areas to the present day and the habitat in Forres is typical of that used by the species elsewhere in Britain: a mosaic of mixed woodland, grassland and scrub on the relatively fertile coastal plane. Most of the ten ponds are widely separated and studies of neighbouring ponds did not produce new records (Langton & Beckett, 1995; Alexander, 1997).

The great crested newt usually exists in metapopulations and models have suggested that isolated populations have a high probability (>95%) of extinction within 20 generations (Halley et al., 1996; Griffiths & Williams, 2000). In the absence of any known metapopulations, the status of great crested newts in the Highlands was at best dubious (Collier in Langton & Beckett, 1995; Beebee & Griffiths, 2000). Further, all but two of the sites were next to schools, houses or main roads. One site was known to be an introduction (Langton & Beckett, 1995) and it was hypothesised that the others may also have been so (Beebee & Griffiths, 2000). Until 1981 biological supply companies and pet shops offered great crested newts for sale and such animals could have been released into Highland ponds.

Since 2000, however, a further 15 great crested newt ponds have been found (HBRG, 2011), including two pond clusters. Rather than being a small isolated pocket, the Highlands holds a fifth of Scotland's recorded great crested newt ponds. The status of great crested newt populations in the Highlands, hence, merits further review, considering whether these populations are likely to have originated through introduction or natural colonisation.

Establishment of Populations by Introduction

At least two Highland sites, in Sutherland (identified after 2000, Iain Macdonald, pers. comm.) and on Skye (Langton & Beckett, 1995), are known to result from introductions. Anecdotal evidence from local people at a third site (Boleskine) suggests that a previous resident, Aleister Crowley, may have introduced the animals to the site for purposes which, given his treatment of other amphibians (Crowley, undated), are best left unknown. Interviews with local residents and landowners undertaken as part of this study found no evidence of introductions at either of the newly discovered clusters of sites. Both of these are well away from housing, schools or main roads. Until recently, one of these sites was extremely difficult to access, due to the hazardous terrain, and so seems an unlikely site for an introduction.

Excluding the known and possible introductions detailed above, and sites without recent records. great crested newts in the Highlands occur in six groups: Strathpeffer; Black Isle; West Inverness; Culloden: Forres and Aviemore. These are all separated by likely barriers to the spread of newts: areas of land with pond densities below 1 km⁻², wide rivers, built up areas or areas of extensive upland heath (Fig. 1). Some of these barriers (e.g. the rivers) are natural. The others have, with the exception of that between Forres and Culloden, been in existence since at least the early 1960s. Thus, unless there were at least five separate introductions, great crested newts must either have been introduced before that time or be native to the area

It is not impossible that there was a series of introductions, or that newts were introduced before the earliest record in 1896, but it is curious that such a pattern is not found in other densely populated areas of Scotland. Other areas of Scotland have similar summer climates to regions of southern Scandinavia where great crested newts are found, so if there had been introductions to these areas, it would seem likely that at least some populations would have survived long enough to be recorded. Great crested newts have not been recorded from apparently suitable areas of Scotland such as Ayrshire, nor between Montrose and Aberdeen, despite considerable survey effort (Trevor Rose, pers comm.).

A Possible Mechanism for Colonisation of the Highlands

Great crested newts presumably colonised Britain between 10,000 b.p. and 7,000 b.p. when rising seas flooded the southern North Sea, cutting the last land-bridge with mainland Europe. We hypothesise that great crested newts were able to colonise the Highlands some time in the last 7,000



Figure 1. Records of great crested newt in the Highlands and barriers between sites (bold lines).

years, following a lag period as they spread from southeast England northwards. Pollen records suggest that broadleaved and mixed woodland, favourable habitats for the species (Latham et al., 1996), were widely distributed across the Highlands up to 3.000 b.p. (Edwards & Whittington, 2003).

Summer climate was in fact 2-3°C warmer between 5,000-7,000 b.p. than it is now. Around 3,000 to 2,500 b.p., a climatic downturn led to the replacement of woodland by upland heath and blanket bog. Very few populations of British great crested newts occur on upland heath (Swan & Oldham, 1993), which is generally considered to be an unfavourable habitat (Beebee & Griffiths, 2000). Heathland ponds tend to be relatively acidic, and the great crested newt is the least tolerant of the British newts to low pH (Griffiths & de Wijer, 1994).

The last land-bridge connected Britain to Europe via Norfolk, and was lost around 7,000 b.p. (Lambeck, 1995). If great crested newts reached the Highlands before the deterioration in habitat around 3,000 b.p., they would have had at least 4,000 years to cover around 800 km from Norfolk to Inverness, a rate of at least 0.2 km per year. This appears manageable, given that studies of the species' dispersal have shown a maximum range of between 0.5 km per year (Oldham & Humphries, 2000) and 1 km per year (Arntzen & Wallis, 1991), and that it would have taken place when there were many more ponds in the landscape and far fewer human-made barriers than at present.

Thus we believe that great crested newts could have reached the Highlands without human aid. The area around the Moray Firth has a relatively benign climate for its latitude (Thompson, 1974), and the Black Isle peninsula in particular has numerous natural springs of base-rich water as well as lochs and ponds of various sizes. However, isolated populations are at greater risk of extinction and the fact that the habitats are currently suitable for great crested newts does not mean they have always been so.

Limits on Current Distribution in the Highlands

The great crested newt has not been recorded from some areas of the Highlands that appear to offer

suitable terrestrial and breeding habitats. Indeed the model proposed by Wilkinson et al. (2011), and confirmed by our own field observation, shows such suitable habitats extending 50 km to the east (Cullen) and 40 km to the north (Brora) of the edge of the observed range of the species. This may be an artefact of under-recording or, given the level of recent recording efforts (HBRG, 2011), it may reflect the impacts of past local climate change.

Climate, and particularly temperature, affect great crested newts' behaviour, reproduction and survival in various ways. In spring, adults do not migrate to breeding ponds until nighttime temperatures reach 5°C (Verrell & Halliday, 1985), and their return to hibernacula occurs when temperatures approach similar levels in autumn. Gustafson et al. (2009) found water temperature to be an important factor in great crested newt distribution in Sweden. The development rates of eggs and larvae are in part related to temperature (Griffiths & de Wijer, 1994), and low temperatures are associated with morbidity of eggs.

Great crested newt distribution is likely to relate not merely to where suitable conditions occur now, but where they have occurred in the past. Isolated occurrences can be relict populations surviving beyond the main range edge. Given that climate was significantly warmer 5,000-7,000 years b.p., it is reasonable to expect that great crested newts once had a more northerly 'climate envelope'. In other words, their northern limit was once further north than it is now. The same is true for any species with thermophilic requirements that limit its northern range. For example, subfossil evidence shows that the European pond terrapin Emys orbicularis was present in southern Sweden 5,000-7,000 b.p. when summers were warmer but has since become extinct there (Gleed-Owen, 1999). Even in East Anglia, there is evidence that the European pond terrapin, agile frog Rana dalmatina, moor frog Rana arvalis and pool frog Pelophylax lessonae were once present where they are now extinct (Gleed-Owen, 2000).

The effect of a long-term climatic cooling on a species with thermophilic requirements is to make its northern range edge uneven and patchy. Locally favourable conditions allow isolated populations to survive while the main range limit shrinks

southwards in response to climate cooling. The result is a scattering of disjunct populations to the north of the main range edge. It is not uncommon for European herpetofauna to have such patchy northern limits (e.g. Gasc et al., 1997).

If we consider climatic variation specifically in relation to the great crested newt, it seems likely that long periods of poor summers would have the greatest impact. Great crested newts start to breed at the age of three to four (females) or two to three years (males) and live to approximately seven to eight years (Hagström, 1977; Dolmen, 1982), exceptionally to 17 (Miaud et al., 1993). If conditions keep breeding success very low for several years in a row, local extinction is likely to occur. For example, the period of poor summers from 1694 to 1701 that followed the eruption of Mount Hekla in 1693, would be expected to adversely affect the species.

Such prolonged periods of unfavourable climate could have led to the loss of great crested newts across most of the Highlands, restricting them to relict populations around Inverness and the Moray coast, where the climate is relatively mild for the latitude. Such range expansions and contractions may have occurred several times. Indeed, if Highland great crested newts have been isolated from the rest of the British population for up to 3,000 years, and subjected to repeated bottlenecks, there may be interesting differences between these animals and the rest of the British population. Unfortunately, subfossil evidence that might show a former wider distribution of great crested newts in Scotland is not currently known.

Conclusion

We suggest that great crested newts colonised much of Scotland, at least as far north as the Black Isle, during the climatic optimum (5,000-7,000 b.p.), but that this was followed more recently by local extinctions in higher parts of the country during poorer climatic conditions. The populations around Inverness are thus relicts of the former, wider distribution. Climate has more recently improved, certainly since the mid-twentieth century, but insufficient time has elapsed and the intervening habitat may be too fragmented, to allow full recolonisation of otherwise suitable areas. Given the possibility of natural colonisation and the unlikely scenario of a series of introductions necessary to have established this number of metapopulations, we suggest that the precautionary approach would favour treating great crested newts as native to the Highlands – at least until further evidence is available. Genetic studies would shed further light on the native status of the Highland great crested newts, as Arntzen et al. (2010) demonstrated the likely natural origin of a cryptogenic population of great crested newts in France. Increasing our knowledge of the distribution of the species would inform land management to protect a potentially distinctive variant of an already uncommon species.

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Reproduction in Kotschy's gecko *Mediodactylus kotschyi* (Squamata: Gekkonidae) from the Greek Islands and Israel

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KOTSCHY'S gecko *Mediodactylus kotschyi* (Steindachner, 1870) is widely distributed in the Old World and has a discontinuous distribution that includes Israel, Jordan, Iran, Lebanon, Syria, AsiaMinor, Greece, Agean Islands, Cyprus, Albania, Turkey, Bulgaria, Hungary and the Ukraine, (Uetz & Hosek 2011). There are anecdotal accounts of M. kotschvi reproduction in Werner (1930), Werner (1966), Loveridge (1972), Beutler & Gruber (1979), Valakos & Vlachopanos (1989), Szczerbak & Golubev (1996), Baran & Atatür (1998), Corti & Lo Cascio (2002), Szczerbak (2003), Beshkov & Nanev (2006), Valakos et al. (2008), Baier et al. (2009) and Stojanov et al. (2011). The purpose of this paper is to add information to the reproductive biology of M. kotschvi by reporting on a histological analysis of gonadal material from the Greek Islands and Israel. Information on the reproductive cycle such as timing of spermiogenesis, number of egg clutches produced and period of vitellogenesis provides essential life history data for formulating conservation policies for lizard species.

MATERIALS AND METHODS

A sample of 29 *M. kotschyi* from Greece (Greek Islands) (10 males, mean SVL = 37.3 mm \pm 4.5 SD, range = 30-44 mm; 14 females, mean SVL = 40.2 mm \pm 3.0 SD, range = 35-44 mm; 5 subadults, mean SVL = 22.0 mm \pm 1.4 SD, range = 21-24 mm) was borrowed from the Peabody Museum of Natural History (YPM), Yale University, New Haven, Connecticut, USA. A further 25 *M. kotschyi* from Israel (8 males, mean SVL = 35.8 mm \pm 5.1 SD, range = 28-42 mm; 16 females, mean SVL = 37.5 mm \pm 5.2 SD, range = 29-45 mm; 1 subadult, SVL = 25 mm) were borrowed from the Tel-Aviv University, Zoological Museum (TAUM), Tel Aviv, Israel for a reproductive study. Lizards from the Greek Islands were collected in 1959, 1961, 1991

and 1999, and from Israel in 1950, 1952, 1953, 1955, 1958, 1959, 1962, 1964, 1965, 1972, 1975, 1984, 1988, 1989, 2002, 2005. *Mediodactylus kotschyi* examined are listed in the appendix.

For histological examination, the left testis was removed from males and the left ovary was removed from females. Enlarged follicles (> 3 mm length) or oviductal eggs were counted. Tissues were embedded in paraffin and cut into sections of 5 μ m. Slides were stained with Harris haematoxylin followed by eosin counterstain (Presnell & Schreibman, 1997). Slides of testes were examined to determine the stage of the spermatogenic cycle. Slides of ovaries were examined for the presence of yolk deposition or corpora lutea. Histology slides were deposited at TAUM or YPM. An unpaired t-test was used to compare *M. kotschyi* male and female mean body sizes (SVL) using Instat (V. 3.0b, Graphpad Software, San Diego, CA).

RESULTS

Mean body sizes (SVL) were not significantly different between males from the Greek Islands and Israel (unpaired t-test, t = 0.69, df = 16, P =0.50). Monthly stages in the testicular cycle in the Greek Islands and Israel are shown in Table 1. Two stages were present in the testicular cycle; (1) Recrudescence: characterised by a proliferation of germ cells for the next period of spermiogenesis (sperm formation), primary and secondary spermatocytes predominate; (2) Spermiogenesis, whereby lumina of the seminiferous tubules are lined by clusters of spermatozoa and/or rows of metamorphosing spermatids. Epididymides were not sectioned but they were enlarged and whitish in colour, consistent with them containing sperm. Testes undergoing recrudescence were noted in March in the Greek Islands and February and November in Israel. The epididymides from these

Month n		Recrudescent	Spermiogenesis
		Greek Islands	
March	2	2	0
May	6	0	6
July	2	0	2
		Israel	
February	2	1	1
March	2	0	2
April	1	0	1
May	1	0	1
November	2	2	0

Table 1. Monthly stages in the testicular cycles of *Mediodactylus kotschyi* from Israel (n = 8) and the Greek Islands (n = 10).

three males were not enlarged. Males undergoing spermiogenesis occurred in May and July in the Greek Islands and February to May in Israel (Table 1). The smallest reproductively active male (spermiogensis in progess) from the Greek Islands (YPM 5795) measured 30 mm and was collected in May; from Israel (TAUM 2965) the smallest measured 31 mm and was collected in April.

Mean body sizes (SVL) were not significantly different between females from the Greek Islands and Israel (unpaired t-test, t = 1.7, df = 28). Monthly stages in the ovarian cycle in the Greek Islands and Israel are in Table 2. Three stages were present in the ovarian cycle of *M. kotschyi*; (1) Quiescent: no yolk deposition was noted; (2) Early yolk deposition: basophilic yolk granules present in the ooplasm; (3) Enlarged ovarian follicles > 3

mm; (4) Oviductal eggs were present. The single clutch from Israel (TAUM 4135) consisted of two eggs. The seven clutches from the Greek Islands (YPM 5798, 5809, 5811, 5812, 5828, 5829, 15154) had a mean of: 1.86 ± 0.38 SD, range: 1-2. The smallest reproductively active female from the Greek Islands (two follicles > 3 mm) measured 35 mm and was collected in May (YPM 15154) whereas those from Israel both measured 45 mm SVL (TAUM 4135): two follicles > 4 mm from January and (TAUM 6081) two oviductal eggs from May. This large minimum body size for reproduction for *M. kotschvi* females from Israel likely reflects my small female sample size. There was evidence from the Greek Islands (YPM 5809, 5798, 5812) and Israel (TAUM 4135) that female M. kotschvi produce multiple clutches during a single year. This was indicated by the presence of oviductal eggs and concomitant yolk deposition in the same females.

Five subadults from the Greek Islands collected in March (mean SVL = 22.0 mm \pm 1.4 SD) were presumably born late the previous fall. One subadult from Israel (SVL = 25 mm) collected in September was presumably born earlier in the same year.

DISCUSSION

Beutler & Gruber (1979) reported that subadults of *M. kotschyi* (20 to 25 mm SVL) became active in March in the Greek Islands and reached adult sizes (30 to 34 mm SVL) in May. *Mediodactylus kotschyi* has an extensive geographic range that encompasses a variety of climates ranging from

Month	n	Quiescent	Early Yolk Deposition	Enlarged Follicles > 3 mm	Oviductal Eggs
			Greek Islands	5	
March	4	4	0	0	0
May	7	1	1	1	4*
June	2	0	0	2	0
July	1	1	0	0	0
			Israel		
January	3	2	0	1	0
February	1	1	0	0	0
March	3	3	0	0	0
May	2	1	0	0	1**
June	2	2	0	0	0
October	2	2	0	0	0
December	3	3	0	0	0

Table 2. Monthly stages in the ovarian cycles of *Mediodactylus kotschyi* from Israel (n = 16)/Greek Islands (n = 14); *three of four females, **one female, with oviductal eggs and concomitant yolk deposition for a subsequent clutch.

Location	Clutch Size	Number Clutches	Reproductive Period	Source
Bulgaria	2	?	summer	Beshkov & Nanev (2006)
Bulgaria	1-2	?	summer	Stojanov et al. (2011)
Crimea	1-2	1	May to July	Szecerbak & Golubev (1996)
Cyprus	2	?	March to June	Baier et al. (2009)
Greece	mean = 2.2	5?	?	Valakos & Vlachopanos (1989)
Greece	1-2	?	Year-round	Valakos et al. (2008)
Greek Islands	1	?	May	Werner (1930)
Greek Islands	2	?	June, July	Loveridge (1972)
Greek Islands	?	?	May to July	Beutler & Gruber (1979)
Israel	1-2	?	May to September	Werner (1966)
Italy	?	1	?	Corti & Lo Casio (2002)
Turkey	2-6	?	?	Baran & Atatür (1998)

Table 3. Previous reports on reproduction of Mediodactylus kotschyi.

tropical, temperate to arid. One would thus suspect some geographic variation in the reproductive cycle. Previous reports on reproduction are mainly anecdotal and are listed in Table 3. Herein I have provided information that multiple clutches are produced both in the Greek Islands and Israel. Whether multiple clutches are produced by other populations of M. kotschyi will require additional investigation. There is a report of year-round reproduction in Greece by Valakos et al. (2008) which requires verification, as it contrasts with other reports of spring-summer reproduction listed in Table 3. My finding of males with testes undergoing recrudescence (renewal) prior to spring in both the Greek Islands and Israel suggests M. kotyschyi exhibits a seasonal reproductive cycle, typical of temperate zone geckos (see for example, Goldberg, 2006), as opposed to tropical lizards which exhibit continuous breeding (Fitch, 1982). The clutch size range of 1-2 is identical to that reported for other geckos (Vitt, 1986). The larger clutches (2-6) reported for *M. kotschyi* from Turkey by Baran & Atatür (1998) should be verified. In view of its extensive geographic range, subsequent analyses of the different populations of M. kotschvi are needed before variations in reproductive cycles of these geckos can be ascertained.

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APPENDIX

Mediodactylus kotschyi examined from Israel (TAUM) (by District) and the Greek Islands (YPM) with longitudes and latitudes.

Israel: Central (32°08'N, 34°92'E): 481, Haifa (32°48'N, 34°59'E): 479, 1321, 2021, 2024, 2965, 9921,13776, 13790, 14879; Jerusalem (31°75'N, 35°00°E): 12823, 15232; Northern (32°70'N, 35°30'N): 477, 3050, 5040, 6081, 12810, 12812, 13624; Southern (31°07'N.35°12'E): 721-723, 4135; West Bank (31°42'N, 35°12'E): 10841; Unknown: 5813.

Greek Islands: Andros Island (37°52'N, 24°46'E): 5813, 5814, 5815, 5816, 5817, 5818, 5819, 5820, 5821, 5822 Astypalaia Island (36°32'N, 26°22'E): 5812, 5830; Crete (35°15'N, 25°00E): 15154, 15155, 15156; Milos Island (36°44'N, 24°25'E): 5761, 5762, 5763; Naxos Island (37°04'N, 25°22'E): 5828; Paros Island (37°02'N, 25°11'E): 5808, 5809, 5810, 5811, 5829; Siros Island (37°25'N, 24°57'E): 5794, 5795, 5796, 5797, 5798.

A survey of herpetofauna on Long Island, Andaman and Nicobar Islands, India

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ABSTRACT - In the last 150 years, herpetological studies in the Andaman and Nicobar Islands have uncovered forty species of terrestrial reptiles and eight species of frogs from the Andaman Islands. However, fine scale information on the distribution and status of the herpetofauna of Andaman and Nicobar Islands is still lacking. In an attempt to fill the gaps in information, as the first in a series, we conducted a short survey of the herpetofauna of Long Island, Middle Andaman. Twenty-nine species were recorded from this small island, including six species of frogs and twenty-three species of squamate reptiles. The efficiency of various sampling techniques used is discussed in the context of the diversity and density of herpetofauna from the Andaman Islands.

C TUDIES of the herpetofauna of the Andaman and Nicobar archipelago date back to the mid 19th Century, with the earliest being those of Blyth (1846), Steindachner (1867) and Stoliczka (1870; 1873). Since then, there have been subsequent descriptions of new herpetofauna, studies and reviews (Smith, 1940; Biswas & Sanval, 1965; 1978; 1980; Tiwari & Biswas, 1973; Das, 1995; 1996; 1997; 1998a; 1998b; 1999; Vijayakumar, 2005; Harikrishnan et al., 2010). The above surveys and studies have accounted for 93 described and extant species of amphibians and reptiles to date. Almost every survey conducted on the islands has found species that are new to science or new distributional records for the islands (see Das & Vijavakumar, 2009; Hallermann, 2009; Harikrishnan et al., 2010). Some surveys have lead to the rediscovery of species that were known only from the original descriptions (Murthy & Chakrapany, 1983; Das, 1997; Vijayakumar & David, 2006). This paper documents a short survey of two months duration on Long Island, Middle Andaman and provides a few noteworthy records.

Long Island is situated east of the Middle Andaman Island at ca. 12.376° N, 92.924° E. The shortest distance between Long Island and Middle Andaman is approximately 1.2 km. The maximum elevation is less than 50 m and it has an approximate area of 14 km² (Davidar et al., 2001). It is 7 km long and only 2 km at its widest point. The northern and central parts of the island are covered by tropical evergreen forests, while the southern part is primarily composed of forest plantations and agricultural land. Mangrove forests occur on the northern and western coasts. The terrain is nearly flat and there are no perennial streams, although there are several small channels that function as annual streams during the monsoons. The island receives the southwest monsoon with the bulk of rainfall falling between June and October. Our survey was conducted during the dry summer months and rainfall occurred only during the last few days of the survey.

MATERIALS AND METHODS

Surveys were conducted from 2 April 2010 to 2 June 2010 both diurnally and nocturnally. We used multiple methods to search for herpetofauna and conclude species richness and abundance for the island. Data were collected using the following five different sampling strategies:

(a) Species richness, encounter rates and relative abundance; We conducted time-constrained visual encounter surveys (VES). Two observers walked through the forest, observing and recording all the individual reptiles and amphibians encountered for one hour at a time. The range of microhabitats examined included rocks, fallen logs, tree trunks, dead bark of trees and streams. We conducted surveys during day and night to record both diurnal and nocturnal species. 'Day' was considered to be

Method	Individuals	Species	Unique Species	Effort (min x 2 observers) Initial/Sample
VES	494	18	4	0 60
Quadrats	30	5	0	0 30
Pitfall traps	5	3	0	180 5
Glue traps	7	3	0	15 5
Opportunist	ic -	23	9	

Table 1. Summary of the methods employed in detecting reptiles and amphibians.

 Unique species are those that were detected by only one sampling method.

the time between 06:00 and 18:00 and 'night' was 18:00 to 06:00, irrespective of sunrise and sunset. we adopted these time distinctions because even though the islands are situated at eastern latitude, they follow the Indian Standard Time (IST). We used the number of person-hours of sampling to derive encounter rate of a species per hour.

(b) Density and species richness of forest floor herpetofauna: We laid quadrats of 5×5 m at random points along trails and at varying distances and directions using a nylon rope. Each quadrat had its closest edge at the random point taken from the trail, and the other corners diverged away from it. A quadrat took up to five minutes for installation, and any animal that was disturbed or ran away from the quadrat area during this was noted. The quadrats were left undisturbed for 15 minutes to minimize the effect of disturbance caused during installation. Thereafter, two observers approached the quadrat from opposite directions. The quadrat being examined was initially checked for arboreal animals on trees, saplings and climbers up to a height of about 3 m. This was followed by extensive search of the forest floor. Two people searched the quadrat starting from the opposite corners and approached the centre in a clockwise manner to minimize the chances of animals escaping before detection. All leaf litter was moved, rocks turned and fallen logs broken to reveal animals. Dead bark was peeled off from the trunk of trees. The time taken for the completion of a quadrat and the number of species and individuals detected during the sampling were recorded. Since detection probabilities were not evaluated, the density thus obtained was not absolute

(c) Pitfall traps: This passive sampling technique was deployed for detecting elusive terrestrial and

subterranean forms. A pitfall trap array consisted of three buckets, 250 mm deep and 240 mm in diameter, buried in the ground with their rims flush with the ground. A 450 mm high and 15 m long plastic sheet placed across the pits served as the 'drift fence' for guiding animals towards them. The pits were located at 5-m intervals. These pitfall traps were placed continuously both during the day and night time for six days per session and were checked twice daily. After a six-day period, the array was moved to a new location.

(d) Glue traps: Cardboard sheets 200×300 mm with a thin layer of mouse glue were used to capture reptiles and amphibians. Ten such traps were placed in a grid of 20×10 m at distances of 5 m from each other. Within the grid, glue was placed on substrates that were likely to increase captures, such as near fallen logs or at the base of trees.

(e) Opportunistic records: These were records and observations of species that were obtained incidentally rather than during a specific sampling occasion. Such species records were pooled with that of the other systematic methods to contribute to total species richness data.

RESULTS

Twenty-nine species were recorded comprising six species of amphibians belonging to five genera and three families, and 23 species of reptiles belonging to 20 genera and 8 families. Twelve species (54.5% endemism) of reptiles endemic to Andaman and Nicobar Islands were recorded. All species were identified in the field using published keys or original descriptions. Therefore, identification was provisional and there were several species whose identity is yet to be confirmed. Table 1 provides a summary of the efficiency of different methods used for sampling. (a) Species richness, encounter rates and relative abundance: Visual encounter surveys were conducted during both the day and night time for 40.8 man hours and yielded 494 individual sightings of 18 species. Encounter rates and relative abundance for individual species recorded during VES were calculated. *Coryphophylax subcristatus* was the most common species, followed by *Cyrtodactylus rubidus* (Table 2). The results of VES surveys are summarised in Table 2. A list of species recorded for Long Island with the sampling methods that recorded each of them is shown in Table 3.

(b) Density and species richness of forest floor herpetofauna: Following the methods of Scott (1976), 18 quadrats of 5×5 m dimension were surveyed which covered a total of 450 m². The average time taken to complete examination of a quadrat was 15 minutes (range 7 to 40 minutes). Thirteen of the 18 quadrats (72%) had animal detection. We recorded 30 individuals of 5 species of reptiles from the quadrats. Only forest floor and semi-arboreal species were found during quadrat sampling. Frogs were not detected in any of the quadrats. The mean density of reptiles in quadrats was 1.66 per quadrat, the median values were 1 and 2 (5 times each), and the maximum was eight. The density of forest floor and semi-arboreal reptiles was 0.07 individuals m⁻² or 700 individuals ha⁻¹.

(c) Pitfall trapping: The pitfall traps were performed for six days in two different locations totalling 12 trap days. Five individual reptiles belonging to three species were recorded using this method. No frog species were recorded in pitfall traps. This was the most efficient method for sampling terrestrial and burrowing forms such as the fossorial skink *Lygosoma* aff. *bowringii*, that was detected just once using other sampling methods. Two other species, *Eutropis andamanensis* and *Coryphophylax subcristatus*, were captured on single occasions in pitfall traps.

(d) Glue traps: Glue traps were highly effective at capturing forest floor reptiles and semi-arboreal reptiles. The ten glue traps captured seven individuals of two species of lizards; *Coryphophylax subcristatus* (n = 6) and *Eutropis andamanensis* (n = 1) during a 12-hour period. The high frequency with which *C. subcristatus* was captured made the traps very difficult to monitor and so they were ceased after 12 hours.

No.	Species	Ν	Encounter Rate/Hour	Relative Abundance	
1	Coryphophylax subcristatus	285	6.97	0.57	
2	Cyrtodactylus rubidus	91	2.23	0.18	
3	Eutropis andamanensis	22	0.54	0.05	
4	Limnonectes sp.	22	0.54	0.05	
5	Gekko verreauxi	17	0.42	0.03	
6	Eutropis tytleri	15	0.37	0.03	
7	Microhyla cf. chakrapani	12	0.29	0.02	
8	Trimeresurus andersoni	6	0.15	0.01	
9	Lycodon capucinus	6	0.15	0.01	
10	Cerberus rynchops	5	0.12	0.01	
11	Bufo melanostictus	3	0.07	-	
12	Bungarus andamanensis	2	0.05	-	
13	Hemidactylus aff. platyurus	2	0.05	-	
14	Xenochrophis tytleri	2	0.05	-	
15	Hemidactylus frenatus	1	0.02	-	
16	Kaloula baleata ghoshi	1	0.02	-	
17	Ingerana charlesdarwini	1	0.02	-	
18	Phelsuma andamanense	1	0.02	-	

 Table 2. Summary of results of VES surveys for 41 person-hours.

 N is the total number of individuals of each species.

	VES	Quadrats	Pitfall Traps	Glue Traps	Opportunistic
Amphibians					
Bufo melanostictus	1	0	0	0	1
Limnonectes sp.	1	0	0	0	1
Ingerana charlesdarwini	1	0	0	0	1
<i>Fejervarya</i> cf. <i>cancrivora</i>	0	0	0	0	1
Kaloula baleata ghoshi*	1	0	0	0	0
Microhyla cf. chakrapani*	1	0	0	0	1
Reptiles					
Varanus salvator andamanensis	0	0	0	0	1
Hemidactylus frenatus	1	0	0	0	1
Hemidactylus cf. brookii	0	0	0	0	1
Hemidactylus aff. platyurus	1	0	0	0	1
Gekko verreauxi*	1	0	0	0	1
Phelsuma andamanense*	1	0	0	0	1
Cyrtodactylus rubidus*	1	1	0	0	1
Gehyra mutilata	0	0	0	0	1
Hemiphyllodactylus typus	0	0	0	0	1
Coryphophylax subcristatus*	1	1	1	1	1
Unidentified agamid	0	0	0	0	1
Eutropis andamanensis*	1	0	1	1	1
Eutropis tytleri*	1	0	0	0	0
Lygosoma aff. bowringii	0	1	1	0	0
Typhlopidae	0	0	0	0	1
Dendrelaphis andamanensis*	0	0	0	0	1
Lycodon capucinus	1	1	0	0	1
Ptyas mucosa	0	0	0	0	1
Xenochrophis tytleri*	1	0	0	0	0
Cerberus rynchops	1	0	0	0	0
Boiga andamanensis*	0	0	0	0	1
Bungarus andamanensis*	1	0	0	0	1
Trimeresurus andersoni*	1	0	0	0	1
Total	18	5	4	3	24

 Table 3. Checklist of species recorded from Long Island, with the methods used. Species that are endemic to the Andaman and Nicobar Islands are indicated by *. Blind snakes, Typhlopidae were only identified to family.

(e) Opportunistic records: The maximum number of species was detected opportunistically. The species recorded only through opportunistic records are: *Fejervarya* cf. *cancrivora*, (n = 1), unidentified arboreal agamid lizard (n = 4), typhlopid snakes (n = 2), Boiga andamanensis (n = 1), Hemidactylus cf. brookii (n = 1), Ptyas mucosa (n = 3), Dendrelaphis andamanensis (n = 16), Hemiphyllodactylus typus (n = 2) and Gehyra mutilata (n = 1). Two blind snakes (Family: Typhlopidae), an Andaman cat snake (Boiga andamanensis) and a lizard resembling the Brook's gecko (Hemidactylus cf. brookii) were observed crossing a road at night.

The green bronzeback (*Dendrelaphis* andamanensis), though very common, was not detected during any of the above sampling occasions but was observed several times while walking along roadsides. Two Indo-Pacific slender geckos (*Hemiphyllodactylus typus*) and the four-clawed gecko (*Gehyra mutilata*) were observed inside an old building.

DISCUSSION

Long Island had relatively high species richness with 23 species of reptiles and six species of frogs. This is probably because of its proximity



Figure 1. Bufo melanostictus common Asian toad.



Figure 3. *Microhyla* cf. *chakrapani* Chakrapani's narrow-mouthed frog.



Figure 2. Kaloula baleata ghoshi Andaman bullfrog.



Figure 4. *Fejervarya* cf. *cancrivora* mangrove frog.



Figure 5. Limnonectes sp.

to the much larger Middle Andaman. From the relatively few quadrats examined, forest-floor reptile density in Long Island appeared to be high. However, this is almost certainly an underestimate, since small open quadrats allow the escape of many individuals before they are detected by



Figure 6. Ingerana charlesdawini Darwin's litter frog.

researchers (Rodda & Dean-Bradley, 2002). The figures reported herein are thus an index of density, and more intensive sampling is in progress in the Andaman and Nicobar Islands to get a better idea of the true species richness and density of terrestrial herpetofauna. Cases of high densities of reptiles on



Figure 7. Lygosoma aff. bowringii Bowring's supple skink.



Figure 8. Eutropis and amanensis And aman litter skink.





Figure 9. Coryphophylax subcristatus Bay Island forest lizard. ▲

Figure 10. *Phelsuma andamanense* Andaman emerald gecko. ◄



Figure 11. Eutropis tytleri Tytler's litter skink.

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Figure 12. *Cyrtodactylus rubidus* Andaman bent-toed gecko.



Figure 14. Lycodon capucinus island wolf snake.



Figure 13. *Hemiphyllodactylus typus* Indo-Pacific slender gecko.



Figure 15. *Cerberus rynchops* dog-faced water snake.



Figure 16. Dendrelaphis and amanensis green bronzeback.







Figure 20. Bungarus andamanensis Andaman krait.



Figure 20. Trimeresurus andersoni Andaman pitviper, dark morph (insert - normal coloration).

islands are known from around the world, and the most compelling explanation for this phenomenon is excess density compensation (Case, et al., 1979; Rodda & Dean-Bradley, 2002).

It is also interesting to note that apart from the human commensals such as house geckos (*Hemidactylus frenatus* and *Hemidactylus brookii*), among the forest reptile community only the genus *Eutropis* had more than one species. This pattern is reminiscent of Fox's rule for the assembly of small mammal communities, in that species are added to a community in such a way that every genus in the available pool is represented by at least one species before a second member of any genus is added to the community (Fox, 1989).

Maximum numbers of species were recorded opportunistically, followed by time constrained VES. Though opportunistic encounters and VES seemed to be the most efficient methods to arrive at species richness of the reptile and amphibian community, they provided meagre quantitative information on the abundance of species. Some species that are common in human habitations, such as green bronzeback *Dendrelaphis andamanensis* and Andaman emerald gecko *Phelsuma andamanense* were not abundant in systematic sampling methods, perhaps because of their preference for more open and disturbed habitats.

An index of density could only be calculated for the limited number (5) of species that were recorded during quadrat sampling. Randomly placed 5×5 m quadrats were inadequate in sampling most species of snakes and amphibians. Large and active species of ground-dwelling skinks, Andaman litter skink Eutropis andamanensis and Tytler's litter skink Eutropis tytleri, were encountered frequently in the forest, but due to their alertness and flight behaviour they were never recorded in the quadrats. Our observations on the behaviour of Eutropis tytleri suggest that this species could be predominantly crepuscular and semi-arboreal in habit unlike its other congeners. Nocturnal species such as Andaman bent-toed gecko Cyrtodactylus rubidus were often seen living in cracks in the soil close to the roots of trees, and could only be sampled during the day by digging the soil.

Pitfall traps with drift fence were effective in capturing small fossorial lizards that were rarely detected using other methods (e.g. Bowring's supple skink *Lygosoma* aff. *bowringii*). Larger lizards (SVL > 100 mm) could not be sampled using the dimensions of our pitfall traps. The glue traps were highly efficient in capturing animals but it was not logistically possible to use them for long periods. The high frequency with which common species were being captured (e.g. *Coryphophylax subcristatus*) meant that the traps had to be checked at least once every hour. This was a severe logistical constraint, and we suggest that these traps be used only when large numbers of specimens have to be collected.

This short survey has revealed that some species are either new records or potentially new species. An arboreal unidentified agamid lizard we saw resembled *Calotes andamanensis*, a species that was described in the 19th Century and known only from a single specimen. Reports of the Indo-Pacific slender gecko (*Hemiphyllodctylus typus*) from the Andamans remain to be confirmed and further examination of these individuals is required. The supple skink (*Lygosoma* aff. *bowringii*) showed consistent and marked morphological differences from populations in Southeast Asia, and we consider its taxonomy to be incomplete.

The Andaman Islands are part of the Indo-Burma biodiversity hotspot and are vital for the conservation of biodiversity. In the Andaman archipelago, there are about 300 islands and very few have been thoroughly inventoried for terrestrial herpetofauna. Effective conservation and management activities require fine scale knowledge of the distribution of species in this large group of islands. This survey is one small step towards gaining a better understanding of the distribution and status of amphibians and terrestrial reptiles in the Andaman Islands.

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Notes on the grass snake *Natrix natrix* in the Derwent Valley, County Durham

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ABSTRACT - Records of grass snakes *Natrix natrix* in the counties of Northumberland and Durham, northeast England, are assessed in the context of national and regional records. The history of the grass snake on the Gibside Estate in County Durham is documented, along with observations of behaviour and discussion of the provenance of the snakes. The Gibside population of grass snakes is put into context and its future prospects discussed.

THIS paper's primary aim is to document the history of the grass snakes of the Gibside Estate in the lower Derwent Valley, northeast England. Secondary aims are to put the Derwent Valley grass snakes into their regional context and to examine whether the snakes are typical of the *helvetica* subspecies native to England. This paper is based primarily upon survey work and observations carried out between 1985 and 1998, supplemented by a review of archived biological records and further information from other naturalists.

For much of its length the river Derwent forms the county boundary between Durham and Northumberland, the lower Derwent Valley falls within the administrative districts of the modern County Durham and the Borough of Gateshead. For the purposes of this paper the Watsonian Vice County (VC) system will apply. Most of the river Derwent therefore divides VC66 Durham from VC67 South Northumberland. The lower Derwent Valley falls within VC66, including the Gibside Estate, which lies on the southern side of the river. Grass snakes at Gibside have been observed to the north of the river in and around Lockhaugh including a defunct sewage works. The Gibside population should therefore be taken to include both banks of the river Derwent.

The Gibside Estate has a long history as a private country estate, eventually becoming the property of the Bowes-Lyons family before becoming vacant in the 1920s. The derelict house and estate passed to the National Trust in 1993, after which time the whole of the estate became publically accessible. In 1989 much of the estate was declared a Site of Special Scientific Interest, partially due to the presence of five native amphibian and four native reptile species.

RECORDS AND LITERATURE REVIEW

Records of the grass snake in northeast England are held by the National Biodiversity Network (NBN) and the Environmental Records Information Centre (ERIC) in Tyne and Wear Museums. The data holdings include duplicates, inaccuracies and incomplete records including those with no provenance and in many cases records that cannot now be verified. Historical written records rarely provide a context from which it is possible to determine validity and yet these records have been used to map the distribution of the grass snake within England. All of the records validated in the course of preparing the current paper have been deposited with ERIC.

In Durham and Northumberland grass snake records occur as far north as Crookham (NT9138), within four miles of the Scottish border, with a scattering of other records across the two counties, widely dispersed in time and space. Breeding records are few with only the Derwent Valley, and in particular the Gibside estate, providing a longterm history of grass snakes in the two counties.

Fawcett (1900) provides the first record of the grass snake in the Derwent Valley in 1886 but with no specific locality given. There are no further Derwent Valley records until the 1960s (Table 1). The late Ken Hopper of Wallish Walls farm recorded grass snakes breeding in the farm manure heap circa 1984 and being present on the

Mereburn, 1960	NZ0854
Edmundbyers, 1960	NZ0149
Shotley Bridge, 1970s	NZ0952
Coombe Bridges, 1972	NZ0548
Ebchester, 1980	NZ1055
Gibralter, 1983	NY9449
Wallish Walls, circa 1984 & 1986	NZ0650
Carricks,1987	NY9851
Blanchland, 1999	NY9650
Shibdon Pond, 2006	NZ1962
Blackhall Mill, 2006	NZ1156

Table 1. Grass snake records for Derwent Valley awayfrom Gibside held by the Environmental RecordsInformation Centre, Tyne and Wear Museums.

farm during the 1980s (K. Hopper, pers. comm).

Gibside grass snakes make their first entry into the ERIC database in 1979 and are recorded every year until 1998 with the exception of 1997. After 1998 records are sporadic.

Coult (1995) summarised the survey history and the historical distribution of the grass snake in Northumberland and Durham with inconclusive results other than to confirm the presence of breeding snakes on and around the National Trust's, Gibside Estate. Durkin (2010) provides detailed distribution maps and a summary of status for all of the Durham and Northumberland reptiles including grass snake.

Langton (1989) records that in 1983 he found a market stall in Newcastle upon Tyne which was selling grass snakes apparently collected in Tyne and Wear. There is no further information on where these snakes came from or who collected them but in the 1980s the Gibside population was the only viable one in the region and is likely to have been the source population.

The grass snake has been recorded as breeding in Northumberland further north than the Derwent Valley, at Fontburn Reservoir, as recently as 1999 (J. Durkin, pers. comm.) but further work is required to fully determine status there.

OBSERVATIONS OF GRASS SNAKES AT GIBSIDE

The author's involvement with the Gibside snakes began in 1985 after being shown a series of photographs taken at Easter 1984 showing seven snakes presumed to be in a mating chase (E.

Morton, pers. comm). A notable feature was that some snakes were atypical in coloration having a pair of pale dorsolateral stripes. Subsequently this colour form was found to make up a substantial proportion of the Gibside population. From 1985 to 1998 the author installed and monitored a manure heap as an egg-laying site on the southern edge of Snipes Dene (NZ183589). Many subsequent observations were made there.

The core area of distribution is approximately the northern half of the National Trust's Gibside land holdings including Snipes Dene, Park Farm and the Lady Haugh along with Lockhaugh, part of Derwent Walk Country Park, Hollin Hill Farm and a disused sewage works (Fig. 1). Durkin (2010) considers the 2006 records at Blackhall Mill and Shibdon Pond to be snakes from the Gibside population, the linking habitat being the River Derwent. There is, however, no evidence of snakes moving between these locations.

Behaviour

Little is recorded of the behaviour of snakes at Gibside. Most of the author's observations were made near the manure heap or by the lily and fish ponds within the estate. Incidental reports record snakes swimming across the River Derwent (K. Gardner, pers. comm.). Snakes with prey bulges have been seen by the ponds having presumably captured prey there.

Breeding

There are two records of mating chases and mating; the mating chase already referred to in 1984 and the author's record of an autumn mating on the 23 September 1989 (Coult, 1989). This latter observation involved a tied pair of snakes and three other males making frenzied passes around the mating pair, within two metres of the manure heap. The snakes were watched for ten to fifteen minutes with the observation finishing at 11.40 am and several photographs taken (e.g. Fig. 2). When the pair finally broke up the other males repeatedly visited the mating spot, rapidly tongue-flicking the ground.

On the 6 June 1990, 27 grass snake eggs were found in the manure heap; most were shriveled but some were fully formed. When cut open one egg



Figure 1. Approximate core distribution area of grass snakes at Gibside.

contained a fully formed dead snake. Grass snakes normally mate in April or May, laying eggs in June or July which hatch in late August or September (Beebee & Griffiths, 2000). June is therefore very early for eggs of that year to contain fully formed young. It is tempting to speculate that these were the failed eggs from the mating of the previous autumn. In captivity autumn matings in grass snakes have resulted in the production of eggs early in the following year (Bolam, 1922; Stein, 1924 in Smith [1954]). Nevertheless, it seems unlikely that this could occur under cooler conditions in the wild, so these eggs may simply have been the result of a spring-time mating, deposited but failing to hatch in the previous year.

On the 30 August 1985 six snakes were seen on the manure heap, five of which were striped, with individuals ranging in length from approximately 23 to 90 cm. Beebee & Griffiths (2000) state that one-year-old grass snakes reach a length of between 25 and 30 cm, in which case the smallest snakes observed indicate that successful breeding took place in 1984.

On 12 October 1985 a single snake was found at a depth of about 13 cm in the manure heap, whether this was a late egg laying effort or an attempt at



Figure 2. Autumn mating, Gibside 1989. A typical and a faintly striped snake are locked in coition with heads together in the centre of the picture and a striped male snake is on the right.



Figure 3. Grass snake eggs, Gibside 6 June 1990.

hibernation is not known. In August 1988 three snakes were seen at the manure heap, one large individual had noticeable skin folds, indicating that egg laying had taken place.

DESCRIPTION

Typical grass snake coloration is an olive-green to brown background colour with a row of vertical black bars along either side of the body, although this may vary to some extent between individuals. Grass snakes have a distinct yellow and black collar just behind the head, varying in size and shape, which is the source of its older name, the ringed snake. This collar may, in older females disappear altogether.

Some of the Gibside grass snakes showed a different colour pattern, having a pair of pale dorsolateral stripes (Fig. 4), noted above, and in some cases either no discernible collar or an indistinct collar. The largest snake seen, captured and measured was 98 cm in length, very dark in colour with no discernible collar and very faint dorsolateral stripes.

Similarly marked grass snakes have been found elsewhere in England. Sunderland (2003) reported a population centred on the Esholt Estate, near Shipley, Bradford in West Yorkshire. Subsequent genetic study determined that these snakes most likely originated from eastern Romania (Nash,



Figure 4. Gibside grass snake showing pale stripes.

2011). Beebee & Griffiths (2000) record a population in Surrey, which they conclude was probably the descendants of snakes from southern Europe which had escaped from a biological supplies station. Vaughan (2007) records his study of a grass snake population at an unnamed site in southern England, which included a proportion of individuals with stripes. He also records his release of a striped female grass snake purchased in a London market in 1973 into his study area some twenty years before the study began and concludes that interbreeding with native snakes took place.

In 1986 the author corresponded with Dr. Roger Thorpe, then of the Department of Zoology, University of Aberdeen. In his letter of reply he relates that it was then unknown for striped grass snakes to be found west of the Po Valley in northern Italy and that it was possible that escaped pets of an eastern origin had interbred with the native population at Gibside and that from photographs supplied the stripes appeared to be consistent with the eastern form.

It seems likely, therefore, that there is a genetic mix of eastern and western grass snakes in the Gibside population. Nash (2011) predicts that interbreeding at Esholt would result in the loss of the non-native genotype through overwhelming dilution and that population fitness may change as a result. If there is a genetic interchange between grass snake populations along the Derwent Valley then it is possible that the eastern genotype will be similarly diluted at Gibside. Alternatively, if the Gibside population is isolated, as seems likely, then a hybrid population may result. Further surveys should be carried out to test Durkin's hypothesis that the population extends along the valley to Blackhall Mill and to Shibdon Pond. If biological material is available it would be informative to have DNA analysis carried out to determine the genetic provenance of the Gibside grass snakes.

CURRENT STATUS OF GIBSIDE GRASS SNAKES

Since monitoring stopped at the site in 1998 records from Gibside have been sparse. Grass snakes were recorded in 2002, with a possible maximum of eight seen but no evidence of breeding or young snakes (Durkin, 2006). A comprehensive survey of the estate was carried out between 2008 and 2009 on behalf of the National Trust. Only two snakes were found, in June 2009, both with typical markings (John Grundy, pers. comm.).

The Gibside SSSI was classified as "*unfavourable recovering*" in its 2011 condition assessment, partly due to the status of the reptile species for which it is partially designated; adder and slow-worm were not found and grass snake numbers were decreasing (Natural England, 2011). Surveys for the other reptile species should therefore be implemented.

Durkin (2006) speculated that the population is under threat due to the large rise in the number of visitors to the Gibside estate since it was wholly opened to the public and the increase in areas of the estate important to the snakes which are now busy with visitors. He concluded that the population will become extinct in the near future unless remedial action is taken. The recent scarcity of snakes (John Grundy pers. comm.) seems to support this conclusion. A management plan for the Gibside Estate has been produced (Searle, 2007), which seeks to harmonise visitor requirements, estate management and the habitat requirements of the grass snakes. It remains to be seen whether the delicate balance required between people and snakes can be achieved and this most important northern population of grass snakes be retained.

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CROTALUS DURISSUS (neotropical rattlesnake): REPRODUCTION. *Crotalus durissus* is the only rattlesnake species in Brazil (Campbell & Lamar, 2004). Its reproductive cycle is seasonal and parturition occurs from December to March, during the summer (Almeida-Santos & Salomão, 1997; 2002; Barros et al., in press). Herein we present a new record of a litter of *C. durissus* from the Brazilian caatinga region, a semi arid area in northeastern Brazil.

Data about the period of copulation, timing of birth, offspring size and growth of seven newborns maintained in captivity is presented. Biometric data of these individuals are available from their birth to approximately one and a half years old. One female *C. d. cascavella*, collected in the city of Salvador (State of Bahia/Brazil) in 2001 and a conspecific male were placed in the same terrarium in early 2006 at the Butantan Institute. Mating was observed in late June 2006 (summer).

The female (1340 mm in snout-vent length [SVL], 90 mm tail length [TL]) gave birth to nine newborns (one dead and eight alive). One newborn died two months later leaving four males and three females. Neonates were maintained in captivity under permit from IBAMA 480548 (number 21154.003193/84-11). The young were kept individually in transparent boxes with cardboard as substrate, water and room temperature of 27.4°C. During the first six weeks they were fed one newborn mouse per week. After this period young were fed once a week with mice weighing 5 g. Later the snakes were fed only once every two weeks.

Biometric data (body mass, SVL and TL) were recorded every three months from December 2006 to July 2008. Student t-tests were used to detect differences in mean values of SVL, TL and body mass (BM) between young males and females. The relative clutch mass (RCM = total clutch mass/ body mass of the mother + clutch mass; see Seigel & Fitch [1984]) was 0.15.

Other species of viviparous terrestrial snakes present higher values of RCM (Shine, 1992). Births generally occur during the summer for C. durissus from northeastern Brazil (Table 1). Body mass and length (SVL) of newborns varied according to clutch size; newborns were larger and heavier when clutch size was smaller (N = 9); this study) than when it was large (N = 17; Barros et al., in press) (Table 1). Male tails were longer than females tails (t = -2.40, p = 0.03) (Fig. 1). The presence of hemipenes inside male tails may explain these differences (Shine et al., 1999). No significant difference was observed in SVL (t =0.22, p = 0.82) and body mass (t = 0.15, p = 0.88) between males and females that were maintained in captivity. The captive snakes also grew equally until 17 months old (Fig. 1).

Differential growth should be observed after sexual maturity is attained in snakes (Shine, 1994). The individual snakes monitored herein were likely still sexually immature, as sexual maturity is attained at 82 cm (males) and 83 cm (females) in *C. durissus* from northeastern Brazil (Barros et al., in press).

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Parturition (months/seasons)	Litter	SVL (mm)	Body mass (g)	Source
December to February (summer)	16 to 22	340 to 345	16 to 24	Cordeiro et al. (1981)
December to February (summer)	15*	401.7 (±29.1)	23.85 (±2.91)	Lira da Silva et al. (1994)
Unknown	17	294.35 (± 6.93)	22.59 (±3.54)	Barros (2007)
December (summer)	9	375 (± 5.7)	34.4 (±1.71)	This study

Table 1. Comparative data on the timing of parturition, litter size, snout-vent length and body mass of newborn *Crotalus durissus*. *Median value for 9 litters.

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Figure 1. *Crotalus durissus* growth curves; male (dotted line) and female (continuous line). A. Snout-vent length. B. Body mass. C. Tail length.

DIPSAS ARTICULATA (Central American snaileater): MAXIMUM SIZE. Dipsas articulata is an uncommon, arboreal and nocturnal snake with a distribution ranging from lowland tropical forests from southeastern Nicaragua to northwestern Panama. On 24 February 2011 at 22:06 we captured an adult male D. articulata perched at a height of 4 m in a tree in Caribbean lowland tropical wet forest of Tortuguero National Park, Limón Province, Costa Rica (Fig. 1). The individual measured 501 mm snout-vent-length, 218 mm tail length, and weighed 16 g. At a total length of 719 mm, this specimen represents the longest known record of D. articulata, exceeding the largest previous published size record of 712 mm total length (Savage, 2002).

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Figure 1. Dipsas articulata. Photograph by Alex Figueroa.

PELOPHYLAX LESSONAE (pool frog): PREDATION BY EURASIAN OTTER LUTRA LUTRA. During surveys carried out as part of a project to reintroduce the northern clade pool frog Pelophylax lessonae to England (Buckley & Foster, 2005), Eurasian otter Lutra *lutra* has been detected at the reintroduction site, in Norfolk, eastern England. The site includes many ponds. The nearest major waterway is a river approximately 2.25 km away at its closest point.

On 26 March 2010, during a night-time, torchlight survey for amphibians, an adult otter was observed in one of the ponds. That particular pond supported great crested newts *Triturus cristatus* and smooth newts *Lissotriton vulgaris* but, at that time, no other amphibian nor fish. During 2010 and 2011, three spraints (otter faeces) were found near to ponds that have been used by pool frogs and which support populations of sticklebacks, primarily nine-spined *Pungitius pungitius* but also small numbers of three-spined *Gasterosteus aculeatus*. The spraints were soaked, separated, and examined by two of us to identify fish and bird (DF) and amphibian remains (CGO).

Spraint 1 was found (18 July 2010) on the bank of a pond used by pool frogs. Bullhead *Cottus gobio* was the most abundant prey item in the spraint, but it also contained bones of eel *Anguilla anguilla*, brown trout *Salmo trutta*, at least two cyprinid species, including minnow *Phoxinus phoxinus*, and some large invertebrates (Table 1). There were no amphibian, bird or mammal remains.

Spraint 2 was found (29 April 2011) on a cut tree stump located between two ponds that are the most frequently used by pool frogs. The material was in poor condition, owing to digestion, but some bones were still identifiable to species. It contained at least one subadult male common frog *Rana temporaria* and one unsexed subadult pool frog (including a diagnostic left ilium). The spraint also included the remains of invertebrates, small fish and a rallid bird, most likely a moorhen *Gallinula chloropus*.

Spraint 3 was found (9 May 2011) on a fallen log lying in the primary breeding pond used by pool frogs. Pool frogs were present and males were calling at the time when the spraint was found

Spraint	1	2	3
Date	18-07-10	29-04-11	09-05-11
Invertebrate	Dytiscus sp. Odonate larva Melolontha melolontha	<i>Dytiscus</i> sp. Aeshnidae larvae	
Fish	Anguilla anguilla Phoxinus phoxinus At least one other cyprinid species Salmo trutta Cottus gobio	Gasterosteidae sp. <i>Cottus gobio</i>	<i>Phoxinus phoxinus</i> <i>Salmo trutta</i> Gasterosteidae sp.
Amphibian	-	Rana temporaria (subadult male) Pelophylax lessonae (subadult)	-
Bird	-	Rallidae sp. (probably <i>Gallinula chloropus</i>)	-

Table 1. Prey identified in otter spraint.

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The only fish species known to occur in the ponds are sticklebacks. The remains of other fishes in the spraints suggest that these prey were captured elsewhere, consistent with otter either passing through the site, or temporarily visiting. The remains of a pool frog in one of the spraints demonstrate that this reintroduced amphibian is prey for otters. The European otter occurs throughout western Europe (MacDonald & Barrett, 1993), encompassing the range of the pool frog.

but it contained bones of fishes only (Table 1.).

Amphibians, mainly anurans, are a significant prey item for the otter, usually secondarily to fish, with numbers taken peaking during the amphibians' aquatic phases such as hibernation and breeding (e.g. Weber, 1990; Clavero et al., 2005; Britton et al., 2006). The scarcity of pool frog remains in spraint at this site suggests that predation of this species has, so far, not been extensive. Otters are opportunistic predators and so although they are unlikely to prey preferentially on amphibians, high rates of predation can occur when the latter are aggregated in water bodies (e.g. Cogălniceanu et al., 2010). An otter chancing upon a breeding aggregation of pool frogs could seriously harm the reintroduction programme while the establishing population remains small and confined to only a few ponds.

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Natural History Notes

PSEUDEMYS CONCINNA (river cooter): UK ALIEN SPECIES. The farming and export of Trachemys scripta elegans for the pet trade and subsequent releases into the wild have been a concern for environmentalists for many years. Releases have resulted in the establishment of feral populations across the globe, including the UK. As a consequence T. s. elegans has been identified as one of the world's top 100 invasive species (Lowe et al., 2000). In 1998 the UK government banned T. s. elegans imports but other species (or subspecies), including several types of sliders (T. s. scripta and T. s. troosti) and river cooter (Pseudemys concinna) continue to be imported. Although T. s. elegans is apparently unable to reproduce successfully in the UK it can persist for many years and sightings of feral terrapins in northern areas of the UK usually concern only this species (RM pers. obs.). This note reports on a sighting of a different terrapin species in northern England.

On 28 July 2011 one of us (JSB) photographed a terrapin basking near the edge of the Leeds/ Liverpool Canal near Saltaire (53°50'N). The weather was sunny and warm and the selected basking site was a log in a semi-shaded area (Fig. 1 above). The terrapin had been seen swimming in the canal some weeks earlier and had an estimated straight-line carapace length of approximately 28 cm and would hence be an adult. It was seen again on 21 August at 08:20 emerging onto the same log to bask. It quickly returned to the water at the approach of cyclists but by 09:12 was back basking on the log. Further observations of basking were made at the same location on 22 August at 02:45 when water temperature was 18.6°C and the air temperature 15.5°C. A further sighting on 4 September, during mainly overcast weather, enabled a photograph of the neck markings (Fig. 1 below).

The canal is frequently used for pleasure boating, disturbing its muddy base, which may explain why the shell pattern is not particularly distinct and appears to differ daily. Wide yellow stripes on the underside of the neck with the central chin stripe dividing to form a Y-shaped mark, and notching at the rear of the carapace indicate it is a river cooter *P. concinna* from the eastern USA (Ernst & Lovich, 2009). The tail and front claws are short suggesting it is female.

River cooters are mainly herbivorous as adults and capable of hibernating at the bottom of ponds for several months (Ernst & Lovich, 2009) and hence have the potential to survive for long periods in the UK. Non-native species may disrupt ecological systems by predation or through competitive exclusion, but the numbers



Figure 1. First sighting on 28 July shows what appears to be a carapace covered in silt (above). Neck markings are those of a river cooter, which is supported by the serrations at the rear of the carapace (below).

of *P. concinna* imported are small compared to the former trade in *T. s. elegans* hence they may not present the same level of threat. However, their influence on UK ecosystems is unknown.

We are grateful to Christine Tilley (British Chelonia Group) for assistance with identification.

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RANA SYLVATICA (wood frog): LARVAL DURATION. Rana sylvatica is a widespread North American frog that breeds primarily in ephemeral wetlands in early spring. The duration of the larval period varies among populations and is influenced by temperature, latitude, altitude, density and pond-drying. Time to metamorphosis is a highly important life history trait in this species, as ephemeral wetlands typically dry by mid-summer in the eastern United States. Wood frog tadpoles that do not complete metamorphosis before ponddrying perish. In 2010 and 2011, I collected wood frog egg masses (total n = 33) from Pennsylvania Game Lands #176, Centre County, Pennsylvania, USA, and raised a subset of tadpoles from each clutch to metamorphosis in the laboratory. I observed a mean larval duration of 62.2 days \pm 0.65 SE for a total of 564 tadpoles that survived to metamorphosis, with larval duration ranging from 34 to 118 days.

One tadpole (not included in the above average) spent 147 days (almost five months) in the larval phase before metamorphosing. This tadpole hatched in the laboratory on 4 April 2011, sprouted one hind limb on 26 August and the second hind limb on 28 August 2011, thus completing metamorphosis approximately three months later than the average tadpole in our study population. At metamorphosis, this individual had a snoutvent length of 11 mm and was 0.612 g, which was close to the averages of other individuals at metamorphosis in this population. Although all tadpoles were raised in the laboratory under a constant temperature (22.2°C), the majority of tadpoles completed metamorphosis before their respective ponds dried in the field. The larval duration of this unusual tadpole even exceeds by 14 days the maximum duration of a high-altitude population in the Shenandoah Mountains, Virginia, where larval duration is typically very long, ranging from 82 to 133 days (Berven, 1982). This intra-population variation is notable in a species with strong selection on larval duration due to pond-drying. This specimen will ultimately be deposited in the Langkilde Laboratory, Penn State University, Pennsylvania, with a voucher number of 1:1.5H.28 Aug 11.

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RHINELLA **GRANULOSA** and PHYSALAEMUS KROYERI: INVERTEBRATE DYTISCID PREDATORS. The dytiscid family of predatory water beetles comprises a large number of species distributed almost worldwide. It includes some of the main predators of adults and larvae of several anuran species, as reported by researchers since 1960s (see Wells, 2007). Dytiscids are important predators of adults and larvae of anurans (Rubbo et al., 2006; Wells, 2007), plaving a fundamental role in the demographic control of amphibian populations (Ideker, 1979; Formanowicz, 1986; Holomuzki, 1986). In addition to anurans, the diet of adults and larvae of dytiscid beetles includes invertebrates (e.g., molluscs, crustaceans, insects, and leeches) and vertebrates such as small fish.

In the present study, we report two events of anuran predation by dytiscids: adults of *Megadytes*

(*Bifurcitus*) *lherminieri* (Laporte, 1835) preying on an adult of *Rhinella granulosa* (Spix, 1824) (Anura, Bufonidae) and larvae of *Rhantus* (*R.*) *calidus* (Fabricius, 1792) preying on larvae of *Physalaemus kroyeri* (Reinhardt and Lütken, 1862) (Anura, Leiuperidae).

Both *Megadytes Iherminieri* and *Rhantus calidus* have a wide geographic distribution. According to the biogeographic categories proposed by Benetti & Garrido (2004) *M. Iherminieri* is a Neotropical species, found from Mexico to Argentina, while *R. calidus* is an interamerican species, found from Canada to Patagonia. Few studies have focused on the ecology of this group of coleopterans. Most are taxonomic studies and do not report on the diet of these species (Benetti & Régil, 2004; Ferreira Jr. et al., 1998).

On 22 October 2010, we observed a breeding event of Rhinella granulosa, in a semi-permanent water body (11 x 7 m) in the rural municipality of Jequié, Bahia state (13°56'34.5"S, 40°06'31.6"W, altitude of 700 m above sea level). Rhinella granulosa is a small frog with a wide geographic distribution (from northern Rio de Janeiro to eastern Minas Gerais, Espírito Santo, Bahia, Piaui, and eastern Maranhão to Pernambuco and Rio Grande do Norte) (Frost, 2011). Two adult M. *lherminieri* were observed attacking and preving on an adult male of R. granulosa (SVL = 50.2mm) (Fig. 1). Before the attack, the frog was floating, possibly actively searching for females, a strategy widely used by frogs of this genus during reproductive events (Haddad & Bastos, 1997; Dayton & Fitzgerald, 2001; Wells, 2007; Narvaes & Rodrigues, 2009). During the attack, the anuran was turned upside down by the two *M. lherminieri*. While partially submersed, the body fluids of the frog were consumed in approximately 40 minutes by the predators. Only the skin and venom glands remained.

Reports of the predation of adult vertebrates by dytiscid beetles are relatively rare in the literature (e.g., Ideker, 1979; Johnson et al., 2003; Caputo et al., 2006). Among invertebrates it is more commonly described for species that present a needle-like proboscis (Haddad & Bastos, 1997; Brasileiro et al., 2003). The absence of a more specialised buccal apparatus in *M. lherminieri* (masticatory apparatus) might indicate a learning process regarding the most palatable portions of anurans or mechanisms to detect the venom produced by the skin and/or paratoid glands of *R. granulosa*.

The second incidence of predation was observed in the laboratory. On 19 November 2010 two clutches of *Physalaemus kroyeri* were collected from another semi-permanent water body $(5 \times 3 \text{ m})$ in the same region and maintained in the laboratory. After tadpoles emerged (24 hrs), larvae of *R. calidus* were also observed, presumably originating from eggs laid on the foam nest. The individuals observed during the predation events were fixed in 10% formalin (adult anuran) and/ or fixed in 70% ethanol, and deposited in the zoological collection of the State University of Southwest Bahia, municipality of Jequié, Bahia state, Brazil.

On 26 November 2010 another nest of the same anuran species was collected from the same water body and maintained in the laboratory without removing larvae of *R. calidus*. All eggs and newlyemerged tadpoles were preyed upon by the larva of *R. calidus*, which also consumed its siblings. Egg deposition on clutches of anurans may be an adaptive behaviour for *R. calidus*, ensuring a food source for its offspring.

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Figure 1. Adult male of Rhinella granulosa being preyed upon by two individuals of Megadytes lherminieri.

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Hunters in the Trees: A Natural History of Arboreal Snakes

Richard A Sajdak 2010, Krieger Publishing, 171 p.



Although at first a little hard to categorise, this is an enjoyable and accessible book that I found at times to be slightly similar in tone and delivery to the two recent Mark O'Shea books (*Venomous Snakes of the World/Boas* and *Pythons of the World*). As with those publications there is a mix of anecdotal observation and scientific fact illustrated by plenty of pictures. The author obviously has a great love of snakes in general and arboreal species in particular, and this enthusiasm comes across well.

The book starts with a chapter entitled 'What is a Tree Snake?' An apparently easy question until you attempt to answer it concisely! Many snakes utilise trees should opportunities for hunting, basking, sheltering or escape arise but would not automatically be described as arboreal. It seems that representatives of at least half of all snake families have been recorded in trees at some point while not necessarily being classed as arboreal and a number of these are mentioned here. The focus of this book, however, are those species that have specialised adaptations leading to an arboreal way of life beyond the opportunistic use of trees seen in many species. It is these morphological and behavioural adaptations that are the focus of the following four chapters.

Chapter 2 covers shape, size and mobility of arboreal snakes and includes a lengthy discussion of the blood flow system and its associated costs, using the giraffe as an extreme example for comparison. Colour, pattern and camouflage are looked at in the next chapter and provide an easily digestible and fascinating read. In contrast I found the chapter entitled 'The Greatest of Ease' - describing the ability of tree snakes to move about so fluidly in their environment - to be as hard work in places as some of the movements described. Some more diagrams would have helped to describe the various modes of locomotion, as it does when showing the amazing take-off sequence of a paradise flying snake Chrysopelea paradisi in the more readable section covering gliding and 'flying'. The chapter closes with an interesting, albeit brief, discussion of rainforest types around the world and how this affects the distribution of the various gliding snake species.

Chapter 5 starts with a nice ecological account of niche separation and feeding guilds before looking at the prey and foraging modes favoured by different groups of tree snakes occupying different niches. Defence and habitat use are also discussed. The remaining sections of this book focus on the various 'groups' of arboreal snakes, organised by prey types and/or foraging mode, beginning with the vine snakes (and very briefly the African twig snakes), and then moving on to frog-eating species (the obvious such as Chironius and Leptodeira as well as some that did not immediately spring to mind such as tree cobras of the genus Pseudohaje). Bird eaters are covered as well as the fact that arboreal snakes are often on the menu for bird species. The generally larger or more venomous mammal eaters feature in their own chapter and then the less well known invertebrate eaters such as the slug-eaters and snail-suckers. The chapter on boas and pythons is followed by a discussion of venomous arboreal species.

The final chapter is about cat snakes and focuses mainly, and not surprisingly, on the invasive brown tree snake *Boiga irregularis* which has had such an impact on the Pacific island of Guam. Although hugely damaging to the native fauna of the island it is difficult not to be impressed by the adaptability and shifts in behaviour patterns demonstrated by this species after its arrival.

Throughout the book there are many good photographs illustrating some of the amazing variety of arboreal snake species. These include two depicting the truly bizarre Madagascan leaf-nosed snake *Langaha madagascariensis*, a logic-defying predation attempt by an Asian vinesnake *Ahaetulla prasina* and many other stunning species. A modest list of citations is provided, which may appear scant compared to other specialist herpetological books but is certainly enough to get the reader on the trail of further information.

I would have liked to have seen some more information regarding the evolutionary aspects of arboreal snakes, how they are related, and why they have come to occupy the places they do and the different niches within their habitats. Perhaps that is the real achievement of this book. It leaves you wanting more due to the many 'snippets' of information provided! Some of the highlights for me include the ongoing 'duel' between woodpeckers and grey/central ratsnakes Pantherophis spiloides in the north American pine forests and a truly fascinating account of the relationship between screech owls and Texas threadsnakes Leptotyphlops dulcis. This latter section leads into what appears at first to be a strange digression to cover the largely fossorial threadsnakes and blindsnakes (Leptotyphlopidae and Typhlopidae respectively) but in fact reveals a surprising arboreal aspect to the ecology of these species.

The book remains largely non-technical throughout but avoids 'dumbing down'. It will provide a lot of information to someone new to arboreal snakes, while at the same time leaving tantalizing trails for a more experienced herpetologist to follow. As a catalyst for inspiring further research I think this book works very well, while also being a good, generally very readable overview of the relevant species with some good photographs to illustrate the diversity described.

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Venomous Snakes of Europe, Northern, Central and Western Asia

Patrick David and Gernot Vogel 2010, Terralog, Edition Chimaira, 160 p.



This is the third of Edition Chimaira's Terralog series focussed on venomous snakes. For those who are not familiar with the Terralog series let me introduce you to it. What Edition Chimaira have set out to do is to produce a catalogue of all the species, including subspecies and their myriad of colour forms, of reptiles known to science in a pictoral form. So what we have in this, the 16th volume, is a catalogue of high quality photographs of all the species of venomous snakes known from Europe and Northern, Central and Western Asia.

As well as being a great source of inspiration to the snake enthusiast, and light bedtime reading rather than being a heavy going scholarly tome, this book is a useful aid to field identification as the photography is top class with many images of unusual colour variations that are not normally seen as well as habitat shots and distribution maps for each species and subspecies. At the beginning of the book there is a detailed, and well referenced, explanation of the taxonomy the authors have chosen to follow in both English and German.

The main issue I have with this book is that as well as producing an identification guide Edition Chimaira have chosen to also have a husbandry aspect to the Terralog series that is limited to a series of symbols that appear as legends below each photograph. While there is the obvious benefit of bringing these species to the enthusiast's eye there are some inherent flaws in encouraging the captive husbandry of obscure subspecies or colour forms some of which have extremely limited ranges and are highly vulnerable to being collected from the wild, something that should be discouraged by publishers, hobbyists and professionals alike. It is the only responsible thing to do. Added to this is the fact that the guidelines for husbandry contained in this book are extremely basic at best.

When one starts looking in detail at the meanings of the symbols it becomes apparent that there have been some oversights that range from being frustrating to potentially irresponsible and erroneous. At the frustrating end of the scale is the fact that the order in which the symbols appear under the photographs is different to that in the section where they are defined. Additionally some of the symbols that refer to different things such as demeanor and food preferences are similar but have completely different meanings. For example, a snake that is considered to be of limited danger is indicated by a face with a straight line for a mouth and a dangerous snake has face with a downturned mouth - fine, except that under diet there is a smilev face that indicates omnivorous tendencies. Not only is this slightly confusing but I do not know of any snake that is omnivorous, the

definition of which, according to the New Oxford American Dictionary is '(of an animal or person) feeding on food of both plant and animal origin'. Apparently according to the authors, for example, the saw-scale viper Echis carinatus sochureki is an omnivore

At the potentially irresponsible end of the scale is the use of the symbol indicating that a species is only suitable for experienced keepers. Why is that a problem? Surely that is a good thing when it comes to keeping any animal responsibly! Well, in principal I agree but then considering every snake in this book is venomous then they should all have this symbol. Suprisingly they do not, and I question why a European adder Vipera berus has this symbol and a species such as a Palestinian viper Daboia palaestinae does not. Whether venomous species should be kept in a domestic setting by anyone, regardless of their experience, is controversial.

While it would be more appropriate for any information about husbandry to be kept to a detailed book dedicated to the subject, if one ignores the symbols and concentrates on the fact that what you have here is a marvellous collection of photographs of some stunning snake species then this book is well worth the money. As is a bottle of correction fluid to remove the husbandry guidelines.

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EDITOR'S NOTE

DEAR READERS - This is the last Herpetological Bulletin from my term as editor. I wish to take this opportunity to thank the council of the British Herpetological Society for the opportunity and for their support during my time as editor.

It has been insightful managing and designing the Bulletin. I have enjoyed its production and meeting so many professionals and keen amateur herpetologists from around the globe.

I especially thank John Baker (Co-editor) for his dedication to detail during the editing process and for the long, interesting and often late night discussions on herpetofauna. John's efforts

significantly improved accuracy and he also continues to help secure more UK content for the publication. Thanks also to Roland Griffin for his enthusiasm in managing the Book Reviews section over the years and for his keen eye in promoting the Bulletin to potential authors.

I thank my family for moral support during the many weekend hours spent at the computer. I also thank Bruce Clark for printing the many editions and for guidance on production. Finally I thank all the authors for their contributions and patience that has continued to ensure the Bulletin's popularity.

Dr Todd Lewis