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Front cover illustration

Anotheca spinosa from the Mosquitia, Honduras. Photograph by J.R. McCranie. See article on page 15.

Response of monitor lizards (*Varanus* spp.) to a repeated food source; evidence for association learning?

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ABSTRACT — Food location times have been recorded in three captive monitor lizards (*Varanus* spp.). The results, in the form of regression equations, showed that in general the time taken to locate the food decreased with the number of times the food was offered.

ITTLE work has been carried out on learning in varanid lizards (Phillips, 1994; Horn, 1999) which is perhaps surprising given their general impression of alertness even to the casual observer. We devised a simple experiment using food as a positive reinforcer to evaluate association learning in three adult monitor lizards from three species. Varanus niloticus ornatus, V. albigularis and V. exanthematicus. We used monitor lizards for two reasons. Firstly there was always a good response to food as a stimulus in our research animals. The second reason was that many types of monitor lizards are intense active foraging predators (Regal, 1978) travelling large distances in their search for food (Thompson & Withers, 1997; Thompson, 1999 and Bennett, 1998 for a review). We predicted that this behaviour, combined with the interest in food, increased the probability of the experiments giving meaningful results. The work was part of a second year HND research project on animal behaviour at Huddersfield Technical College carried out by IF, MT and MR under the supervision of RM.

METHODS AND MATERIALS

A variety of assumptions must be made when selecting methods of evaluating learning in animals. The method employed here was based on showing the lizards a food item then repeatedly placing it in the same location in an enclosure where it could not be visually observed. The time taken to locate and consume the food item was then recorded. We assumed that if the lizards were learning from experience then the time taken to locate the food should decrease with the increase in the number of trials. The trials were run from midday onwards which allowed approximately four hours for the animals to heat up and activity body temperatures to be attained. Skin surface temperatures of the lizards were measured with a non-invasive Omega OS204 Digital Thermometer immediately before the commencement and at the conclusion of each trial -i.e. just after the animal had swallowed the food. All enclosures had heating facilities to allow the lizards to bask if required but this was not observed during the trials. The experimental arenas were different for each lizard, all of which were imported into the UK as juvenile animals.

Enclosures

Varanus niloticus ornatus (male approximate length 1.2 m). The nervous disposition of this species is well known and our lizard's behaviour was no different. Therefore to avoid any unnecessary stress to the animal, the trials were



Figure 1. A graph of food location time plotted against the number of trials in three monitor lizards. The lines taken through the data are derived from the regression equations given in the text.

conducted in its permanent housing. This was a three-tiered enclosure with lengths of 3.5 m and widths of 1m in the top and bottom levels. The middle level had similar dimensions but a length of 1.3 m. A facility for passage between levels was by way of a tree trunk running vertically from the bottom to the top floor. The top floor had a 2 x 1 m pool and a series of horizontal branches, the bottom floor large rocks and a 0.6×0.4 m hide box. The overall height of the enclosure was 2 m. The placement of the food was carried out when the lizard was in the top floor and located at the furthermost point of the bottom level from the point of the lizard's entry.

Varanus albigularis. (male approximate length 1.2 m). The trials for this lizard were also conducted in its regular enclosure. This had a length of 3.5 m by 1.5 m wide and 3 m high. Two hide areas, a horizontal tree trunk, and a living evergreen tree (*Ficus* sp.) whose growth reached the roof of the enclosure were the main furnishings. The food was shown to the lizard when it was in the top of the tree and placed in an area out of view on the ground.

Varanus exanthematicus. (female, approximate length 0.6 m). The trials for this animal involved its transfer from rather small housing conditions to an enclosure 10 m in length by 5 m wide. Ten wooden boxes were placed at equal distances on both the right and left hand sides of the unit to act as visual barriers. The food item was then shown to the animal and located at the opposite end of the enclosure.

RESULTS

Body temperatures of V. niloticus ornatus during the trials were from 27-35°C, mean = 31.6°C, in V. albigularis from 18-34°C, mean = 27.0°C and in V. exanthematicus from 18-34°C, mean = 32.0°C. Figure 1 shows the amount of time taken for the lizards to locate the food in respect to the number of times the food was offered (trial number). The lines taken through the data are derived from regression equations of the form y = b + mxwith the time taken to locate the food treated as the dependent variable y and trial number as the independent variable x. Coefficients of determination (r^2) have been attached to each equation to estimate the amount of variation in food location time that can be explained by the increasing number of trials. The results produced negative slopes in all three data sets with the following relationships:

V. niloticus ornatus: Location time = 25.9-1.71trial number, $r^2 = 55.2\%$.

V. albigularis: Location time = 18.7-1.27trial number, $r^2 = 31.7\%$.

V. exanthematicus:

Location time = 23.1-1.00trial number, $r^2 = 16.7\%$.

The negative slopes indicate shorter food location times with the increasing number of trials. If there had been no improvement in the times taken to find the food regression coefficients of 0 would have been found. To test for departures from this hypothetical value, a *t*-test at *n*-2 degrees of freedom was applied to the regression coefficients (Bailey, 1981). The results showed significant departures from 0 in *V. niloticus ornatus* (t = -3.84, p = 0.002, d.f. = 12) and *V. albigularis* (t = -2.35, p = 0.03, d.f. = 12) but not in *V. exanthematicus* (t = -1.62, p = 0.13, d.f. = 13). The latter statistic is probably due to the initial slower location time (greater scatter) in this animal up to trial 10 (see Fig. 1).

DISCUSSION

The learning capabilities of the monitor lizards used in this study are perhaps not unexpected. Consider the problems of a hungry monitor lizard. a foraging predator faced with a series of alternative foraging routes, one of which gives a better food reward than the others. Clearly, if the lizard behaves optimally it should follow the route that gives the better food reward but how is the animal to find this out? In theory it has to spend time sampling all foraging routes before settling down to exploit the best one which is essentially what our results appear to show, with the initial lengthy foraging periods (of around 40 minutes) gradually reducing to lapsed times of as little as 2-3 minutes. The apparent slower learning response in V. exanthematicus is readily explained by what we considered a more difficult learning task at the commencement of the experiments than for the other lizards, i.e. the trials were carried out in a larger enclosure that was not used for the animals regular housing. However continuation of the trials in this lizard would perhaps have improved the r^2 values and given a significant departure from the 0 hypothetical coefficient.

The results of this study provide good evidence that our monitor lizards learned with experience, which is in agreement with learning experiments involving other types of reptiles in mazes. These

have included V. albigularis (Phillips, 1994) where a gradual reduction of running latency was observed - the time from entering to the time of exiting a maze box (Burghardt, 1977), and autoshaping experiments on V. bengalensis where, after initial training, the lizards solved problems correctly 85% of the time (Loop, 1976). Horn (1999) proposed that an intensive foraging lifestyle is a precondition for complex data collecting in animals and that many monitor lizard species fall into this category; large (and hence complex) home ranges and elaborate behaviours increase the volume and range of information that needs to be processed for storage and retrieval by the brain during daily movements. The brain therefore evolves in association with these constraints and the whole process is a basis for the evolution of higher order decisions and associations. A foraging lifestyle places much greater demands, for example, on the problem solving requirements of sit-and-wait predators with limited home ranges (Harvey & Bennett, 1983) and even cruising foragers (Horn, 1999). This relationship between lifestyle and brain morphology has been observed even in closely related lizards, for instance the relative size of the hippocampus is larger in the active foraging Acanthodactylus boskianus than in its sit-and-wait congener A. scutellatus (Day et al., 1999).

Although temperature effects were not recorded in our study, we recognise that this is a potentially important aspect for learning in reptiles. For example, in a study of learning in Desert Iguanas (*Dipsosaurus dorsalis*) it was found that lizards with high body temperatures learned mazes significantly quicker than lizards with low body temperatures (Krekorian et al., 1968), whilst other lizard species have demonstrated operant responses to thermal rewards (Regal, 1971). These findings suggest, at the very least, that learning studies involving reptiles should ensure that the animals are able to operate within normal activity body temperatures for the results to be meaningful.

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Varanus niloticus. Reproduced from Reise Nach Mossambique, Zoologie, by Wilhelm C.H. Peters. 1882.

Night counting, netting and population dynamics of Crested Newts (Triturus cristatus)

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ABSTRACT - Surveillance of a population of Crested Newts (Triturus cristatus) has been undertaken at Shillow Hill, Cambridgeshire during each breeding season from 1983 to 2002 by means of torch counts of adults. Reproductive success has been monitored by netting larvae each summer since 1986. The introduction of springtime netting for adults in 1993 enabled levels of recruitment and survival to be studied for the period 1993-2002. The population was at a low level in 1993 following drought in 1990-1992. Successful emergence in each year from 1993 to 1996 resulted in recovery between 1995 and 1998 through recruitment to the adult population two or three years later. Size of larvae at the end of development was inversely related to density. The adult population stabilised during 1998-2002, when the likelihood decreased of a larva returning as an adult, perhaps because of emigration of metamorphs. Annual survival of adults showed no significant trend during the study, mean survival being estimated at 71%. In 2001 and 2002, adults remained in the breeding pond for longer into the summer and few metamorphs emerged, apparently due to cannibalism. The effect of this regulation should be felt as reduced recruitment to the adult population during 2003-2005. Over the entire 20 years of surveillance, most of the larger inter-year fluctuations in counts of breeding newts resulted from changes in suitability of the pond rather than real changes in the level of the population.

ALTHOUGH the Crested Newt (*Triturus cristatus*) is widespread through much of lowland Britain, it is strictly protected by law and is the subject of considerable survey and conservation effort (Griffiths & Inns, 1998; Langton et al., 2001; Baker, 2002). Counting adult newts at night with a powerful torch is the usual method for determining the conservation status of populations breeding in sites with relatively clear water. An extension of such work is to repeat night counting over a period of years, perhaps to monitor populations subject to conservation action or potentially damaging operations, or because a population is of local or national importance.

An example of the last type of surveillance has been undertaken at Shillow Hill in Cambridgeshire since 1983. Mean numbers of adult Crested Newts counted at night each year, 1983-1993, varied between 3 and 183 (Cooke, 1995). While it was possible to speculate about the causes of a significant increase in adult numbers in 1985 and a decrease in 1989, there was limited underpinning evidence. To provide a better understanding of variations in numbers counted, additional field techniques, involving netting, have been introduced. These have now been in operation for at least ten years, and results for the years 1993-2002 are the main focus of this paper. The regular application of night counting and associated netting techniques over a number of years may further our understanding of the population processes of this species. Here this is based on comparisons rather than by deriving absolute population data as in other studies on this species (e.g. Arntzen & Teunis, 1993; Baker, 1999). Such knowledge is crucial to the surveillance and management of Crested Newt populations, both at specific sites and in general.

THE SITE

The site has been described by Cooke (1985, 1986, 1995 and 2002) and Cooke & Arnold (2001). The Shillow Hill site (grid reference TL 2882) is in Cambridgeshire and extends to 2 ha of seminatural habitat. It is bordered by a road, the B 1040, and isolated by at least 500 m of arable farmland from its nearest neighbouring Crested Newt breeding pond. Significant natural immigration is therefore very unlikely; the extent of permanent emigration is unknown, but newts are found on the surrounding arable land close to the site at certain times of year.

There was a prolonged drought during 1990-1992; few newts were counted during the breeding seasons because of low water levels, and further desiccation in summer meant little or no emergence of metamorphs. During 1993-2002, successful breeding by Crested Newts was restricted to a single pond, Top Pond. When full, Top Pond has 48 m of edge and a depth of 1.4 m. Prior to creation of the sump in 1991, it was only 0.7 m deep. Crested Newts bred in Wood Pond in the 1980s, but this later suffered persistent desiccation problems and only a single Crested Newt was recorded there during 1993-2002.

METHODS

If pond and counting conditions can be strictly controlled, changes in numbers of adults counted at night in Top Pond may reflect changes in the size of the newt population using the pond. During 1984-1986, night counts in the pond were positively related to totals caught by a standardised bottle-trapping method, an independent quantitative measure (Cooke, 1995). In 1984, the mean night count of adults represented 23% of the total estimated to be present in Top Pond by markrecapture methods (Cooke, 1985).

The number of adult Crested Newts that might be counted at night in a breeding pond depends on many factors. First, number of adults will depend on recruitment via immigration or young becoming sexually mature and on losses through emigration or death. Immigration at Shillow Hill can probably be discounted. Secondly, the proportion of the population in the water will depend on season, pond suitability and possibly population size. Even at the height of the breeding season, some newts will be on land. Thirdly, not all newts in the water will be counted. Newts in a pond may be inactive and/or may hide from view. Whether a newt is visible will depend on factors such as time of day relative to sunset, season and weather conditions. It is also possible that newt behaviour may be related to density in the pond. Fourthly, the nature of the pond will influence the count, with newts being easier to see in small ponds with clear water, little or no aquatic vegetation and where there is access for the observer to the whole shore. Finally, an ability to see and count newts at night depends on power of torch and the skill and care of the observer.

Each breeding season 1993-2002, five night counts were undertaken in Top Pond at roughly fortnightly intervals from the second week of April to the first week of June (numbers of counts 1983-1992 are given in the legend of Figure 1). Over the last 20 years, there has been no significant trend in the timing of the peak count. Counts were made between 50 and 120 minutes after sunset. Whenever possible, counting was avoided when rain was falling or at air temperatures of $< 5^{\circ}$ C. Each night visit consisted of counting, on a single circuit, adult and immature Crested Newts seen in the whole of the margins of the pond plus its centre. Smooth Newts (Triturus vulgaris) also breed in the pond but their numbers are not reported in this paper.

Water conditions in Top Pond were classified each spring (as well as each summer and autumn) as: 'full' (if the whole bed of the pond was covered), 'sump' (if only the sump held water), or 'dry'. In early April each year, filamentous algae and twiggy debris were raked from the edges of the pond. When counting at night, percentage cover of surface vegetation was recorded and a stick was used to move aside surface or submerged vegetation that might be obscuring newts. Water turbidity was scored by eye from 0 (clear) to 3 (turbid). If possible, counting was avoided for several nights after heavy rain, because turbidity usually increased. All night counting was undertaken by the authors, with the aid of torches of up to 70,000 candlepower. So, while many factors could be controlled, this was not (completely) the case with amount of water in the pond, amount of aquatic vegetation or turbidity. Some precautions could be taken, but the principal approach with these variables was to record them, and check later whether they may have influenced results. For instance, a major difference in turbidity in successive years could produce a spurious inter-year comparison.

Other fieldwork involved netting adults in the spring and larvae in the summer. Once per year since 1993, during late April or early May, about 30 minutes were spent netting at night. Adult Crested Newts were caught, weighed and measured from tip of snout to end of tail and returned to the pond. An index of body condition was derived by dividing the weight (in mg) by the cube of the length (in cm). Adults were classified as 'large' (males > 106 mm, females > 120 mm) or 'small', these size thresholds were derived by measuring a sample of adults in 1993 after three years of virtually total breeding failure (Cooke, 2002). The inference was that large newts tended to be aged at least four and small ones tended to be three years old or less. If it is assumed that small and large newts can be seen or caught with equal ease, then mean numbers counted at night can be apportioned into the two classes. This forms the basis for understanding fluctuations in recruitment and for estimating adult survival. Annual adult survival was derived by dividing the estimated

mean number of large newts counted in a year by the total number of adults (i.e. small + large) counted in the previous year.

During July and August 1986-2002, Top Pond was netted during daylight on four occasions, usually at about one week intervals,

Table 1. Conditions duringthe four years when suitabilityof Top Pond and the ease ofseeing newts were consideredto be atypical.

to provide an indication of relative larval abundance at metamorphosis. For each metre of shore, a 2 m sweep was made through the water and aquatic vegetation. When water remained only in the sump, one sweep was made per 2 m^2 of surface area. Newt larvae were identified and counted. Length was measured for Crested Newt larvae at the 'walking' stage, immediately prior to emergence (Cooke & Cooke, 1992). Any adults or immatures that were caught were recorded. All newts were returned to the pond.

RESULTS

During night counting in six of the ten years, 1993-2002, Top Pond was full, had a mean turbidity score of 1 or less, and aquatic plant cover reached at least 60%. Such conditions are taken to be typical. Conditions in the four remaining atypical years are listed in Table 1, together with predicted effects on numbers of newts in the pond and the ease with which newts might be seen. In the spring of 1997, only the sump was available, conditions which had previously resulted in few newts attempting to breed (Cooke, 1995); the small size of the sump should have made the newts easier to see, but turbidity was high. In 1999, high turbidity would have made them harder to see, but this effect might have been cancelled out by less plant cover. Very high turbidity in 2001 probably reduced counts, but low plant cover in 2002 should have made them easier to record; comparisons of night counts in 2001 and 2002, in particular,

Year	Water level	Mean turbidity	Maximum plant cover (%)	Effect on newt numbers in pond	Effect on ease of seeing newts
1997	Sump	1.3		Reduction	?
1999	Full	1.6	30	No effect	?
2001	Full	1.8	60	No effect	Harder
2002	$t_{i}^{\mu}C_{i}t$	0.9	35	No effect	Easier



Figure 1. Mean night counts (+SE) of adult Crested Newts in Top Pond, 1983-2002. Means are based on a single count in 1983, nine counts 1984-1987 and five counts 1988-2002. Springs when only the sump was available are indicated (s).

should therefore he treated with caution.

Mean night counts for 1993-2002 are depicted in Figure 1, together with counts for the previous ten years. The period 1993-2002 was preceded by a drought between 1990 and 1992, when few adults attempted to breed and virtually no metamorphs emerged. There was a general increase in adults counted from 1993 to 2002 ($r_s = 0.636, P < 0.05$). Testing between mean counts of adults in pairs of years, 1993-2002, counts increased significantly in 1996 (Table 2, $t_8 = 2.54$, P < 0.05) and 1998 ($t_8 =$

3.83, P < 0.01), with a decrease in 1997 ($t_8 = -4.70$, P < 0.01). The decrease in 1997 and subsequent recovery in 1998 confirmed the expected temporary reduction in 1997 resulting from the unusual pond conditions described above. During 1993-2002, counts of immature newts were highest in 1994 and lowest in 1997 when there was water only in the sump (Table 2).

Using the observed proportion of small newts in the population (Table 2), mean night counts have been divided into two components representing small and large individuals (Table 3). The small newts are assumed to be the newer recruits to the adult pool, but they may have been breeding for more than one year. To provide some information on the age of newts in the two size classes, estimated number of small or large newts counted each year was compared in rank correlation tests with mean numbers of larvae caught a certain number of years before (N_{i}) . Larval counts 1993-2002 are listed in Table 4 and those prior to 1993 are given in Cooke (1995). Adult count data from the unusual year of 1997 have been omitted because their inclusion could result in misleading conclusions (see Cooke & Arnold, 2001).

For small adults, there were no significant relationships with reproduction in any individual previous year, but numbers of small adults were related to mean catch of larvae in combinations of

the following consecutive

Year	Spring water level	Mean adult count ±St	Mean immature count <u>+</u> SE	Propn small adults in netted sample (no. in sample)	Mean body condition index ±SE for large adults (no. in sample)	years: two-three years before, $(N_{.2} + N_{.3})/2$ $(r_s = 0.717, P < 0.05)$; and two- four years before $(N_{.2} + 1)/2$
1993	Full	42 <u>+</u> 14	0.2 <u>+</u> 0.2	0.00 (15)	6.3 ± 0.2 (15)	Table 2. Results of spring
1994	Full	28 <u>+</u> 3	5.2 ± 3.5	0.00 (11)	6.0 ± 0.2 (11)	counts of adult and immature
1995	Full	36 <u>+</u> 5	1.0 <u>+</u> 0.0	0.29 (21)	5.7 ± 0.2 (15)	Crested Newts are based on
1996	Full	71 ± 13*	2.4 ± 0.7	0.65 (20)	5.3 ± 0.3 (7)	five night visits. The
1997	Sump	9 <u>±</u> 4**	0.0 <u>+</u> 0.0	0.60 (25)	5.2 ± 0.2 (10)	and body condition index for
1998	Full	102 ± 24**	1.2 ± 0.7	0.35 (17)	6.8 <u>+</u> 0.3 (11)	large adults are based on a
¹ 999	Full	62 <u>+</u> 21	3.4 ± 1.5	0.33 (9)	5.1 <u>+</u> 0.4 (6)	single netting visit. See text
2000	Full	76 <u>+</u> 22	2.2 <u>+</u> 0.7	0.30 (30)	6.4 <u>+</u> 0.2 (21)	for definitions of small and
2001	Full	60 <u>+</u> 20	1.2 <u>+</u> 0.6	0.23 (13)	5.6 <u>+</u> 0.3 (10)	different from previous
2002	Full	107 <u>+</u> 11	2.2 <u>+</u> 0.7	0.24 (29)	5.8 ± 0.2 (22)	mean, $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

 $N_{-3} + N_{-4}/3$ ($r_s = 0.679, P < 0.05$). Numbers of large adults were related to N_{-4} ($r_s = 0.779$, P <0.05); they were also related to N_{-2} ($r_s = 0.654$, P <0.05), but not to N_{-3} ($r_s = 0.050$) nor to N_{-5} ($r_s =$ 0.179). It is probably more relevant for the large adults to examine when increases in their numbers occurred: 1998, 2000 and 2002. Both 2000 and 2002 were two and four years after years of high larval numbers. 1998 was two years after the productive year of 1996. However, 1998 was also five years after the initial productive year of 1993; had water conditions been suitable in 1997, this might also have been a good year for large adults. The initial productive year of 1993 was not followed two years later by an increase in large adults. These results are consistent with the small adults mainly being two and three year olds and large adults tending to be four years of age or older. They do not, though, exclude the possibility of older newts occurring in the sample of small adults and younger newts being in the sample of large individuals.

For numbers of small adults, the best fit was found with larval numbers two-three years previously. How the ratio of small adults per larva varied over time is examined in Figure 2. No small adults were recorded in 1994 (data from 1993 were used to define the size classes). Small adults were first recorded in 1995, and numbers per larva reached a peak in 1996, the first year of the study in which two year olds and three year olds could return. After 1996, a small adult was less likely to result from a larva dating from two or three years before. Taking 1993 as Year 1 and 2002 as Year 10, numbers of small adults can be described by the quadratic equation: Number = 0.463Year -0.0397Year² - 0.521 (F_{2.6} = 6.38, P < 0.05).

Estimates of annual adult survival (Table 3) will be lower than true survival if some newts breed as small adults for more than one year, but higher than true survival if some newts breed for the first

Figure 2. Variation over time, 1993-2002, in the estimated count of small adult Crested Newts divided by the mean number of larvae caught two and three years previously. Data for the unusual year of 1997 are omitted. The line shown is: Number = 0.463Year - 0.0397Year² - 0.521 (where 1993 = Year 1 etc).

Year	Estimated r	Estimated mean count				
	Small adults	Large adults				
1993	0	42	-			
994	0	28	67			
995	10	26	93			
996	46	25	69			
997		-				
998	36	66				
999	20	42	41			
2000	23	53	85			
2001	14	46	61			
2002	26	81	135			

Table 3. Estimated mean counts of small and large adults and estimated annual survival, 1993-2002. Large males are those > 106 mm, large females > 120 mm. Data are omitted from the unusual year of 1997. Adult survival is calculated as the number of large newts in a year divided by the total number of both small and large newts in the previous year.

time as large adults. The first two estimates of annual survival (67% for 1993/1994 and 93 % for 1994/1995) will not incur the first of these errors because small newts did not return to breed until 1995. Survival was not estimated for 1996/1997 or for 1997/1998 because of the unusual conditions in 1997. The estimated survival of 135% for 2001/2002 probably exceeded 100% because of the difficulty in counting in the first year and the ease of counting in the second. There was no significant trend towards better or worse survival during 1993-2002, the average of the seven figures for annual survival being 79%. However, the estimate for 2001/2002 is





Figure 3. The relationship between mean larval length just prior to emergence and mean number caught per sweep of the net. Each dot represents data from a single year, 1993-2002. No larvae survived in 1997.

unrealistically high and that for 2000/2001 is probably too low. The mean of the remaining five estimates, 71%, is likely to be a more accurate overall figure.

Body condition index varied with size and sex, being greater for smaller individuals and males. Condition index for the large adults (Table 2) was not significantly related to their survival (Table 3, $r_s = 0.546$), but in two years for which survival data were unavailable, 1993 and 1998, condition index was high following a year or more of minimal breeding activity. It should also be noted that in 1999, survival and condition index were both at their lowest values. Condition index did not change over time ($r_s = -0.103$).

Top Pond was dry during the summer of 1997 and reproduction failed totally, while the pond was reduced to the sump in the summers of 1995, 1996 and 2002 (Table 4). Even in years when the pond remained full in summer, number of larvae caught varied considerably from three in 2001 to 119 in 2000. A feature of the summer netting was the incidental capture of adult and juvenile newts. Adults were caught in four summers, especially in 2001 and 2002 (Table 4). In those two years, adult numbers tended to decrease through the sequence of four netting visits: 4, 5, 2 and 0 adults respectively in 2001; 7, 1, 0 and 0 in 2002. Single juveniles were caught in 1998, 2001 and 2002. Multiple regression analysis of mean number of larvae caught against mean number of adults counted in the spring and mean number of adults caught in summer with all 10 years' data showed that larval catch was positively related to adult night count (t = 2.63, P < 0.05) and negatively related to number of adults netted in summer (t = -2.71, P < 0.05). Larval numbers could be defined as: Number = 4.4 + 0.877 Adults^{spring} -28.3Adults^{summer} ($F_{2,7} = 4.99$, P < 0.05). If data from the unusual summer of 1997 are omitted, the negative relationship with numbers of adults caught in summer remained (t = -2.53, P < 0.05), but the positive one with adults counted in spring disappeared. The overall relationship with both variables was no longer significant ($F_{2.6} = 3.59$, 0.1 > P > 0.05).

Year	Summer water leveł	Mean no. sweeps <u>+</u> SE	Mean no. larvae caught <u>+</u> SE	Mcan no. larvae per sweep <u>+</u> SE	Mean larval length <u>+</u> SE mm (no. in sample)	Mean no. adults caught <u>+</u> SE
1993	Full	47 <u>+</u> 1	53 <u>+</u> 4	1.1 ± 0.1	46 ± 1 (12)	0.0 <u>+</u> 0.0
1994	Full	38 <u>+</u> 3	30 <u>+</u> 5	0.8 <u>+</u> 0.2	51 <u>+</u> 1 (8)	0.0 <u>+</u> 0.0
1995	Sump	19±5	14±4	1.2 <u>+</u> 0.6	53 <u>+</u> 1 (8)	0.0 <u>+</u> 0.0
1996	Sump	15±6	65 <u>+</u> 13	7.1 <u>+</u> 2.6	39 <u>+</u> 1 (15)	0.3 <u>+</u> 0.3
1997	Dry	0	-			-
1998	Full	38 <u>+</u> 2	80 <u>+</u> 22	2.0 ± 0.5	51 <u>+</u> 3 (11)	0.5 <u>+</u> 0.3
1999	Full	25 <u>+</u> 4	36 <u>+</u> 11	1.3 <u>+</u> 0.4	56 <u>+</u> l (25)	0.0 <u>+</u> 0.0
2000	Ful1	37 <u>+</u> 4	119 <u>+</u> 16	3.2 <u>+</u> 0.1	44 <u>+</u> 1 (17)	0.0 <u>+</u> 0.0
2001	Full	34 <u>+</u> 4	3 <u>+</u> 1	0.1 <u>+</u> 0.0	64 (1)	2.8 ± 1.0
2002	Sump	15 <u>+</u> 4	5 <u>+</u> 2	0.3 <u>+</u> 0.1	64 <u>+</u> 3 (6)	2.0 ± 1.7

Mean number of larvae caught per sweep of the net is a comparative measure of larval density each summer (Table 4). This varied from 0.1 when few larvae survived in the full pond in 2001 to 7.1 in the sump in 1996. Larval length was inversely related to numbers caught per sweep (Figure 3, r_s = -0.750, P < 0.05).

Table 4. Results of summerfieldwork, 1993-2002. Meannumber of sweeps and meannumbers of Crested Newts caughtare based on four visits. Larvallength was measured just prior toemergence.

DISCUSSION

The Crested Newt population at Shillow Hill declined significantly in 1989 (Figure 1). Severe drought from 1990 until 1992 saw Top Pond reduced to its sump in the spring of 1991 and throughout the first half of 1992; and dry in the summers of 1990 and 1991. As a consequence, night counts of adults declined further to a mean of only three in 1992. Virtually no emergence occurred in any of the three summers 1990-1992 (Cooke, 1995; Cooke & Arnold, 2001). In the spring of 1993, it was anticipated that, with the pond full again, more adults would return to breed

- this expectation was realised with a mean count of 42 adults. Many of the adults probably originated from the successful breeding seasons in the late 1980s (Cooke, 2002). The second expectation was that, in the absence of prolonged drought in the future, the level of the population would recover further as breeding became successful again and recruitment occurred (Cooke, 1995). Apart from 1997, drought conditions did not return. The years of 1993, 1994, 1995, 1996 and 1998 had very similar count conditions allowing comparisons in adult counts to be made. A steady rise was recorded for these years from 1994 until 1998, with a significant increase between mean counts in 1995 and 1996. After 1998, there were no significant changes. It is possible, therefore, to define two recent periods for the newt population at Shillow Hill: recovery during 1993-1998 and relative stability during 1998-2002.

What processes lay behind the recovery? Breeding was reasonably successful in the summer of 1993 (Table 4). No small adults were recorded in the spring of 1994 (Table 3), but there were comparatively high numbers of immature newts (Table 2). Small adults were first recorded in the spring of 1995 (Table 3), presumably being two year olds from 1993. The spring of 1996 saw an increase in adult numbers, with about two thirds being small adults. These small newts will tend to have been two year olds from 1994 and three year olds from 1993. Elsewhere, Crested Newts have been reported to mature as early as two years of age, but with others maturing at three or older

	Years	% change in mean night count	Reason for change
Increase	1992/1993	+1300	Recovery in pond suitability
	1997/1998	+1000	Recovery in pond suitability
	1984/1985	+360	Good recruitment
	1995/1996	+97	Good recruitment
	2001/2002	+78	Variation in counting conditions
Decrease	1990/1991	14	Pond less suitable
	1988/1989	-71	Poor survival of adults and immatures
	1991/1992	-84	Pond less suitable
	1996/1997	-87	Pond less suitable

Table 5. Occasions when mean night counts of Crested Newts in Top Pond changed by > 40% between years, with the likely principal reason for each change.

(Smith, 1969; Dolmen, 1983; Francillon-Vieillot et al., 1990; Arntzen & Teunis, 1993; Baker, 1999; Kupfer & Kneitz, 2000; Cummins & Swan, 2000). Numbers of large adults decreased steadily from 1993 to 1996 as survivors from the 1980s died (Table 3). The population had a lean year in 1997: few adults were counted in the sump in spring (Table 2), and breeding failed in the summer when the pond desiccated (Table 4). By 1998, 35% of the adults were small, a percentage that changed little over the rest of the study (Table 2). Numbers of small adults counted for each larva caught two or three years previously were highest in 1996 and 1998 (Figure 2).

How then did the period of stability, 1998-2002, differ from the previous period of expansion? A reduction in adult survival can be discounted, as survival did not change significantly over time (Table 3). There was, however, evidence of a higher probability of a small adult originating from a larva in 1996 and 1998 than in later years (Figure 2). Arntzen & Teunis (1993) noted in their French population that adult survival was stable for several years, but there were few immatures adult numbers became high. when One explanation for this observation is that, as adult (and immature) numbers built up, there was increasing pressure on metamorphs to migrate away from the site. Kupfer & Kneitz (2000) contrasted the high site fidelity of adult newts with the wider-ranging behaviour of metamorphs; the latter migrated from their natal pond in an arable field by up to 860 m in a few weeks. In a study at Shillow Hill in 1985, metamorphs were not trapped on the surface of the adjacent arable fields (Cooke, 1986), and any attempts at emigration were more likely to occur along ditches between the fields.

However, this observation of possible densitydependence is only part of the story. In 2001 and 2002, adults tended to remain in the pond in significant numbers until further into the summer (see also weekly netting data for adults, mid March-early July 1986; Cooke, 1995). The presence of the adults in 2001 and 2002 was associated with considerably reduced numbers of larvae (Table 4), the inference being that the adults preyed on the larvae. For much of their development, Crested Newt larvae tend to be pelagic, which may reduce the risk of cannibalism by the more benthic adults (Beebee & Griffiths, 2000). Nevertheless, in a small, densely-populated pond such as Top Pond, there must be frequent opportunities for cannibalism. At what stage in development cannibalism may occur remains to be elucidated, but observations at this site of adult Crested Newts occasionally swallowing adult Smooth Newts suggests they can tackle even fullgrown larvae of their own species. Significant predation by invertebrates can be ruled out as there is no evidence that they control numbers of larval newts at this site, and counts of invertebrate predators were low or moderate in 2001 and 2002 (Cooke, 2001 and unpublished). Fish have been shown to be important predators of Crested Newt larvae (e.g. Baker, 1999) but fish have not been recorded in Top Pond. It is possible that a high density of newts on land triggers a response in adults to remain longer in the pond. In addition to the adult population having stabilised, 2001 and 2002 immediately followed the year with the highest recorded larval production (Table 4). This apparent cannibalism should result in lower recruitment to the adult population during 2003-2005. With hindsight, the effects of cannibalism may have been apparent in the 1980s. For instance, 1987 had the highest mean night count of adults (183, Figure 1), yet mean larval catch was only 16 despite the pond remaining full into the summer (Cooke, 1995; Cooke & Arnold, 2001).

There is a trade-off in the pond between larval density and size (Figure 3). The few larvae that managed to survive to metamorphosis in 2001 and 2002 tended to be large. This may have put them at a selective advantage in maturing earlier (Arntzen & Teunis, 1993). There was no evidence from our study, however, of larval size markedly affecting recruitment to the adult population in subsequent years. Thus, the small larvae comprising the metamorphosing cohorts in 1993, 1996 and 1998 appeared to result in later increases in adult numbers.

Mean annual survival for adult newts at Shillow Hill was estimated at 71% for 1993-2000. Elsewhere, annual estimates have been between about 30 and 100%, with most being in the range 50-90% (e.g. see Arntzen & Teunis, 1993; Oldham, 1994; Baker, 1999; Cummins & Swan, 2000; Kupfer & Kneitz, 2000). Adult survival would be expected to be good within the Shillow Hill site. Food and refugia should be plentiful, vehicle access within the site is relatively rare and disturbance to habitat is restricted. The situation is different beyond the boundaries of the site. A main road runs past the site about 70 m from Top Pond. but live or dead newts have never been seen on it and it is unlikely that many newts try to cross (see also the radio-tracking study of Jehle, 2000). Newts do, however, utilise the adjacent arable land around the other three sides of the site, this being especially true of adults prior to harvest (Cooke, While there, they will be exposed to 1986). hazards such as spraying, combining and, in the past, straw burning. Mean night count in Top Pond decreased from 136 in 1988 to only 39 in 1989, a decrease of 71% which could not be explained by any change in the condition of the pond (Cooke, 1995). A change of this magnitude must have been due primarily to unusually poor survival, catastrophic losses presumably occurring outside the site. As this is likely to have affected immatures as well as adults, recruitment failure will also have resulted and the population remained low into 1990 (Figure 1).

The need for long-term studies is often emphasised (e.g. by Arntzen & Teunis, 1993; Cooke, 1995; Baker, 1999). Surveillance at Shillow Hill is the longest continuous study on this species, and it is worthwhile examining by how much and why adult night counts varied during the entire surveillance period, 1983-2002. As Baker (1999) has pointed out, while longevity and relatively high rates of survival of adults provide the potential for population persistence. population size may fluctuate considerably. At Shillow Hill, inter-year comparisons of counts varied by < 40% for ten of the 19 pairs of years. Such variations will have tended to stem from fairly minor fluctuations in population level, in pond suitability or in counting conditions. Of the remaining nine occasions, four involved decreases of 44 to 87%, and five were increases of 78 to 1300%. These years and likely reasons for change are listed in Table 5, and the information reinforces the view that many of the major fluctuations in counts at this site resulted from changes in pond suitability. The most extreme example of this effect was in 1992 when the mean count was only three; because of the small size of the pond and because a stick was used to move aside water plants, it should have been possible to count all of the newts in the water (Cooke, 1995). When the pond refilled in 1993, the mean count was 42, all of which were large adults (Table 3), demonstrating that an unusually small proportion of the adult population was in the water at any one time in 1992. In the study of Arntzen & Teunis (1993), all adults were believed to breed each year. At Shillow Hill, it is not known whether the low counts, as in 1992, resulted from all of the newts returning to the water for unusually short periods or a only few newts returning for normal periods of time.

Turning to apparently real changes in the population (as opposed to changes in the counts), only a single decrease of > 40% was recorded (in 1988/1989), the likely reason being poor survival, as discussed above. There were two examples of increases of > 40% (1984/1985 and 1995/1996), both probably being due to good recruitment. Attention should also be drawn to the increase of 78% in 2002 (Table 5). The years 2001 and 2002 were the only pair during the detailed study of 1993-2002 when counting was difficult one year but easy the next. Precisely how much this counting discrepancy contributed to the observed change is unknown. However, survival was estimated at 135% in 2002; if high turbidity in

2001 depressed the mean count by, say, 20% but low weed cover in 2002 elevated the count by 20%, then survival would be lowered to a more "realistic" level of 90%. Survival in 2001 would then be estimated at 73% (from 61%). Such a 20% adjustment to both counts in 2001 and 2002 would result in an increase in night count in 2002 of only 19% over that in 2001.

These observations emphasise that pond and count conditions may greatly influence surveillance results. While it is not possible to make quantitative adjustments to counts without detailed studies on changes in the probability of detecting individuals under different ambient conditions, being aware of these limitations allows some data to be ignored or qualified, and conclusions to be derived more objectively. It is also worth noting that if water conditions make a pond unattractive to newts, there may be similar effects on any population assessment based on studying newts at the breeding site, irrespective of the degree of scientific rigour with which it is undertaken.

Under ideal conditions, the Shillow Hill site can support a Crested Newt population that equates to a mean night count of 100 or more adults (Figure 1). Catastrophic losses in 1988/9 and drought during 1990-1992 and 1997 meant such counts were not realised between 1989 and 1997 inclusive. In 1984 when mean night count was 33, the adult population was estimated to be in the region of 500, based on recapture on land of newts caught and marked during the aquatic phase (Cooke, 1985, 1995). While the relationship between counts and population size will vary between sites, a mean night count of 100 at Shillow Hill may suggest a population of about 1500 adults at a density of 750 per ha for the core area of 2 ha. Even with hindsight, it is difficult to see what could have been done to have improved population levels between 1989 and 1997. The initial mortality seemingly could not be prevented, and regional drought had substantial effects in the early 1990s. The sump was created in 1991. Its value to conservation of the population lies not in providing suboptimal aquatic habitat to the few adults in the sump in drier springs, but in allowing emergence in drier summers such as 1996 (Cooke & Arnold, 2001). It is important to take a strategic long-term view of Crested Newt conservation.

In Britain, a Pilot Monitoring Project on Crested Newts was undertaken in four areas in 2002 as preparation for a future national scheme to measure trends in population status (Baker, 2002). Night counting of adults provides a key component of this work. Hopefully, results and conclusions from our study at Shillow Hill will be of value to those responsible for this national scheme at various stages from planning through to interpretation.

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Distributional comments on some members of the herpetofauna of the Mosquitia, Honduras

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THE herpetofauna of the Mosquitia, the eastern lowlands of Honduras, has been traditionally the least well known in the country. Our recent fieldwork, however, has been directed largely toward improving our knowledge of the composition and distribution of the amphibians and reptiles of this important region of Honduras (Nicholson et al., 2000; McCranie et al., 2001; McCranie et al., 2002). During July and August of 2002, we spent five weeks in the eastern portion of the Mosquitia. We surveyed three areas, all of which have or are proposed to be designated as protected areas within Honduras. These three areas are the Río Kruta Biological Reserve, the Rus Rus Tawahka-Biological Reserve, and the Asangni Biosphere Reserve.

From 9th-11th July, we collected in the lower reaches of the Río Kruta, a river arising in the Llanos de Iltara and emptying into the Caribbean Sea at Barra Kruta and Cocotingni between Laguna de Caratasca and Cabo de Gracias a Dios. The area in which we worked is located within the Río Kruta Biological Reserve. From 12th-27th July, we worked in the environs of Rus Rus, a Miskito village on the road between Puerto Lempira on the shore of Laguna de Caratasca and Awasbila on the Río Coco. Our work was centered in the immediate vicinity of Rus Rus and at a hunting camp known as Bodega de Río Tapalwás, located along the Río Tapalwás, a tributary of the Río Rus Rus, both localities being located within the proposed Rus Rus Biological Reserve. From 30th July to 6th August, we sampled the herpetofauna in the region of Caño Awalwás, a tributary of the Río Coco located within the Tawahka-Asangni Biosphere Reserve. Voucher specimens of the specimens collected will be deposited at the National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.

Agalychnis calcarifer Boulenger

This species has been known heretofore from Honduras on the basis of a single adult specimen from near Baltituk, on the Río Plátano, Depto. Gracias a Dios, and a series of tadpoles and eggs taken at Quebrada El Guásimo, Depto. Olancho, along the Río Patuca (McCranie & Wilson, 2002). A second adult specimen (Fig. 1) was collected by us at Bodega de Río Tapalwás (Bodega from this point onward), Depto. Gracias a Dios, at 190 m elevation on 17th July 2002. This specimen documents the occurrence of *A. calcarifer* in the Río Coco drainage. The specimen is an adult female with a snout-vent length of 68.9 mm. It was collected at night (21:00 hrs) on the frond of an understory palm.



Figure 1. Agalychnis calcarifer. All photographs except Figure 3 by J.R. McCranie.



Figure ². Corallus annulatus.



Figure 3. Rhinoclemmys funerea. Photograph ©J. H. Townsend.

Anotheca spinosa (Steindachner)

Only a single specimen of this hylid frog has been known heretofore from Honduras, taken at the confluence of Quebrada Siksatara with the Río Wampú (Río Patuca drainage) Depto. Olancho (McCranie & Wilson, 2002). On 16th July 2002, we found a second specimen (see front cover) at Bodega at 190 m elevation. The specimen, an adult male with a snout-vent length of 61.4 mm, was collected at night (20:50 h) while sitting on a vine a little above head height alongside a trail. As with the specimen of *Agalychnis calcarifer* discussed above, this specimen documents the occurrence of *Anotheca spinosa* in the department of Gracias a Dios and in the drainage of the Río Coco.

Rhinoclemmys funerea (Cope)

The presence of this aquatic turtle in Honduras has been based on a single specimen from the Río Coco near Krasa, Nicaragua (Meyer & Wilson, 1973). Given the fluid nature of the political border between Honduras and Nicaragua along the Río Coco, it is not entirely clear whether this specimen originated on the Honduran or the Nicaraguan side of the river. On 4th and 5th August 2002, two specimens of this turtle were collected in the region of Caño Awalwás at 90 and 100 m elevation. One specimen (Fig. 3) was collected during the day by snorkeling at the mouth of the river (caño in Miskito). The other, the larger of the two, was collected at night while feeding on leafy vegetation along a tributary river of the Caño



Figure 4. Dendrophidion vinitor



Figure 5. Leptophis nebulosus



Figure 6. Pliocercus euryzonus

Awalwás. This turtle, called tortuga negra, is well known to the locals, is purported to be widely distributed in tributaries of the Río Coco, and is actively hunted for its meat during the dry season when the water in the rivers is relatively clear.

Corallus annulatus (Cope)

In June 2001, Franklin E. Castañeda collected an adult specimen of *Corallus annulatus* in the Rus Rus region at Bodega, Depto. Gracias a Dios, in northeastern Honduras. The specimen was collected at 190 m elevation at 22:00 hrs as it was crawling down a vine leading to the canopy. This specimen unequivocally establishes the presence of this species in Honduras (McCranie et al., 2002). On 3rd August 2002, a second specimen (Fig. 2) was collected by us at Caño Awalwás, at an elevation of 100 m. This specimen is a juvenile and was found active in a tree at night (20:50 hrs) about 4 m above a small river feeding into the caño.

Dendrophidion vinitor Smith

Wilson & Meyer (1985) indicated by an asterisk behind the name vinitor in their key to Honduran species of Dendrophidion that this taxon was not then known from Honduras, but could be expected to be eventually found there. On 21st July 2002, we collected a single adult specimen (Fig. 4) of D. vinitor at Bodega at an elevation of 190 m. The specimen was crawling on the forest floor at about 12:00 hrs. In addition, on 3rd August 2002, we found a single juvenile specimen of this snake at Caño Awalwás at an elevation of 100 m. This specimen was sleeping on low vegetation at night. A third specimen was collected by Tomás Manzanares Ruís on 30th February 2002 at Crique Ibantara (near Rus Rus) at an elevation of 70 m. These three records support the recognition of D. vinitor as part of the Honduran snake fauna.

Leptophis nebulosus Oliver

This species has been known heretofore from Honduras on the basis of a single specimen from Patuca, Depto. Gracias a Dios (Wilson & Meyer, 1985). This old specimen was collected 24^{th} July 1891. On 9th July 2002, we collected a second specimen (Fig. 5) from Krahkra, Depto. Gracias a Dios, on the Río Kruta, at an elevation of 5 m. It was found sleeping at night (about 22:00 hrs) on a frond of a thorn palm growing in a swamp. Oliver (1948) and Savage (2002) gave a range of 150-160 ventrals and 146-151 subcaudals for *L. nebulosus*. The new Honduran specimen is a female with 146 ventrals and 134 subcaudals, thus extending the known variation in these two characters.

Pliocercus euryzonus Cope

Wilson & Dugas (1972) reported this species from Honduras on the basis of a single specimen from Tela, Depto. Atlántida. Savage & Crother (1989) identified the same specimen as P. elapoides and Smith & Chiszar (1996) considered it representative of their P. dimidiatus. Our opinion is that this specimen is a *P. euryzonus* with erroneous locality data. Tela was the location of a serpentarium and was used as the locality for many specimens that actually originated in other locales (see the discussion in McCranie & Wilson, 2002, about a specimen of the frog Hyla crepitans purported to be from Tela). We suspect this is also the case with the specimen reported by Wilson & Dugas (1972). As such, the specimen we report herein is the first definitive evidence that P. euryzonus is part of the Honduran snake fauna. This specimen (Fig. 6) was collected at 100 m elevation at Caño Awalwás, Depto. Gracias a Dios on 3rd August 2002. It was found at night (21:50 hrs) as it was crawling on a steep bank above a small tributary river of the Caño Awalwás. Savage & Crother (1989), Wilson & McCranie (1997), and Wilson et al. (1996) have all espoused that further collecting in eastern Honduras in the hiatus between the two nominal forms of Pliocercus may demonstrate that these two forms are conspecific. Subsequently, we collected two additional specimens of Pliocercus in eastern Honduras that, contrarily, seem to strengthen the recognition of both P. elapoides and P. euryzonus as distinct species. One specimen collected at Ouebrada Machín, Depto, Colón, resembles the other Honduran populations of P. elapoides to the west in having the red rings longer than the black rings (it has an incomplete tail). The second specimen from Caño Awalwás, Gracias a Dios. resembles P. euryzonus from Nicaragua to northern South America in having the black rings longer than the red rings. The latter specimen has a complete tail with 119 subcaudals. That number is four subcaudals more than the maximum number recorded for P. elapoides by Savage & Crother (1989), but lie near the upper limits for P.

euryzonus given by Savage & Crother (1989) and Savage (2002). The colour pattern of the Honduran specimen of *P. euryzonus* is indistinguishable from specimens of this species from Nicaragua, Costa Rica, and western Panama (see plate 405 in Savage, 2002, fig. 246 in Köhler, 2001, and fig. 1 in Smith & Chiszar, 2001).

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Record of the colubrid snake *Philodryas simonsii* Boulenger from Chile

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THE genus Philodryas (sensu Thomas, 1977), is represented in Chile by four species (Donoso-Barros, 1965, 1966, 1970; Peters & Orejas-Miranda, 1970): P. chamissonis (with two subspecies: P. c. chamissonis and P. c. eremicola), endemic to Chile, is the most widely distributed, ranging from Second Administrative (25°S) Region to Tenth Administrative Region (40°S); P. elegans (with two subspecies, P. e. elegans and P. e. rufodorsatus), of which the the nominal form has been recorded only from Arica's valleys (south of 18°S), in First Administrative Region; P. tachymenoides, reported only from Arica's valleys; and P. simonsii, represented by a literature record from Arica's valleys (Thomas, 1977).

The species *Philodryas simonsii* has been reported from three South American countries; Ecuador, Perú, and Chile (Donoso-Barros, 1965, 1966, 1970; Peters & Orejas-Miranda, 1970; Thomas, 1977; Veloso & Navarro, 1988). Donoso-Barros (1966) reported the species from northern Chile, but did not mention voucher specimens. Veloso & Navarro (1988) followed Thomas' arrangement, and included this species in their list of Chilean reptiles. Núñez & Jaksic (1992) deleted *P. simonsii* from the Chilean herpetofauna because of its occurrence in the highlands of Perú and Ecuador (fide Peters & Orejas-Miranda, 1986), and because of the absence of specimens collected in Chile.

A young male (snout-vent length 272 mm, tail incomplete) *Philodryas simonsii*, (Museo Nacional de Historia Natural de Chile, MNHN 3480) from Pampa Colorada, North of Arica, First Administrative Region of Chile, was collected in December 1999. Its characters, including colour, agree with descriptions of the species by Donoso Barros (1966) and Thomas (1977): Ventral plates 183; smooth dorsal scales; anal plate divided; nasals completely divided; prefrontals not contacting supralabials, small loreal; preoculars 1/1; postoculars 2/2; temporals 1+2+2/1+2+2; supralabials 8/8, fourth and fifth contacting the eye; infralabials 10/10, with the first pair in contact behind mental.

The discovery of this specimen confirms the occurrence of *Philodryas simonsii* in Chile, as originally intimated by Donoso-Barros (1965, 1966, 1970).

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Preliminary investigation of a one-hundred-year-old population of introduced water frogs in Britain

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ABSTRACT — We investigated the taxonomic composition and habitat selection of the longest surviving introduced water frog population in Britain. Water-frogs were first introduced to Beam Brook (Surrey, southeast England) around 1905. Using RAPD analysis of embryos and larvae, we identified three taxa (*Rana esculenta*, *R. lessonae* and *R. ridibunda*) and detected a fourth for which we had no RAPD reference material. We consider this was likely to be *R. perezi*, since male advertisement calls of this species as well as those of *R. bergeri* (closely related to *R. lessonae*) were recorded recently at Beam Brook. We have no evidence of adult male *R. ridibunda* at Beam Brook, and the embryos of this species were probably produced by matings of *R. esculenta*. The water frogs bred in a subset of the 44 ponds present at the site. There were no sharp distinctions among the different taxa with respect to ponds used for breeding. However, stepwise multiple regression analysis indicated that *Rana lessonae* reproduction was preferentially associated with the warmest ponds, *R. esculenta* spawn and larvae were most abundant in densely vegetated pools, and *R. ridibunda* was associated with relatively low oxygen concentrations.

THE British Isles have an impoverished L herpetofauna relative to mainland Europe (Gasc et al., 1997). This is largely due to relatively cool summer temperatures in Britain, but is also in part an accidental consequence of post-glacial colonisation processes. Biogeographical patterns in the recolonisation of Europe are discussed by Taberlet et al. (1998) and Hewitt, (1999). Many species spread north as the climate ameliorated during the postglacial warming, but there was only a limited window of time during which Britain could be colonised. Initially joined to mainland Europe by a land bridge, Britain finally became separated by sea around 7500-8000 years ago (Lambeck, (1995). Evidence suggests that at least nine species of amphibians reached Britain naturally before that time. Six species (Triturus helveticus, T. vulgaris, T. cristatus, Bufo bufo, B. calamita and Rana temporaria) are still extant, while three (R. dalmatina, R. arvalis and R. lessonae) have subsequently become extinct

(Gleed-Owen, (1998). A 'northern clade' of *R. lessonae*, found also in Norway and Sweden (but morphologically distinct from pool frogs in mainland Europe), survived in England as a single isolated population until the 1990s (Zeisset & Beebee, 2001; Wycherley et al., 2002).

By contrast there have been many introductions of amphibians into Britain, both accidental and deliberate, over the past 200 years (Lever, 1980). Water frogs have been among the most widespread of these introductions, with the first (probably mixed *R. lessonae* and *R. esculenta*) documented in 1837 (Smith, 1951). Most populations of these frogs became extinct within a few years, but there have been notable exceptions. The most successful amphibian invader in Britain is *R. ridibunda*, which was introduced to south-east England in 1935 and is now widespread in large wetland areas (Menzies, 1962; Beebee & Griffiths, 2000). However, the longest surviving introduced water frog population in Britain exists at Beam Brook in Surrey. Frogs have been present at this site for almost 100 years (Gillett, 1988) and continue to thrive there. Repeated introductions, into artificial ponds created at a commercial nursery, occurred over many decades until the mid-1960s, when introductions ceased. Although the origins and species were not documented, the water frogs at Beam Brook were certainly of mixed taxa and were probably imported mainly from Belgium, France, the Netherlands, Italy and Spain. Since the late 1980s the frogs have extended their range in the Beam Brook area, coinciding with a general climatic warming (Beebee, 1995; Walther et al., 2002), and now occur over some 150 square kilometres (Wycherley & Anstis, 2001).

The Beam Brook water-frogs have not been studied previously and are of interest for several reasons. Firstly, their taxonomic composition is unusual and, because of their mixed origins, may be more complex than can be found at any natural site in Europe. Analysis of male advertisement calls at Beam Brook has indicated the presence of R. bergeri, R. esculenta, R. lessonae and R. perezi (Wycherley et al., 2003). Because of their complex hybridogenetic reproduction mechanisms (Tunner, 1974; Graf & Pols-Pelaz, 1989; Roesli & Reyer, 2000), other forms - such as female R. ridibunda and cryptic hybrids - might also occur at the site. In addition, the spread of water frogs associated with climate change might pose threats to native communities and it will be important to evaluate the impact of this highly unusual water frog complex in future years. In this paper we report a preliminary investigation of the water frog community at Beam Brook and its association with pond habitat features.

Study site

METHODS

The Beam Brook Field Station comprises 44 ponds within about 2 ha of low-lying field habitat in Surrey, southeast England. The substrate is clay and all the ponds were created artificially within the past 100 years. Most of the ponds contain abundant growths of macrophytes, especially *Glyceria fluitans, Potamogeton natans* and

Nymphaea species. There were several amphibians in addition to the water frogs considered here. These included both native species (*Triturus* vulgaris, *T. cristatus*, *Rana temporaria*) and other introduced species (*T. alpestris* and *T. carnifex*). Fish, notably *Gasterosteus aculeatus* and *Carassius auratus*, occurred in some – but not all – of the pools. Invertebrates were abundant, especially odonate larvae, dytiscid water beetles, and bugs such as corixids and Ilyocoris cimicoides. A random selection of 12 ponds at Beam Brook was used in the present study.

Water frog observations

The Beam Brook ponds were visited twice weekly between March and July 2000. Numbers of adult frogs visible in the water or on the bank were counted in each pond, on sunny days, at every visit. These numbers were used as minimum estimates of the numbers of water frogs in each pond, and to compare relative numbers of frogs in the 12 study ponds. The onset and completion of calling, and the onset of spawning, were recorded separately for each pond. Spawn was visible among the aquatic vegetation, and its occurrence was recorded at every visit during the breeding season. We did not attempt to quantify the amount of spawn in each pond because female water frogs each deposit several small clumps, some of which are hidden in dense vegetation. From every pond where breeding occurred (n = 7), at least five clumps of spawn were collected at widely separate localities to ensure they came from different females. Spawn samples from each pond were pooled together, 25 embryos were selected at random, and these were allowed to develop for six weeks. The survivors were then stored in ethanol for later genetic analysis. Later in the season (late July/early August) larvae from the same breeding ponds were sampled. We used a sweep net to sample round each pond perimeter, then bulked the catch from each pond into separate buckets, and finally took a random subsample of 10 individuals per pond. These were also stored in ethanol pending genetic identification.

Genetic identification

Entire embryos or small sections of larval tails were digested overnight at 55°C with proteinase K. (Hitchings & Beebee, 1998). DNA was extracted using phenol/chloroform, precipitated with ethanol, and then each sample was redissolved in 50 µl distilled water. The concentration of DNA in each sample was determined by measuring absorbance at 260 nm. Water frogs were identified by RAPD analysis as outlined by Zeisset & Beebee (1998). 25 ng of DNA were used in PCR assays with primer PR6, and products were electrophoresed through 1.5% agarose gels together with known reference standards (DNA extracted from individually identified Rana lessonae, R. esculenta and R. ridibunda). After electrophoresis at 60 volts for about three hours, gel was examined under each a UV transilluminator and then photographed using an Eagle-Eye imaging system (Maniatis et al., 1982).

Habitat features

Habitat data were collected at Beam Brook between March and July 2000. We measured the following abiotic factors: the pond dimensions surface area and maximum depth, early and late in the season (March 25 and May 25, respectively); water temperatures on visit days, and maximum and minimum water temperatures (recorded weekly), all at a fixed depth of 15 cm in each pond; oxygen levels (mg/litre), taken weekly in each pond using a portable meter at a fixed depth of 15 cm, always early in the day and away from vegetation to minimise effects of photosynthesis; and pH, using a portable meter away from vegetation on a single sampling date in April. We also measured biotic factors: presence or absence of fish as revealed by observation and sweep netting; the distribution and abundance of macrophytes in each pond on March 25 and May 25; and the nature of macroinvertebrates at a single sampling time in early July. For vegetation cover, each pond was divided into 1 x 1 metre grid squares and the extent of macrophyte growth (submerged, surface and emergent combined) was estimated for each. Data from all the squares in a pond were assembled together to obtain an estimate for the entire pond. The survey methods

we used for invertebrates were based on standard three-minute hand-net sampling (National Pond Survey: Pond Action, 1998). Three-minute subsamples were taken around the entire pond edge. All the main mesohabitats in each pond were sampled. Each mesohabitat was netted vigorously to collect macro-invertebrates. The total pond sample was then placed in a labelled bucket and taken to the laboratory for identifications. In subsequent analysis we used the Biological Monitoring Working Party (BMWP) score system for freshwater macroinvertebrates. Eighty-five macroinvertebrate families or taxa each attract a score from 1-10 reflecting tolerance to pollution or oxygen depletion. High scoring families are sensitive to oxygen depletion. The sum of the BMWP scores for each pond gives the final BMWP score. The Average Score Per Taxon (ASPT) is calculated by dividing the BMWP score by the number of scorable families present. (Williams et al., 1998; Biggs et al., 2000).

Data analysis

We used the statistical program Statistix 7.0TM (Analytical Software, Tallahassee, USA) for data analysis. All data were checked for normality by the Shapiro-Wilks test and, where necessary, log10- or arcsin-transformed before use. When transformations to normal distributions were not possible, nonparametric tests were employed. Comparisons of ponds with respect to water-frog use were made with Kruskal-Wallis one-way Analysis of Variance (ANOVA). To investigate relationships between pond use and pond features we used correlation and stepwise multiple regression analyses, including the range of biotic and abiotic independent variables described above.

RESULTS

Pond use by all water frogs

A summary of our observations at Beam Brook is provided in Table 1. Examples of how water-frog sightings increased in two of the Beam Brook ponds as spring 2000 progressed are shown in Figure 1. These examples show two extremes, with one heavily used (13) and one relatively little used (28) pond. Frogs first appeared in mid-April, and



Figure 1. Comparison of frog numbers visiting two sample ponds. $C1 = 1^{st}$ calling day, E1 = time eggs first observed, $C2 = 1^{st}$ calling day, E2 = time eggs first observed.

peak numbers were observed by early May. Excluding the first three weeks of observations before day 110 when very few frogs were seen anywhere, over the subsequent nine weeks there were significant differences in frog numbers among the 12 ponds (Kruskal-Wallis ANOVA statistic = 28.12, P = 0.003). Frogs were seen in all 12 ponds, however, and the highest average number between mid April and July was 32.1 per visit (pond 13) while the lowest was 8.3 per visit (pond 28). Mean numbers of frogs seen per pond over weeks 4-12 inclusive correlated positively with pond surface area (r = 0.862, df = 10, P =0.0003) but not with any of the other independent variables we measured. Bigger ponds had more frogs than small ponds.

Despite the occurrence of water frogs in all 12 of the study ponds, only seven ponds were used for calling and spawning. There was no significant difference between the numbers of frogs seen in breeding pools (mean 18.6) and non-breeding pools (mean 16.0) between weeks 4 and12 (Kruskal-Wallis statistic = 9.11, P = 0.427). However, breeding pools had higher average oxygen concentrations (6.6 mg/litre) than nonbreeding pools (4.7 mg/litre), ANOVA F = 5.44, df = 1,10, P = 0.042. Breeding pools also had lower average macrophyte vegetation in May (61%) than non-breeding pools (96%), ANOVA F = 8.73, df = 1,10, P = 0.014. Fish were present in both nonbreeding (one out of four) and breeding (three out of seven) pools.

Both calling and spawning started around April 20th, within a week of frogs appearing in the ponds in significant numbers. There were differences among the breeding ponds with respect to the start and end of breeding activity. As shown in Figure 1, calling started 20 days and spawning 26 days earlier in pond 13 relative to pond 28. Calling onset was associated with minimum water temperatures as revealed by stepwise multiple regression:

First calling day = 7.329-2.866 (log₁₀ mean minimum water temperature, °C)

In this regression, adjusted $r^2 = 0.8143$, P = 0.0034. Ponds that warmed up earliest in the season were used first. Duration of calling in a particular pond was significantly related to its depth in July, with deeper ponds sustaining calling for longer periods than shallow:

Calling duration (days) = 1.00 + 11.60 (July depth, cm).

In this case, adjusted $r^2 = 0.941$, P = <0.001. First spawn date was also strongly correlated with temperature – in this case, the actual water temperature measured on the day:

First spawn day = -0.385 + 0.214 (water temperature, °C).

This relationship was highly significant (adjusted $r^2 = 0.944$, P = < 0.0001) and shows that ponds where spawning started late were, by that time, warmer than ponds where it started early.

Use of ponds by different water-frog taxa

Table 2 summarises the genetic identification, by RAPD analysis, of embryos (April) and wellgrown larvae (July/early August) in the seven ponds used by water frogs for breeding. Spawn samples varied between ponds with respect to embryo viability, and in particular this was relatively low (<70% overall) in ponds 28 and 30. Water frogs clearly identified at Beam Brook by the genetic analysis were *R. lessonae*, *R. ridibunda* and *R. esculenta*. However, there was also a fourth taxon with a distinctive RAPD profile for which

Pond	1	3	5	8	13	14	16	17	28	30	36	37
Rightic fontures												
Maan no	16	12	1.4	12	10	12	0	F	F	-	6	7
Frogs/pond	10	15	14	14	19	15	0	5	2	/	0	/
Spawn present	1.	+	-	+	+	+	+	-	+	+	_	-
Fish present	+	+	-	+	+	_	-		-		-	-
No. predatory	5	5	5	3	5	5	4	4	3	4	4	2
invertebrate taxa												
Diversity ASPT	4.47	5.0	4.58	4.12	4.47	4.73	4.79	4.5	4.59	4.19	4.43	4.0
index												
% vegetation cover	40	35	78	34	46	29	79	86	33	30	83	15
(March)												
% vegetation cover	90	46	97	42	84	58	100	93	67	30	100	100
(May)												
Abiotic features												
Surface area (m ²)	133	190	105	166	185	174	47.6	59.6	51.1	6.6	21.7	19.8
Maximum depth in	0.5	0.8	0.12	0.58	0.56	0.47	0.39	0.32	0.22	0.44	0.53	0.35
m (March)												
Maximum depth in	0.81	0.92	0.08	0.62	0.8	0.59	0.2	0.31	0.32	0.41	0	0
m (May)												
Water temperature	-	17.1	-	19.2	19.5	28.0	22.2	-	21.3	24.0	1	
at spawning onset												
(C)												
Mean maximum	18.1	23.5	25.4	23.2	21.1	22.8	21.8	22.1	19.9	20.5	23.7	21.4
temperature (C)												
Mean minimum	9.8	10.9	8.6	11.4	10.8	10.9	9.6	9.6	8.7	11.0	9.6	10.4
temperature (C)												
Mean oxygen	5.09	5.09	4.85	7.18	7.87	8.43	6.31	6.25	6.76	6.87	3.83	3.72
concentration												
(mg/l)												
pH	7.2	7.0	6.7	7.3	7.2	6.7	6.7	6.7	6.8	7.3	7.2	7.3

Table 1. Biotic and abiotic characteristics of study ponds.

Water frogs in Britain

we did not have a reference marker. We have assumed that this was probably *R. perezi* because the presence of this frog at Beam Brook, in addition to other water frogs, was demonstrated by analysis of male advertisement calls (Wycherley et al., 2003).

Rana lessonae and R. esculenta embryos were present in all seven ponds. R. ridibunda were found in six ponds, and 'R. perezi' in five. Rana lessonae and R. esculenta genotypes were almost equally common, constituting 36% and 38% respectively of the embryos surviving to hatch. *Rana ridibunda* and *R. perezi* were both much rarer, with the former at 14% and the latter at 11% of the total. However, since *R. ridibunda* at this site were probably all derived from the matings of *R. esculenta* (see Discussion), their viability is expected to be low (Graf & Pols-Pelaz, 1989). Two of the ponds with relatively high numbers of *R. ridibunda* (28 and 30) were also those with

Table 2. RAPD Identification of Water frog eggs and larvae. The percentage occurrence of each taxon is listed for individual ponds.

Pond							
	3	8	13	14	16	28	30
% egg survival	100	100	100	100	100	64	64
Percentage tax	on comp	osition of	embryos				
R .lessonae	44	60	36	40	24	31	36
R. esculenta	28	40	32	40	60	50	25
R. ridibunda	24	0	8	8	4	19	21
"R. perezi"	4	0	24	12	12	0	17
Percentage tax	on comp	osition of	larvae				
R. lessonae	30	40	30	50	0	10	0
R. esculenta	60	40	40	30	60	20	0
R. ridibunda	10	10	0	0	20	30	0
"R. perezi"	0	10	30	20	20	40	0
Percentage tax	on comp	osition of	pooled e	mbryo an	d larval s	amples	
R. lessonae	40	54	34	43	17	23	36
R. esculenta	37	40	34	37	60	38	25
R. ridibunda	20	3	6	6	9	23	21
"R. perezi"	3	3	26	14	14	15	17

substantial embryonic mortality prior to analysis, and it may be that at fertilisation the percentage of *R. ridibunda* was higher in these ponds than our data suggest.

No larvae were later found in pond 30. Rana lessonae larvae were not found in pond 16, but otherwise both R. lessonae and R. esculenta larvae were detected wherever they occurred earlier as spawn. Rana ridibunda larvae were not found in two ponds where they occurred in spawn (13 and 14) but were caught in one pond (8) where they were not detected in the spawn sampling. 'Rana perezi' was absent from one pond were its genotype was seen in spawn (3), but was found in two where it was not seen in spawn (8 and 28). Indeed, in pond 28 'R. perezi' larvae occurred at relatively high abundance. These differences between spawn and larval samples indicated a substantial sampling error, and necessitated caution when analysing the taxon-specific data. Combining both the embryonic and larval genotype identifications, it was evident that all four taxa occurred in all seven ponds.

Despite the proportional changes among species between two sampling times, we considered it safest to use the average proportions (embryos + larvae) as indicators of pond suitability for each species. This should reduce the effects of sampling error at each of the two separate sampling times and give some idea as to which features were, over the entire breeding period, most associated with After pooling data for the two each taxon. sampling times, arcsin transformations of proportional use by each taxon were normally We therefore investigated by distributed. regression analysis whether any biotic or abiotic factors were associated with pond use by each taxon, as judged by proportional representation in each pond. Since all the breeding ponds were heavily used, proportionality data were not likely to be strongly biased by (for example) a high proportional value in one pond representing only a very small amount of spawn altogether. For R. lessonae, stepwise multiple regression identified just minimum average temperature as an associated variable.

Arcsin [proportion of R. lessonae] = -0.866 + 0.103 (average minimum temperature, C)

In this case adjusted $r^2 = 66.0\%$ and P = 0.016. Rana lessonae therefore showed a preference for relatively warm ponds. Multiple regression for *R*. *esculenta* yielded only pond vegetation cover later in the season as a significant predictor:

Arcsin [proportion R. esculenta] = 0.233 + 0.228arcsin (proportion vegetation cover).

For this regression, adjusted r^{2} = 62.8% and P = 0.021. *R. esculenta* therefore showed a preference for the more vegetated ponds. In the case of *R. ridibunda*, only average oxygen concentration was significant:

Arcsin [proportion of R. ridibunda] = 0.417 - 0.044 (average oxygen concentration, mg/litre).

In this case adjusted $r^2 = 52.5\%$ and P = 0.040. Rana ridibunda was therefore associated with the less-well-oxygenated pools. No significant predictor was found for '*R. perezi*'.

DISCUSSION

The Beam Brook ponds have supported introduced water frogs since 1905 (Gillett, 1988). Our combined studies of male advertisement calls and genetics (RAPD analyses) suggest that at least five different taxa were present in 2000, notably R. bergeri, R. esculenta, R. lessonae, R. perezi and R. ridibunda. It is likely that our genetic methods would not distinguish R. lessonae from its close relative R. bergeri, both of which were detected on the basis of male advertisement calls (Wycherley et al., 2003). We do not have separate RAPD reference material for these two taxa, but microsatellite analysis of R. lessonae at Beam Brook revealed allelic phenotypes subtly different from those seen elsewhere (I. Zeisset, pers. com.). It may be that there is currently some type of hybrid lessonae/bergeri population at Beam Brook, and this clearly requires further study. We detected R. ridibunda embryos and larvae by RAPD analysis but did not record R. ridibunda male advertisement calls at Beam Brook. This lack of ridibunda calls is explicable because ridibunda progeny in a LE system would all be females. Although ridibunda genomes normally have low viability in this situation due the accumulation of deleterious mutations, there may be many different ridibunda clones at Beambrook consequent on the multiple importations from widely different geographical locations in the early twentieth century. Such 'distant' ridibunda clones often generate viable progeny when esculenta interbreed (Guex et al., 2002). It is extremely unlikely that R. bergeri (from Italy) and R. perezi (from Spain) coexist anywhere under natural conditions. The fact that they are present together at Beam Brook, together with R. lessonae, R. esculenta and R. ridibunda, probably make this a unique situation. Lode & Pagano (2000) found smaller differences between the male advertisement calls of R. esculenta and R. perezi than between the calls of R. ridibunda and R. perezi. They suggested that the former mating combination was the most likely for the origin of the hybrid R. kl. grafi, so the possibility exists for this taxon also to occur at Beam Brook, though we have not detected it. Rana lessonae and R. esculenta together constituted the great majority (> 70%) of the water frog embryos and larvae we sampled at Beam Brook, and the site therefore supports what is primarily a LE-like breeding system.

We also found some evidence of the ecological factors at Beam Brook that may influence the success of water frogs there. Breeding ponds generally had high oxygen concentrations and low amounts of aquatic vegetation relative to nonbreeding ponds. These factors may be relevant to the survival of spawn and larvae. Spawning was not synchronous, and late spawning was associated with higher temperatures rather than with ponds which simply warmed more slowly than early ponds. Although not statistically significant, it was notable that our "fourth" species (putatively R. perezi) seemed to be associated with late spawning in very warm ponds such as pool 28 (where 40% of larvae were identified as the 'fourth' species). Rana lessonae was also associated with reproduction in relatively warm ponds. This accords with previous studies of R. lessonae elsewhere in Europe (Negovetic et al., 2001). Rana esculenta embryos and larvae correlated most strongly with the extent of aquatic vegetation during the summer months. This in turn was negatively associated with pond depth (multiple regression adjusted $r^2 = 37.2\%$, P =0.021). Larvae of this hybrid have a fitness advantage in temporary or otherwise unpredictable habitats (Semlitsch & Reyer, 1992), in keeping with the Beam Brook results. Rana ridibunda

larvae were associated with ponds relatively low in oxygen. This was unexpected, because *R. ridibunda* larvae are less tolerant of anoxia than those of either *R. esculenta* or *R. lessonae* (Plenet et al., 2000). It is probably unlikely, however, that any of the breeding ponds at Beam Brook become dangerously anoxic during the summer months. All are rich in macrophytes and invertebrates, and ASPT scores at Beam Brook were all relatively high (>4.0). Ponds rarely have ASPT values above a score of 5 (J. Biggs, pers.com.). All ponds at Beam Brook scored in the very good category. Between 12 and 19 invertebrate groups occurred in each pond.

Evidently there is still much to discover about the water frog community at Beam Brook. It would be interesting to know in detail how mating systems operate between the various taxa present, and whether hybrids such as *R. grafi* also occur. Indeed, the taxa identified separately by male advertisement calls and RAPD analyses still require complete formal reconciliation using a wider range of RAPD reference material. It will also be important to determine whether just some or all of these taxa are involved in the colonisation of surrounding ponds and watercourses that has accelerated in recent years.

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On the presence of *Python sebae* Gmelin, 1788 (Ophidia: Pythonidae) in Mauritania

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THE African Python (Python sebae) occurs in several countries of West Africa (Villiers, 1975; Chippaux, 2001). It was not listed by Welch (1982) and Chippaux (2001) for Mauritania, but had previously been suspected to occur in this country (Villiers, 1975; Ineich, 1997). Villiers (1975) cited a number of localities where local people had spoken about snakes and whose descriptions agreed with *P. sebae*. The localities cited by this author were Boudami in the Wilaya



Gorgol and M'Bout and Meyane in the Wilaya Guidimaka (Figure 1), all within the Sahel savanna of Mauritania. Ineich (1997) also described having heard local people speak about pythons, and noted that the presence of this species would be plausible in Lake R'Kiz and in the wetlands of Diawling National Park, both in the Wilaya Trarza (Fig. 1). It was occasionally mentioned for the country by Shine et al. (2001) without any additional information. The aim of this paper is to report the

> first confirmed records of *P.* sebae for Mauritania, and to present all available information about the distribution of this species in the country.

> During fieldwork in Mauritania between April and August 2002 we found pythons in two wetlands: Mahmûdé

Figure 1. Distribution of Python sebae in Mauritania, Numbers indicate the localities where pythons were actually found; letters indicate the uncertain records. 1: Mahmûdé Lake (16°29'58"N, 7°42'55"W); 2: 30 km N of N'Diago, Diawling National Park (16°26'16"N, 16°28'00"W); a: Boudami (coordinates not found); b: M'Bout (16°01' 42"N, 12°34'38"W); c: Meyane (coordinates not found); d: R'Kiz Lake (16°55'7"N, 15°14'26"W); e: Tamourt Bougari (16°32'2"N, 10°47'54"W); f: Tamourt en Naaj (17°53'N, 12°07'W).

Lake (Wilaya Hodh Ech Chargui) and Diawling National Park (Fig. 1). Mahmûdé is a 16,000 ha seasonal wetland (locally named Tamourt). During our visit the lake was dry and only some patches of riparian vegetation were available as refuges for the pythons. We observed six specimens; five were dead, killed by local people near vegetation (one skull is deposited in Museo Nacional de Ciencias Naturales, MNCN-41781). One of them was a gravid female. Only one specimen was found alive, among riparian vegetation (Figure 2). It was an adult male (total length: 300 cm; snout-vent length: 273 cm). The skin of another specimen was found 30 km N of N'Diago, in the Diawling National Park, near the Senegal border, confirming its occurrence in this area as previously suspected by Ineich (1997). Local people informed us about the presence of pythons at two other localities, the Tamourt Bou Gari (Wilaya Assaba) and the Tamourt en Naaj (Wilaya Tagant) (Figure 1). This latter site may represent the northernmost record for the species.

Python sebae seems to be restricted in Mauritania to the isolated wetlands of the sahel savanna. This is a xeric area with seasonal rainfall and strongly influenced by the extreme dry conditions of the Sahara. These factors are almost certainly responsible for its relictual distribution in the area. The same pattern is seen in other waterdependent vertebrates such as crocodiles. amphibians and fishes (pers. obs.), which have survived in the area probably since the last major wet period during the late pleistocene (Böhme 2000). Some of the wetlands suffer from a high level of human pressure through cattle raising, water exploitation and agriculture. In view of this, and the apparent relictual, isolated distribution of P. sebae in Mauritania, I consider this species as vulnerable and in urgent need of protection.

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Figure 2. Python sebae in the Mahmûdé Lake (Wilaya Hodh Ech Chargui) of Mauritania. Photograph by author.

de la Biosfera en Mauritania. Le Homme et la Nature: Mauritanie kindly provided working facilities. Thanks to C. Carballo, M. Deida, E. Mohamed Saleh, Jaques de Maille, M. Fadel, M. Urcera and R. Garcia.

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Amphibians and Reptiles of Surrey

Julia Wycherley and Richard Anstis Surrey Wildlife Trust. 2001. 112 pp. £13.00

One of the success stories of wildlife conservation in Britain is how the enthusiasm, expertise and dedication of field naturalists have been harnessed to such good effect. The conservation problems that species are facing are so overwhelming, that the role of local voluntary groups in raising the conservation profile of wildlife on their 'patch' has steadily increased in recent years. This is particularly the case for amphibians and reptiles. Indeed, much of the activity of local amphibian and reptile groups has focused on surveying and recording - if species are to be protected against ravages of habitat destruction the and development, then we must know where they occur to start with. What are starting to emerge from these initiatives are local atlases of amphibian and reptile distribution. Although not the first local guide of its kind, Amphibians and Reptiles of Surrey is arguably one of the most comprehensive accounts of a regional herpetofauna produced to date.

The Surrey Amphibian and Reptile Group (SARG) is one of the most active regional groups in the country, and this book is a testimony to the recording work carried out by this group over many years. However, this book is much more than a local atlas. Preceding the species accounts is a comprehensive introductory chapter that covers the geology of Surrey, historical issues, landscapelevel pond surveys, amphibian and reptile biology, surveying and general conservation issues. Much of the information presented here is of general interest and relevant nationally as well as locally. As Surrey is one of the few counties in Britain that contains all twelve species of native amphibians and reptiles (thirteen if the pool frog is included in this category) - as well as a fair number of aliens

- the species accounts pretty much cover the complete British herpetofauna. Each species description contains information on distribution, habitat, morphology and behaviour, and is accompanied by an excellent line drawing of the species concerned by Paul Veenvliet together with a dot-map showing those 10 km grid squares within the county where the species has been recorded. Records known only prior to 1980 are recorded as grey rather than black dots. In the centre of the book are over 70 colour photographs of the species and their habitats. Of particular interest here is the sequence of photos demonstrating how the position of the heel can be used to distinguish between pool, edible and marsh frogs when the hind limb is drawn forward (if in any doubt a diagram is also included in the text). A novel feature of the book that no doubt reflects the first author's personal research interests are the frequency spectrograms and oscillograms of the calls of the frogs and toads. Four appendices provide useful information on important herpetological sites in Surrey, a bibliography of reference books and a list of relevant organisations and societies.

This is the seventh book in a series published by Surrey Wildlife Trust covering Surrey's fauna. Rather surprisingly, it is the first in the series to deal with a vertebrate group, and in this respect the authors have stolen a march on the many ornithologists and mammalogists who vastly outnumber herpetologists within the Wildlife Trusts. The text is written in a lively and engaging style that will appeal to a broad audience. Indeed, the book can be recommended to anyone seeking a concise general introduction to amphibians and reptiles, even if they live beyond the borders of Surrey.

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THE HERPETOLOGICAL BULLETIN

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BOOK REVIEW

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