The HERPETOLOGICAL BULLETIN

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

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All submissions and correspondence arising from the Bulletin should be sent to the Editor, Peter Stafford, c/o Dept. of Botany, The Natural History Museum, Cromwell Road, London, SW7 5BD. *E-mail: pjs@nhm.ac.uk*

Front cover illustration
Site of anuran monitoring project in Belize with (inset from top to bottom) Red-eyed Treefrog (*Agalychnis callidryas*), Hourglass Treefrog (*Hyla ebraccata*), and amplectant Blue-spotted Treefrogs (*Smilisca cyanosticta*). See article on page 7.

MEETINGS

THE EDWARD ELKAN MEMORIAL LECTURE PRESENTED IN FLORIDA

THE fourth Edward Elkan Memorial Lecture was given on Friday 21 September 2001 in Orlando, Florida, U.S.A. The lecture formed part of the Annual Conference of the Association of Reptilian and Amphibian Veterinarians (ARAV), which was held in conjunction with the American Association of Zoo Veterinarians (AAZV).

The speaker was Elliott Jacobson DVM, PhD, internationally renowned for his work in the field of herpetological medicine, whose subject was: 'Reptile Disease: Past, Present, Future' — a comprehensive historical review of the subject with a forward-looking perspective. Dr. Jacobson emphasised the advances that have been made in our understanding of infectious diseases of the class Reptilia and stressed that many of these were attributable to close collaboration between herpetologists and veterinary pathologists. Margaret Cooper LLB welcomed approximately 100 guests to the gathering and outlined the history of the Memorial Lecture and previous lecturers. Edward Elkan's life and work were recounted by John Cooper FRCVS who also introduced the speaker. The vote of thanks was given by Martin Lawton FRCVS, followed by an outdoor reception, enabling the attendees to meet and talk.

Many people contributed to this successful evening — all those mentioned above, together with Wilbur Amand VMD, Charles Innis VMD and other American colleagues. The ARAV very kindly incorporated the lecture into their scientific programme and assisted with funding for the reception. In the U.K. Sally Dowsett designed and produced the publicity material and the presentation certificate, while Elizabeth Allen MIBiol provided background information for the lecture.

This series of lectures commemorates the life and work of Dr. Edward Elkan, who died in 1983 at the age of 88. Dr. Elkan, who was medically qualified, had a life-long interest in comparative pathology and was a pioneer in the study of

The lecturer, Dr. Elliott Jacobson (2nd from right), with (from left) Mr. Martin Lawton, Mrs. Margaret Cooper and Prof. John Cooper.

diseases of reptiles, amphibians and fish. He published widely and was a mentor to many young veterinary graduates and biologists.

Following Dr. Elkan's death a Memorial Fund was established in order to perpetuate his name and work and to preserve and maintain his extensive collection of microscope slides, transparencies, pathological specimens, photographs, drawings, books and other material. This material includes what is undoubtedly a unique series of scientific papers, correspondence and histological sections relating to *Xenopus*, much of it of historical as well as scientific importance. The 'Edward Elkan Reference Collection of Lower Vertebrate Pathology' remains available for study by herpetologists, pathologists and research workers.

The first 'Edward Elkan Memorial Lecture' was given by Prof. John Cooper on the Pathology of Reptiles and Amphibians at the International Colloquium held in Nottingham, England in 1984 and the second by Dr. Fredric Frye at the World Congress of Herpetology in Canterbury, England in 1989. The third was presented by Prof. Peer Zwart at a British Chelonian Group Symposium in Bristol, England in 1993.

Further information about the Edward Elkan Reference Collection is available from ourselves. Offers of assistance are always welcome as are contributions to the Memorial Fund. The latter enable restorative work to be carried out on the

Collection as well as helping to cover some of the costs of Memorial Lectures. All donations are acknowledged and reports on the Collection, the lectures and the fund are published regularly in veterinary and herpetological journals.

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OBITUARY

HUBERT SAINT-GIRONS, 1926-2001

BORN in 1926, Hubert Saint-Girons, perhaps France's leading herpetologist, died on 18 April 2001. In recognition of his distinguished work in France, Britain's closest European neighbour, Prof. Saint-Girons was elected an Honorary Life Member of the British Herpetological Society in 1984. He was in France perhaps the equivalent of Prof. Angus Bellairs in Britain. His inability to write in English, albeit that his prose-style in French was much admired in France, did not prevent him on one occasion from submitting a long article in French, co-authored with his wife, Marie-Charlotte Saint-Girons, to what was then the British Journal of Herpetology 'Contribution à la morphologie comparée des érythrocytes chez les reptiles', and this was published, with an English summary, in volume 4(4): 67-82, June 1969. It caused some muttering among the linguistically-inept English-speaking denizens of Anglophone nations then making-up the majority of members of the British Herpetological Society! Probably with a sense of fun, he also once addressed a meeting of the American Society of Ichthyologists and Herpetologists that was being held, in 1986, in Victoria, British Columbia, with a paper 'Introduction à la reproduction des serpents' in French, on the basis that Canada - certainly with Québec Province, rather than British Columbia - is officially bilingual! He did distribute an English summary. He worked closely with his wife (also a scientist) as a team, and both had a passion for Morocco, where they had spent some time together during the 1950s when still a French possession, Hubert subsequently publishing articles on the reptiles and Marie-Charlotte on the rodents and climate.

Hubert was an elegant man, in a special Gallic way, spending some six months of the year on fieldwork near his small chateau at Bohallard, by Puceul, about 30 kilometres north of Nantes, which his wife used as her institutional address, and the remainder at the Laboratoire d'Evolution des Etres Organisés at the Université Pierre et Marie Curie in Paris, which Hubert used as his. Sadly, Marie-Charlotte pre-deceased Hubert by some five or so years, and his zest for life after this loss became somewhat tempered, but his passion for herpetology remained intact. In their last few years together, both enjoyed visits to New Zealand among other places, and Marie-Charlotte reported observations made on the Tuatara at the 3rd Ordinary General Meeting of Societas Europaea Herpetologica in Prague in August 1985, when it was in fact the last time that I personally saw, and had the chance to speak with them both together. Indeed I sat next to Hubert on the coach for part of the wine-tasting excursion to Moravia.

Hubert Saint-Girons published over 200 papers, many on snakes — a life-long interest. A comprehensive appreciation of his contribution to herpetology and the man himself has already been published in an obituary in the U.S.-based Society for the Study of Amphibians and Reptiles (SSAR)'s Herpetological Review [32(1), 9-10, March 2001].

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ARTICLES

'MOULT OF THE SERPENS [*SIC*], THEIR LAYING, THEIR DISSECTION'. AN INTERESTING DOCUMENT FOR THE HISTORY OF EUROPEAN HERPETOLOGY BY GEORG SEGERUS, PHYSICIAN TO THE POLISH KINGS

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GEORG Seger (1629-1678), or Segerus (in its Latin form), was born at Nuremberg and studied medicine at Leipzig, Wittenberg and Koenigsberg. On completing his studies he became tutor to the children of Polish aristocrat Teodor Potocki and he accompanied them on their travels throughout Europe. He spent five years in Copenhagen under the supervision of the illustrious teacher of anatomy Thomas Bartholin (1616-1680). He then proceeded to Basel, where he took his doctor's degree in 1660 with *De Hippocratis Orthodoxia in Doctrina de Nutritione Foetus Humani in Utero*. After holding a medical appointment at Torun (Thorn), where he also taught in the highly regarded local high school, he was appointed medical officer to the city of Gdansk (Dantzig) in 1675. He was also court doctor to three Polish kings: Jan Kazimierz, Michal Wisniowiecki and Jan Sobieski. His studies in comparative anatomy were stimulated by the Academia Naturae Curiosorum, of which, however, he was apparently not a member.

Collegium Academia Naturae Curiosorum was created in 1652. Cole (1944) stated 'The researches of the Academy during the seventeenth century cover a sufficiently wide field, and this is their chief and indeed almost sole merit. Of the 104 animal types examined the internal organs of a moderate number only were dissected, and in most of cases the author contents himself with listing the organs found, which are more or less accurately named, but no figures or adequate descriptions are included. Still less are there many attempts to compare one animal with another. The contribution of the Academy to the fabric of comparative anatomy, therefore, is unimportant, especially when compared with the almost contemporary record of Perrault and his colleagues at Paris, who brought to the task not only greater skill but a more prophetic vision of the speculative aspects of taxonomy. Apart from one mollusc, three crustacea, two arachnids and thirty-six insects the German Academicians were more interested in the vertebrates and their list include the Lamprey and eleven teleosts, three reptiles, sixteen birds and thirty-one mammals are represented [*sic*]. Muralt was incomparably the leading zootomist, contributing almost half of the total observations published, Seger coming next with eight'.

Segerus published the majority of his work in the journal edited by Bartholin Epistola Bartholini, *Thomae Bartholini epistolarum medicinalum a docti vel ad Doctos scriptarum, centuria I, II, II, IV, Hafniae (1663-1667).* He wrote numerous papers on anatomy, physiology, pharmacology and comparative anatomy. Parts of these papers were also published in *Miscellanea Academia Naturae Curiosorum* and in the *Collections Académiques* edited by the Académie Royale in Paris. Some of this work was of major importance in the history of medicine. He is recognised as one of the first to describe cystic fibrosis (Bush, 1995). His work on animal anatomy was often quoted at the time, for example his work on the anatomy of the male Hare, an anatomical description of two Hare foetuses, dissection of an Otter, dissection of a Mole, dissection of two Hedgehogs, the search for the sense of hearing in fish, description of a Musk Deer skin, and anatomy of a female seal. Segerus was also associated with the Gdansk school of anatomy. At the end of the 16th century a new high school was founded in Gdansk and anatomy was taught there from 1658 onward. The fact that Gdansk was a major centre for naturalist collections was of great assistance to Sergerus in his work. A large part of the Dresden Saxony Royal Collection of crocodiles and American, African, and Asian snakes was brought here (Eilenburger, 1755) and reflects the great variety and quantity of reptile specimens to be found in Gdansk at the time.

The role of the Gdansk school of anatomy in the history of herpetology is little known. Only the work of Jakob Theodor Klein (1685-1759) and particularly *Tentamen herpetologiae* is well known (Johnson et al, 1984). We do, however, know that other Gdansk naturalists also worked on reptiles and amphibians, e.g. Johannes Philippus Breynius (1680-1764), author of *De Coronis Serpentium*, and Michael Christophorus Hanovius (1695-1773), who commented on Indian snakes (1753) and dedicated one chapter of his *Zoologia Sive de Animali Regio* (1768) to the subject of reptiles.

Segerus' published work on snakes is his only work in the domain of herpetology. It is true that he wrote a paper on toads, but this must be considered as a curiosum medicum and not as a serious zoological work. In this paper he recounts the story of an apprentice butcher who fell ill after drinking puddle water. On being treated with snake fat he is said to have regurgitated three toads. This type of observation was very common — 'There are many reports of animals such as frogs, toads, eels, lizards and snakes which are supposed to have lived in the stomatch, intestine, urinary bladder, female genital organs and even abcesses. Indeed, it is impossible to resist the conclusion that doctors were much misled by their malingering or hysterical patients who deliberately added various animals to their urine or faeces' (Foster, 1965).

Segerus' work on serpents was first published in Denmark under the title *De Serpentum Anatome Corum Exclusione Vernatone* in *Epistolae Bartholinii E.N.C Dec 1 Ann. 11*. It was also published in *Miscelleana* in the form of a letter from a Torun doctor to his colleague at Wroclaw, Dr. Philippe Jac Sachs de Lewenhaimb, and was later published in France in the *Collections Académiques*. The fact that it was published three times, and that Segerus was a highly respected scientist known throughout Europe, might lead us to believe that it was a much-quoted work. However, this was not the case. It was in fact cited only very rarely and was quickly forgotten. In the 20th century it was quoted only by his biographers and historians commenting on the Gdansk anatomy school (Loth, 1928; Fedorowicz, 1968). It is not mentioned in the history of herpetology in German speaking areas (Obst, 1996). It is, however, mentioned by F.J. Cole (1944) in his history of comparative anatomy — 'Seger's paper on the structure of a snake (1670), probably the Grass Snake, *Tropidonotus* [an earlier synonymy of *Natrix*], includes notes on all the more obvious organs without disclosing anything novel or important'. It is difficult to agree with this opinion. From the viewpoint of comparative anatomy, Segerus' work cannot be said to be innovative, but it is nevertheless comparable with the finest work available at the time. Its weakness lies in the lack of illustrations.

His work remains important by virtue of the fact that it describes moult and oviposition of snakes in captivity. It is also very probably the first work to describe the keeping of snakes in captivity for scientific, as opposed to religious, purposes. Segerus was the first to observe the 'moult and oviposition' of serpents in captivity. He went on to publish his description of this observation. The pioneering character and importance of this publication quickly becomes apparent when we compare it with the most important zoological works of the time, those of Gesner & Wolphius (1621) and Aldrovandi & Bartholomaeus (1640). In *their* works the information concerning the behaviour of snakes, still relatively legendary, generally does not come from direct observation but from bibliographical compilations of classical authors. Segerus's description is therefore probably the first viable information concerning serpent moulting in the history of herpetology.

Segerus describes 'Having found near Copenhagen in 1656 a large quantity of serpents of the species known as Aesculapian Snakes, because they are in no way dangerous and are without venom, I took some of them alive and placed them in a basket which I had taken to my study. Initially, for reasons of personal safety I removed their little forked tongue, which they constantly moved, following the popular opinion that by means of it they could inflict normal wounds; but later becoming more courageous I left them this organ as being perfectly harmless. The snakes from which I had removed the tongue remained for three days sad and motionless in the basket filled with soft and moist earth, except if irritated. But once they recovered their former vigour, they soon explored my study fearlessly returning to the basket only in the evening'. This document confirms the existence in Central and Northern Europe of the superstition whereby snakes could inflict mortal wounds with their tongues. Segerus' attitude indicates his distrust in this belief.

On the subject of moult and oviposition Segerus writes 'One day I noticed that one of them made great efforts to get in between the basket and the wall against which I had placed the basket. I therefore removed it in order to observe the reason why the serpent sought out such a narrow space. It instantly began to shed its skin, starting with the head. Whereupon I took hold of the skin and helped it. Once the task was completed, the snake retired to its nest for a few days until the new scaly skin had acquired a suitable consistency. On another occasion I observed that one of the female snakes, having rolled about on the tiles, laid an egg thereon. I immediately took the snake and placed it on a table and with gentle treatment I helped it to lay thirteen eggs. The laying of the eggs lasted approximately one hour and a half as each egg took a half quarter hour, and when I stopped helping the female it took longer to lay the eggs, from which I concluded that it was not indifferent to my assistance, particularly since, in the course of the operation, it never ceased to rub its head gently against my hands as if to stroke'.

It is interesting to speculate on the species of snake described by Segerus. He uses the name Aesculapian Snake, but the absence of a more precise description makes it impossible to affirm that it really was an *Elaphe longissima* and not a Grass Snake, *Natrix natrix*. It is easy to confuse these two species beacause juvenile Aesculapian Snakes and Grass Snakes have similar markings, characterised by nuchal collars. It should be pointed out, however, that it was possible at the time to find Aesculapian Snakes in the area of Copenhagen: 'The present continuous range of *E. longissima* is restricted to the southern part of Europe, mainly Italy, the Balkans and the northern part of Greece. In addition, there are smaller, isolated populations further north in Europe (Böhme, 1993). On the Danish island Zealand, three records of *E. longissima* from the last century are available, the most recent from 1863 (Hvass, 1942). These isolated populations, restricted to areas with favourable, warm and dry microclimate, are probably remnants or relics of an earlier continuous distribution' (Ljungar, 1995). Gasc et al. (1997) state: 'Though it is not shown on the map, this species occurred in Denmark before 1900'.

The question remains open as to whether Segerus was able to distinguish between these two species. The Aesculapian Snake was a great centre of attention at the time because of its role in ancient mythology and history. According to legend, the same species is Epidaurus serpent, believed to have vanquished the plague in Rome under Q. Fabrius and Q. Brutus. According to 19th century Déterville's *Dictionnaire des Sciences Naturelles*, the Aesculapian Snake was 'very common in Italy where they are trained to come when called, to perform tricks of various sorts, which is to say that it is very gentle and adapts easily to man'. It is probable, however, that this snake was then better known in southern Europe than in Germany, Poland or Denmark. One sentence in Segerus' work nevertheless causes us to wonder. When describing the reproductive organs he says 'but I could not state it beyond doubt because I did not have the occasion to open male snakes (...) not being able to return to the place from whence I had brought those I describe'.

He acquired his animals for dissection from various sources: some were gifts from friends, others he bought from fishermen or farmers and yet others he himself found on his explorations. We know that he could easily have bought snakes from apothecaries. Given these circumstances, it is difficult to believe that in Torun he could not have found and recognised the Grass Snake, *Natrix natrix*, which was without doubt a very common species in Pommerania at that time. It is therefore quite possible that his specimens were, in reality, Aesculapian Snakes, *Elaphe longissima*.

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PROJECT ANURAN: A MULTI-SPECIES MONITORING PROJECT AT THE TROPICAL LOWLAND FOREST SITE OF LAS CUEVAS, CHIQUIBUL FOREST RESERVE, BELIZE

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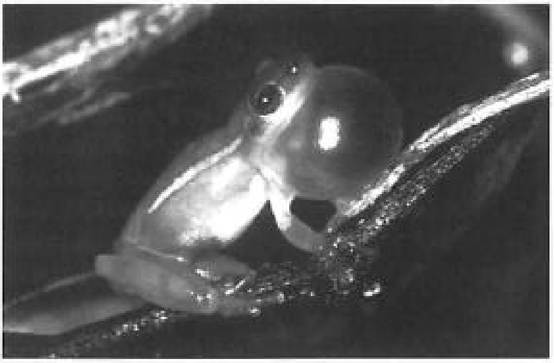
IN the decade following the establishment of the Declining Amphibian Populations Task Force (DAPTF) of the IUCN in 1990, an increasing number of reports from monitoring projects, comparative studies, and experimental research worldwide, have identified the observed phenomenon of declining amphibian populations as being both real and global in nature (Lips, 1998; Wake, 1998; Alford & Richards, 1999; Houlahan et al., 2000; Young et al., 2001). Particular concern for the plight of amphibians in comparison to other taxonomic groups has come from reports of declines across entire amphibian communities, and from areas that are largely intact from direct human impacts (e.g. Drost & Fellers, 1996; Laurance et al., 1996; Lips, 1998). Despite this concern there are three main questions concerning amphibian declines in which a large amount of uncertainty remains:

(1) How to distinguish real long-term declines from natural or stochastic population fluctuations?
(2) Whether human agents can be isolated as the potential cause of declines?
(3) Whether a small number of global agents are responsible for the majority of declines?

Although the picture is far from clear, convincing new research suggests that the majority of declines are unlikely to be the result of a small number of independent global agents, but rather the result of a complex interaction of local processes in the context of human-induced environmental change (Kiesecker et al., 2001; Pounds, 2001). Unravelling such complexity will allow for more confident and efficient isolation of population declines, the establishment of effective conservation management plans, and even a capacity to predict impending declines. Central to these aims is a need to improve our understanding of the levels of variability naturally inherent in amphibian populations, and how the forces that influence these dynamics vary across different spatial and temporal scales, and across different environmental conditions.

Project Anuran is an undergraduate monitoring project established in 1999 as a joint venture between the University of Edinburgh and students in Belize, which through the intensive monitoring of an entire frog (Amphibia: Anura) assemblage is attempting to improve our understanding of some of the issues raised above. Data collected include information on the population dynamics, reproductive behaviour, and environmental requirements of all local species during each breeding season (2000 and 2001 to date). The purpose of this article is to provide the reader with a preliminary insight into both the project in general and the natural history of the amphibian community at Las Cuevas, Belize.

Our study serves to complement existing work by concentrating on both an area and species assemblage that remain largely unstudied. The study site at Las Cuevas, the Natural History Museum's research station, lies within the Chiquibul Forest Reserve, which represents one of the most pristine and extensive stretches of forest in Central America (Furley, 1998). The vegetation type can best be described as a mosaic of



Hyla picta. Photograph © Project Anuran.

deciduous semi-evergreen and deciduous seasonal tropical forest punctuated by stands of pine (*Pinus carribea*). Despite the biological importance of the region, the basic ecology of many of the amphibian species in Belize remains largely unknown. Furthermore, there remains a desperate need for monitoring studies throughout the tropics (Wake, 1991, 1998; Pearman et al., 1995; Houlahan et al., 2000), and in particular in the neotropics where amphibian diversity reaches its peak (Lee, 1996). A recent workshop involving herpetologists from across Latin America noted that despite over 50 declines reported in 13 countries from across 30 amphibian genera, only 5% of studies have been published, whilst the vast majority of both sites and species remain poorly understood (Young et al., 2001). The DAPTF are presently co-ordinating a monitoring program entitled the Maya Forest Anuran Monitoring Program (MAYAMON), as part of a large internationally funded biological monitoring project of the entire Selva Maya region (Carr & de Stoll, 1999). The information collected by Project Anuran is fed into a regional picture collated by MAYAMON using data from studies throughout Belize, the southern states of Mexico, and the Péten of Guatemala. Our study site at Las Cuevas is able to provide a good comparison against many more disturbed areas in other parts of the region.

Monitoring protocol

Monitoring of vocalising and non-vocalising frog species was carried out using two separate survey

Hyla microcephala. Photograph © Project Anuran.

techniques. For vocalising species, a series of seven (increasing to nine in Phase II) breeding sites representing a variety of habitat types were chosen. Surveys of species richness, relative abundance and environmental variables were conducted between 19:00 and 02:00 h, with measurements of each being taken at half-hourly intervals. The index of relative abundance follows the protocol used in the regional MAYAMON scheme, and assigns the number of calling males heard during the first 15 minutes of each recording to a Vocalisation Category (Meyer, 1999). An additional index of Vocalisation Intensity was also noted to allow for analysis of patterns of the overall vocalisation activity for each species.

Digital recordings of all species were made using a Sony mini-disc recorder, copies of which can be obtained from the authors. Measurements of the abiotic environment, which were also taken every half-hour, included air and water temperature, rainfall duration for the previous half-hour, and relative humidity. Measurements taken once for each site visit were: length of two principle pond axis, water pH, phase of moon and summary weather conditions. Repeat surveys of each study site were conducted at even intervals throughout the study period, with a minimum of three repeat visits per site in Phase I (2000), increasing to a minimum of five in Phase II (2001) (increased effort was made possible due to increased manpower, which can be adjusted to allow for comparison between years). The main features of the floristic community were also recorded for each site.

With respect to the second part of the survey work, non-vocalising or leaf litter species are far more difficult to assess, owing to their rather cryptic and solitary nature. In view of the variability in effectiveness between different methods in relation to different sites, species, and environmental conditions (Pearman et al., 1995), we employed three techniques: intensive surveys of randomly sampled 8 x 8 m plots, less intensive visual surveys of 6 x 600 m transects, and five pitfall trap arrays. Techniques follow standard protocol outlined in Heyer et al. (1994) — traps using two arrays; 8-bucket/4 fence cross and 6-bucket straight-line fences. Weather recordings of rainfall volume and duration, relative humidity, ambient temperature, maximum/minimum temperature, and cloud cover were taken at 09:00 h throughout the duration of each study period from the main site at the research station.

Family	Species
Leptodactylidae	*Eleutherodactylus chac*
	Eleutherodactylus laticeps
	Eleutherodactylus rhodopis
	Eleutherodactylus sabrinus
Bufonidae	*Bufo campbelli*
	Bufo marinus
	Bufo valliceps
Ranidae	*Rana berlandieri*
	Rana juliani
	Rana vaillanti
Hylidae	*Agalychnis callidryas*
	Agalychnis moreletii
	Hyla ebraccata
	Hyla loquax
	Hyla microcephala
	Hyla picta
	Smilisca baudinii
	Smilisca cyanosticta
Microhylidae	*Gastrophryne elegans*
Centrolenidae	*Hyalinobatrachium fleischmanni*
Rhinophrynidae	*Rhinophrynus dorsalis*

Table 1. A complete species list of anurans identified at Las Cuevas during both study periods.

Amphibian fauna of Las Cuevas

In light of the large size of our data set a comprehensive account of our results to date is inappropriate for this journal (both the main report Phase I and preliminary report Phase II are available on request from the authors). Our intention is therefore to provide the reader with an overview of the diversity, relative abundance, and vocalisation activity of the amphibian community at Las Cuevas.

Table 1 presents the total anuran species richness recorded at Las Cuevas from across both field studies. A total of 21 species identifies the site as being one of the most diverse with respect to amphibians in Belize (Miller & Miller, 1995). In order to provide a clear picture of the anuran fauna at Las Cuevas, it is appropriate to consider the species with respect to their method of surveillance — i.e. vocalising or non-vocalising.

Table 2 presents the summary of relative abundance statistics for all 21 species in Table 1. Due to the fact that two distinct survey techniques were used it is impossible to standardise across all species. Despite this, Table 2 gives an appreciation of the relative abundance amongst both the vocalising and non-vocalising species. A number of species were recorded under both methods, whilst one (*Smilisca cyanosticta*) was not recorded under either. Clear inadequacies in both methods are identified by the high number of anecdotal recordings of species that were rarely observed in official surveys — notably explosive breeding species (e.g. *Gastrophryne elegans*).

Vocalising species: The nine breeding sites under study can be divided into two principle habitat types: (1) those characterised by an almost complete canopy cover, a palm dominated flora, and little herbaceous vegetation, and (2) relatively open sites with less than 30% canopy cover, often with dense herbaceous vegetation.

The closed-canopy sites were almost exclusively dominated by the two *Agalychnis* species — *A. callidryas*, the Red-eyed Treefrog,

Species	Summed maximum Vocalisation Category	Transect encounter rate (individuals/km)	Anecdotal sightings
Agalychnis callidryas	20	-	20-50
Agalychnis moreletii	15	-	10-20
Bufo campbelli	-	0.2	28
Bufo marinus	-	0.1	3
Bufo valliceps	4	0.25	20-50
Eleutherodactylus chac	-	-	1
Eleutherodactylus laticeps	-	0.2	8
Eleutherodactylus rhodopis	-	0.1	2
Eleutherodactylus sabrinus	-	0.7	4
Gastrophryne elegans	6	0.1	350-400
Hyalinobactrachium fleischmanni	-	0.1	0
Hyla ebraccata	4	-	10-20
Hyla loquax	13	-	20-50
Hyla microcephala	12	-	10-20
Hyla picta	11	-	20-50
Rana berlandieri	3	-	10-20
Rana juliani	-	1.05	13
Rana vaillanti	-	2.5	2
Rhinophrynus dorsalis		-	10-20
Smilisca baudinii	12	-	50-100
Smilisca cyanosticta	1	-	26

Table 2. Summary of relative abundance indices for all 21 anuran species. Index values relate to the appropriate survey technique for each species, as such comparisons between all species are impossible. Data are only taken from 2001, which due to a higher sampling effort allows for a more accurate resolution of the true relative abundance. For vocalising species this is given as a summed Vocalisation Category across all study sites (taking the maximum category value for which each species was observed at each site in turn — maximum from across all recorded hours at each site). Vocalisation categories; 1 = 1-5 individuals, 2 = 6-20, 3 = 21-50, 4 >50. For leaf-litter species the appropriate index is their encounter rate from across the total transect distance surveyed (20 km) (using data from all five transect lines). Anecdotal sightings during 2001 are also given for each species, representing an estimate of the number seen outside any official survey period. Note that this column includes a number of species not recorded using either survey technique. The absence of any value indicates that the species was not assessed under that technique.

and *A. moreletii*, Morelet's Treefrog. The Red-eyed Treefrog is a very common inhabitant of the Yucatán Peninsula, making its high local abundance unsurprising. However, Morelet's Treefrog, which we found in almost equal numbers (Table 2), has been rarely reported in Belize (Lee, 2000). Aside from being found at sites with similar physical properties, the ecological similarity of these two species is further emphasised in their vocalisation behaviour, with both displaying patterns typical of prolonged breeders (sensu Wells, 1977); males were heard calling for a large proportion of the night, and across the whole range of environmental conditions experienced in each study period.

On one occasion a male *A. callidryas* was observed in amplexus with a female *A. moreletii*, which succeeded in producing a small cluster of eggs. The eggs were monitored closely whilst being protected from predation (using a mosquito net and an empty dustbin); however, they proved to be unviable. Despite the lack of viability, the event highlights the remarkable similarities in the ecology, breeding requirements, and physical acoustic properties of the two species. As an aside it is interesting to note that over 150 hours of recorded observation of these species allowed for a number of rare observations of aggressive fighting between males, with each female being hounded by anything up to six males!

Whilst both *Agalychnis* species were frequently active during relatively dry conditions in the absence of any other species, periods of intense rain stimulated the arrival of a number of explosive breeders (sensu Wells, 1977) to the closed canopy sites. This emphasises the importance of frequent site visits in order to capture the variation in community level amphibian dynamics over the suite of potential environmental conditions. Such species included the ubiquitous Mexican Treefrog (*Smilisca baudinii*), the more elusive Elegant Narrowmouth Frog (*Gastrophryne elegans*), and the remarkable Mexican Burrowing Toad (*Rhinophrynus dorsalis*).

In contrast to the closed-canopy breeding sites, the open-canopy sites exhibit a much higher level of species richness. It seems intuitive that as the complexity of the surrounding vegetation matrix increases the observed diversity also increases, perhaps due to an increase in the availability and diversity of calling and oviposition sites. Commonly observed species at these sites included *Hyla loquax* and *H. microcephala*, with *H. ebraccata*, *H. picta*, *Bufo valliceps* and *Rana berlandieri* being recorded less frequently (Table 2). *Agalychnis callidryas* was also recorded across all of these sites and on a large proportion of the study nights, although *A. moreletii* was not observed outside of closed-canopy ponds at all during 2000, and only rarely during 2001. Although an ecological explanation for the observed spatial and temporal distribution of species across study nights is far from clear, some indication is given from analysis of the data describing vocalisation activity patterns. These data (taken from all study nights) clearly indicate that despite significant levels of variation, different species were recorded exhibiting peaks in their calling activity (an index incorporating both relative abundance and individual calling rates) at different times throughout any one night (Figure 1).

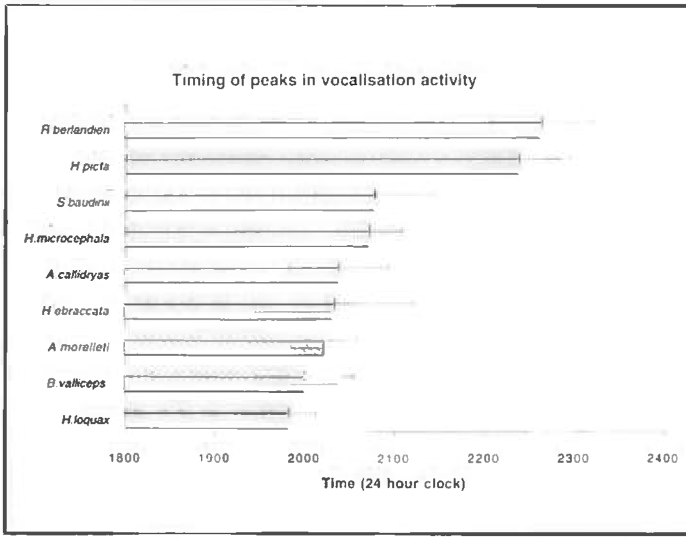


Figure 1. Timing of peaks in vocalisation activity of anuran species local to Las Cuevas (24 hour clock) each bar length gives the mean time of peak +/- 1*SE. Vocalisation activity is measured as Vocalisation Category (audible abundance) multiplied by Vocalisation Intensity. Data taken from 2000 only.

This temporal partitioning could be interpreted as a result of strong inter-specific competition for acoustic space — a conclusion that has been made by a number of other studies (Bowker & Bowker, 1979; Aichinger, 1987; Rand & Myers, 1990; Donnelly & Guyer, 1994). Support for this theory comes from the belief that breeding call characteristics are thought to be some of the most important reproductive isolating mechanisms that allow amphibian coexistence (Fouquette, 1960). For the case of *A. moreletii* it would therefore follow that its absence from open-canopy sites was due not to the lack of any specific habitat requirement at those sites, but rather to the excluding effect of other (more acoustically dominant) species. It is important to note here that an understanding of the relative importance of factors that structure the spatial and temporal dynamics of amphibian communities is an important asset for conservation. Such an understanding allows some prediction as to the potential effect of environmental and habitat

Above: Morelet's Treefrog, *Agalychnis moreletii*. Photograph © Project Anuran.

Left: amplectant male *A. callidryas* with female (larger) *A. moreletii*. © Project Anuran.

Broad-headed Robber Frog, *Eleutherodactylus laticeps*. Photograph © Project Anuran.

Elegant Narrowmouth Frog, *Gastrophryne elegans*. Photograph © Project Anuran.

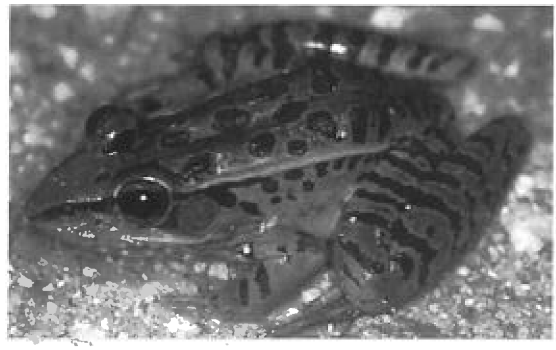
Maya Mountains Frog, *Rana juliani*. Photograph © Project Anuran.

Vaillante's Frog, *Rana vaillanti*. Photograph © Project Anuran.

change, as well as the consequences of alterations in population size and reproductive activity of any one species on the dynamics of the rest of the community. Aside from this, an understanding of both temporal and spatial community patterns is critical in optimally allocating time and resources in budget-constrained monitoring projects — a fundamental exercise throughout much of the tropics (Guyer, 1990; Pearman et al., 1991).

As noted above for the closed-canopy sites, the group of species described as explosive breeders were also found at high levels of relative abundance following intense rainfall events at the open canopy sites. It seems clear that the distribution and reproductive activity of these species is determined far more by rainfall patterns than by any local environmental characteristics. It is interesting to note that all the explosive breeders observed at Las Cuevas have either a very loud (e.g. *Rhinophrynus dorsalis*, *Bufo valliceps*, *Smilisca baudinii*) or distinctive (*Gastrophryne elegans*) vocalisation. These characteristics are perhaps a result of a selection pressure for a call that has dominant acoustic properties, thus ensuring reproductive success when the rare, but appropriate conditions are presented. The high level of variability in the presence and level of reproductive activity of these species, in addition to the unpredictability in weather patterns, imposes serious caveats in our ability to monitor populations effectively and reliably. This fact serves to re-emphasise the importance of frequent site-survey repeats, and recording over a significant proportion of the night in order to capture true measures of relative abundance.

One disturbing result from the weather recordings was an increase in the length of dry periods throughout the wet season of 2001 — a trend that appears to be relatively long term following anecdotal reports (N. Bol pers. comm. — Las Cuevas Operations Manager). Although the volume of rainfall seems to show little change, there seemed to be a change in the pattern of rainfall events — with rain falling in intense, relatively short time periods, interspersed by long dry spells. This is shown by the fact that many of our study sites that were permanently active during 2000 remained empty for up to 80% of the 2001 study period. Clearly such long periods of desiccation between breeding attempts will have drastic consequences for the reproductive success of many species — most of which require more than 10 weeks for the tadpoles to develop (Lee, 2000). Although no evidence exists from Las Cuevas, alterations in weather patterns throughout Central America following increasingly intense El Ninô events (Holmgren et al., 2001) have been causally linked to amphibian declines in Costa Rica (Pounds et al., 1999; Pounds, 2001).



Rio Grande Leopard Frog, *Rana berlandieri*.
Photograph © Project Anuran.

Non-vocalising species: Non-vocalising leaf litter anurans have been assessed using three methods, resulting so far in over 100 hours of intense plot searching, 20 km of transect surveys, and over 1000 pitfall trap nights. This has provided us with a valuable comparison of the effectiveness of these three commonly employed survey methods. The analysis of this is intended for independent presentation, although in summary, transect searches returned by far the highest numbers of species and individuals (see Table 2), with inter-specific differences being observed between day and night transects, whilst plots and pitfall traps proved to be almost useless (i.e. less than 0.05% trap success, and almost all species were observed to have the ability to escape).

A number of interesting recordings of the non-vocalising group were made. Two sightings of *Eleutherodactylus rhodopis*, the Polymorphic Robber Frog were of particular interest, having been described by Meyer & Foster (1996) as having only one record from Belize, 50 years ago. The Maya Mountains endemic *Rana juliani*, for which few records exist outside Caribbean Pine (*Pinus carribea*) formations, was found to be locally abundant close to small streams (Table 2). The newly described *Eleutherodactylus sabrinus* (Campbell & Savage 2000) was also found in relatively high numbers alongside both minor water-courses and the main Monkey Tail river. The Broad-headed Rainfrog (*Eleutherodactylus laticeps*) noted to be much rarer than the closely related Chac's Rainfrog (*Eleutherodactylus chac*) in field guides (e.g. Lee, 2000), was actually found in significantly higher numbers than the latter species (Table 2). It is important to note with respect to the above records, that for many ground-dwelling amphibians next to nothing is known about their basic ecology. It is therefore likely that records of rare species, or relatively high local abundances, better reflect a deficiency in survey work than any ecological significance of the Las Cuevas site.

CONCLUSIONS

Following the aim of Project Anuran to increase our understanding of the ecology and population dynamics of anuran populations at Las Cuevas, we have collected data over two field seasons on species richness, relative abundance (including levels of spatial and temporal variation), and where possible, vocalisation activity patterns, and environmental associations. This account has provided a brief overview of a number of salient points. It is hoped that following future studies such a comprehensive consideration of an entire assemblage across multiple sites, and different temporal scales, will provide valuable information on the natural levels of variability in amphibian populations — an understanding that is essential for conservation planning.

Few conservation projects in developing countries have the levels of expertise, money or time necessary for thorough ecological assessments (Pearman et al., 1995). Project Anuran has benefited from having had access to all of these, and it is our belief that through the collaboration of student communities from countries rich in such resources with those from developing parts of the world, where so many of today's conservation projects are focussed, a great deal of progress can be achieved.

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A CASE STUDY IN THE EVOLUTION OF CRESTED NEWT CONSERVATION

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ABSTRACT.— Crested Newts (*Triturus cristatus*) have received ever-increasing amounts of attention in recent decades. This paper reviews changes and events on the northeast edge of Ramsey in Cambridgeshire. It highlights how lack of conservation action evolved first into a reactive approach, then into a more thoughtful strategic operation, which is now beginning to result in benefits for the newts.

CONSERVATION of the Crested Newt (*Triturus cristatus*) is a topic that occupies the time of increasing numbers of people, not only in Britain, but throughout the species' range. As with much of British herpetology, there are so many urgent tasks and so many crises that there is seldom time to reflect on what progress may have been made. As someone who has been involved with herpetological research and conservation for more than 30 years, I am conscious of the fact that today's tasks and crises, real as they are, are often a function of our increased awareness, knowledge and expectations. We have changed from simply not knowing about losses, to trying to prevent them, and then to trying to anticipate and plan action strategically. These changes have occurred gradually. While it is not the purpose of this short paper to document them, I would suggest that two key events were the introduction of the Wildlife and Countryside Act in 1981 and the publication of the Species Action Plan in 1995. It could, however, be argued that these events themselves were precipitated by others.

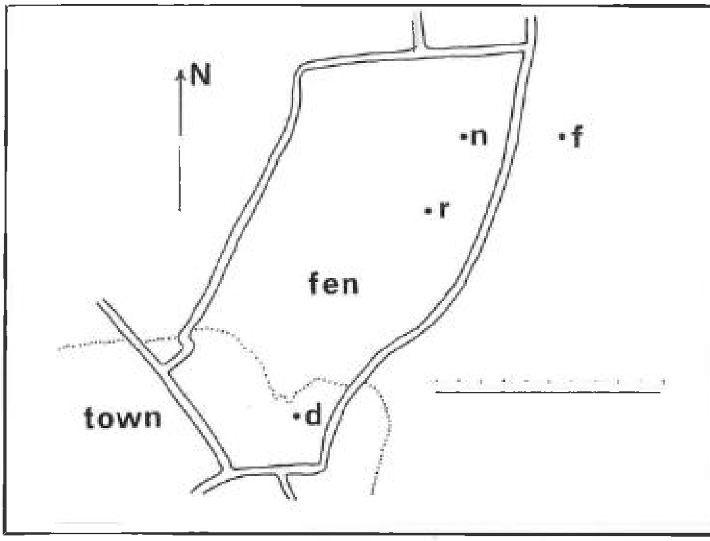
Inclusion of the Crested Newt as a protected species on Schedule 5 of the 1981 Act catapulted it into the limelight. A start was made documenting where it occurred, studying its ecology (Oldham & Nicholson, 1986) and attempting to safeguard individuals and populations. Still, though, the species continued to decline, in part because much of the thrust of the work was reactive, trying to hold on to what we had. Hopefully the Action Plan and its Work Programme will lead to a much greater emphasis on a proactive approach in an attempt to halt and perhaps even reverse the continual loss of populations.

The account below of a translocation at Ramsey in Cambridgeshire is presented not just as a scientific report on the work, but as an illustration of how aims and actions have evolved over the last 50 years or so and how they continue to evolve.

THE DISTANT PAST: THE NEGATIVE PHASE

A summary of the fortunes of Crested Newts in the second half of the last century has been pieced together by interviewing long-term residents of Ramsey. The species was abundant around the northeast edge of the town during the 1950s. An important and traditional breeding pond occurred at TL 291853 on the edge of the town (pond 'd' on the Map). Beyond is a block of fen edge farmland of about 150 ha bordered by roads (see Map). This area is more undulating than typical fenland; one third is high organic matter peat fen, while the remainder is sandy clay loam. At least six ponds occurred there in the past, one of which was known for its Crested Newts.

Crested Newts in the area of Ramsey have suffered from a similar variety of problems to those elsewhere in the country (e.g. Cooke & Scorgie, 1983; Oldham & Nicholson, 1986; Hilton-Brown & Oldham, 1991). From the 1960s, building work on the outskirts of town will have removed much of their damp foraging habitat, and possibly breeding sites too. By the 1980s, pond "d" was hemmed in by housing and was more or less totally shaded by mature trees; in 1984, accumulated silt was removed from the pond by the landowner. On the farmland, with a diminishing need to provide water for stock, ponds were allowed to silt up or were actively filled in. Only two ponds existed in the fenland block in the 1990s, and these had both been re-dug for conservation purposes in 1989 (shown on the Map as 'r' and 'n').



A sketch map showing the area to the northeast of Ramsey in Cambridgeshire. Principal ponds mentioned in the text are marked as d (donor), r (receptor), n (northern) and f (farmhouse pond at entrance to Worlick Farm). The on-site substitute pond is at the same location as the donor pond. Main roads are indicated and the approximate current edge of the built-up area shown as a dotted line. The scale bar represents 1 km with sub-divisions at 100 m.

THE RECENT PAST: THE REACTIVE PHASE

Donor pond 'd' and its on-site substitute

Despite undertaking local surveys and enquiries into Crested Newt sites in the early and mid 1980s, I failed to find the donor pond itself, although I knew non-breeding newts had been seen nearby. I first visited the pond in September 1988, by which time its Crested Newt population had all but disappeared. It measured about 11-12 m x 5-6 m and was more than 1 m deep. Recent events at the site are listed chronologically in Table 1 and night counts are summarised in Table 2. The pond was initially scheduled for destruction in 1991, but, because of delays, it survived until 1999.

Translocation began in 1991 and finished in 1993, by when it was no longer cost-effective in terms of time. Newts were caught both by netting at night and by bottle-trapping. Eggs laid on plastic strips were also transferred. Resources were not available to fence the pond and intercept immigrating or emigrating newts. Numbers of adults caught were: 1991, 13 netted and 4 trapped; 1992, 4 netted; 1993, 2 netted. Prior to release into the receptor pond 'r' about 1 km away, the total length of each adult newt was measured (mean ± SE for 7 females = 136±4 mm, for 16 males = 128±2 mm). No immature Crested Newts or larvae were encountered and the lack of any adult <120 mm implied a population whose recruitment was failing. This was subsequently confirmed in 2001 when males from the receptor pond were measured (see below). During these operations, Smooth Newts (*Triturus vulgaris*), Common Frogs (*Rana temporaria*) and Common Toads (*Bufo bufo*) were recorded in small numbers and some were translocated, but details are not given in this paper.

A decrease in population size, perhaps associated with translocation, was confirmed for Crested Newts with mean night counts declining significantly 1989-1999 (Table 2, $r_s = -0.914$, $n = 6$, $P<0.05$). Searches were made during draining in July 1999, but no adult, immature or larval Crested Newts were found. Thus there was no evidence that any left behind in 1993 had survived and/or bred during the time that the pond remained.

The on-site substitute pond was dug in 1999 (Table 1) shortly before the donor pond was

Date	Event
September 1988	Asked to check for Crested Newts by landowner who was applying to renew planning permission to build houses in paddock containing the pond. Nothing found, but informed by neighbour that Crested Newts still occurred.
Spring 1989	Night counts confirmed presence of newts (Table 2). Landowner undertook to safeguard newts within the development, including managing the pond positively.
November 1990	Informed by landowner that site plan agreed with District Planning Officers, but pond would need re-siting by 15-20 yards, probably in 1991. I expressed disappointment, but agreed to help and advise. Decided to move newts to receptor pond to safeguard them during construction and to establish a new breeding population. If the on-site substitute pond was suitable and well-managed, some would be returned.
Springs 1991-1993	Newts and eggs transferred to receptor pond.
Mid 1990s	Donor pond too overgrown for making observations.
Spring 1998	Site had changed ownership and was being developed by a local builder. Surrounding scrub removed, so night counting resumed (Table 2).
July 1999	Pond drained and substitute pond dug and filled with water. House construction started.

Table 1. Events at the site of the donor pond (and the substitute pond), 1988-1999.

drained. It was located less than 20 m away, was of similar size, and water pumped from the donor pond was used to fill it. The substitute pond was subsequently sold as a feature of the front garden of one of the new houses. Its Habitat Suitability Index was in the region of 0.5-0.6 in 2001, suggesting it might support a small population (Oldham et al., 2000). However, the pond lacks any suitable terrestrial habitat around its edges and has barriers to migration on all sides. The owner reported having seen no residual wildlife, such as newts, in the pond.

Receptor pond 'r' and northern pond 'n'

The receptor pond is located at TL 297862, and measures a maximum of 12 x 10 m, being typically >1 m deep. Although situated in arable farmland it is adjacent to ditches and old, broad hedges along which newts might move and forage. In 2001, its Habitat Suitability Index was assessed as 0.71. The initial aim was to provide a site into which the translocated newts could settle and breed.

Night counts revealed an increasing population, 1991-2001 (Table 2, $r_s = 0.900$, $n = 9$, $P<0.01$). Illness prevented night counting in 1999 and 2000. The pond dried in the summer of 1992, so there was no metamorphosis that year; and this perhaps resulted in the low numbers of adults two years later. Immature newts were recorded at night in most years. Small fish, assumed to be Sticklebacks, were common in 1995, but disappeared before they could be positively identified. No Smooth Newts or other amphibians have been seen in this pond, indicating its isolation from colonising sources and supporting the contention that its Crested Newt population resulted from the translocation.

A sample of nine adult male Crested Newts was netted at night in April 2001 and measured for comparison with the original males; they were significantly shorter than the 16 males caught at the donor pond, 1991-3 (mean ± SE = 117±3 mm, $t_{23} = 3.36$, $P<0.01$). Of the nine caught in 2001, only three were longer than the smallest translocated male. As newts continue to grow after they become sexually mature (e.g. Baker & Halliday, 2000; Cummins & Swan, 2000), the data confirm that the original translocated adults did not include any younger recruits and had probably not bred successfully for several years. Similar observations have been made on adult newts about 5 km away at Shillow Hill, when three years of breeding failure were followed by successful breeding (unpublished observations).

The northern pond is 400 m along ditches and hedges from the receptor pond (TL 297866). Its Habitat Suitability Index was calculated as 0.72 in 2001, so it is of comparable suitability to the receptor pond. Although night visits were made annually from 1995 to 1998, and again in 2001, no newts or other amphibians have been recorded.

THE PRESENT AND FUTURE: THE PROACTIVE PHASE

The point reached in 2001 is that a traditional, but failing, Crested Newt population in the town has been translocated to the re-created receptor pond on the farmland, thereby establishing a new and larger colony. While this is reasonably satisfactory, it should not be seen as an end point. The Action Plan Work Programme for the species identifies the need to create new ponds and colonies so as to reverse the long-term loss of populations.

Year	Donor pond		Receptor pond	
	No. of counts	No. of newts	No. of counts	No. of newts
1989	2	4.5±1.5	-	-
1990	0	-	0	-
1991	10	1.7±0.4	2	0
1992	8	0.6±0.4	4	4.0±1.7
1993	8	0.6±0.3	3	4.7±0.9
1994	0	-	3	1.7±1.7
1995	0	-	3	7.3±3.0
1996	0	-	3	15.3±2.9
1997	0	-	3	18.3±7.2
1998	1	0	3	14.0±2.5
1999	1	0	0	-
2000	-	-	0	-

Table 2. Mean night counts of adult Crested Newts ± standard errors, 1989-2001. The donor pond was destroyed in the summer of 1999, while the receptor pond was re-dug in 1989.

Scientific studies, including modelling, can help inform on actions on the ground. Thus the receptor site is isolated, being about 700 m from the nearest Crested Newt population in a farmhouse garden ('f' on the Map), and is therefore more liable to extinction in the longer-term (Griffiths & Williams, 2000). The northern pond is about 400 m from the receptor pond, but remains uncolonised. Baker & Halliday (1999) reported that Crested Newts failed to colonise new farm ponds that were 400 m or more from existing breeding sites. A new pond was, therefore, created mid-way between the receptor and northern ponds in May 2001. A decision needs to be made whether to wait to see if colonisation occurs naturally or whether introductions should be made from the receptor pond (or from elsewhere to improve the gene pool). Hopefully, in time these three ponds will together provide habitat for a larger, and less vulnerable, population. Thus the original aim has now evolved into establishing a robust and self-sustaining metapopulation (see Griffiths & Williams, 2000). It is also possible that the substitute pond beside the original donor site may one day prove suitable to receive stock back from the new sites on the farmland.

It is worthwhile summarising the changing fortunes of ponds and of Crested Newts in the fenland block enclosed by roads (i.e. excluding the farmhouse pond, see Map). At least six ponds occurred there until the 1970s, and one is reported to have been good for newts. By the mid 1980s, all of the ponds may have been lost. Excavations in 1989 re-created two of them, and one of these had newts established in the 1990s. Creation of a third pond in 2001 opens up possibilities for enhancement.

The farmhouse pond is at the entrance to Worlick Farm. Cooke (2001) described the recent establishment of a Crested Newt population in six historic fishponds at the Farm, about 1 km to the east of the farmhouse pond. The farmhouse pond itself provided poor habitat for newts when visited one night in 1990, being silted and marshy; only a single Crested Newt was seen (Cooke, 2001). This pond was re-dug in 1997, and on the next night visit in May 2001, 25 Crested Newts were counted. This additional area at Worlick Farm, which is also about 1500 ha in size, has seven ponds, all of which have been re-dug during the last 20 years, and two Crested Newt populations of reasonable size and robustness. The environment is improving gradually.

CONCLUSIONS

This case study is another example of how translocation of Crested Newts may be made to work. Fortunately, the temptation was resisted to assume the substitute pond would be satisfactory and the newts would be safeguarded on-site during construction of the new houses. It should, however, be pointed out that the initial criterion for success was limited to the newts settling and breeding in the receptor pond. Furthermore, this account should not necessarily be taken as an endorsement of the benefits of translocation. Despite goodwill and commitment on all sides, the operation could have failed for a number of reasons. For instance, the newts were only moved 1 km, and might have tried to return to the donor site. Secondly, the newts have been — and still are — dependent on a single pond, so being vulnerable to catastrophic factors that might have caused extinction, e.g. fish predation on larvae or certain farm operations. It is as well to remember that both translocation and doing nothing involve taking risks. All the more reason therefore to embrace a proactive and strategic approach.

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DEATH FROM PESTICIDES REVIEWED AMONG NON-TARGET AMPHIBIANS IN SUB-SAHARAN AFRICA

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ABSTRACT.— Pesticides are used in sub-Saharan Africa to control household, agricultural and disease vector pests. Within the context of biodiversity conservation, these complex man-made chemicals can threaten populations of non-target amphibian species in their natural habitats. Most deaths from pesticides recorded among frogs and toads in sub-Saharan Africa were due to insecticides used to control tsetse flies (*Glossina* spp.), vectors of trypanosomiasis or sleeping sickness in cattle. Organochlorine (OC) insecticides such as DDT and dieldrin, used at respectively 180 and 800 g ha^{-1}, caused deaths among adult *Bufo* sp., *Xenopus* sp. and *Ptychadena oxyrhynchus* in Nigeria, while endosulfan used at 200 g ha^{-1} resulted in dead tadpoles in Burkina Faso, and adult *Ptychadena maccarthyensis* and *P. francisci* in Niger. Tadpoles were also killed by a toxaphene cattle-dip spill entering a river in South Africa, and by the organophosphate (OP) insecticide, iodofenphos, and a substituted di-anyl-alkane under test, during use in Ivory Coast against the aquatic larvae of black flies (*Simulium* sp.), vectors of onchocerciasis or river blindness in humans. Death among tadpoles from tsetse fly control was also caused by the pyrethroids, cyfluthrin (40 g ha^{-1}) in Cameroon, and deltamethrin (12.5 g ha^{-1}) and permethrin (11.5 g ha^{-1}) in Burkina Faso. A very abundant frog species *Tomopterna cryptotis*, was found, as a bioindicator of non-contamination, at the bottom of hand-dug, dry river-bed wells. To test sensitivity, two small samples were placed consecutively in contact with wetted highly contaminated soil containing an OC/OP mixture (up to 3728 ppm) from spillage of a destroyed pesticide store near Hargeisa in Somalia's North-West Zone. The frogs perished within 40-65 min, and whole body total-insecticide residue load (geometric mean at 30.9 ppm wet weight) was elevated 168 times above the baseline control value (0.2 ppm) — the OC, ß-HCH, with levels 15-times higher, was taken in more readily than dieldrin. As elsewhere in the world, amphibians were thus found to be sensitive to pesticides in countries of sub-Saharan Africa, where, commensurate with development, usage and problems associated with storage are generally on the increase.

THE effects of pesticides and other chemical contaminants on amphibians during different stages of their life cycle were reviewed some years ago by Power et al. (1989). The amphibian life cycle is biphasic, and generally involves both aquatic and terrestrial stages. Pesticides during the aquatic stage can thus affect eggs, laid as static masses or in strings embedded in gelatine, or larvae, which, as mobile tadpoles, respire by gulping water and forcing it over delicate gill membranes, with some gaseous exchange also achieved through the skin. Metamorphosis then takes place, and pesticides can affect adults during the terrestrial stage when absorbed through the skin, ingested with contaminated prey and inhaled during lung breathing. Adult anurans consume both vertebrate and invertebrate prey, while urodeles - occurring primarily in temperate zones - have a similar diet, but tend more to inhabit moist locations under logs, rocks and leaf litter, returning to the water in spring to breed.

Pesticides may be acutely or chronically toxic to amphibians, usually affecting the nervous system, and, at low levels of contamination, may be absorbed, with residues becoming concentrated in different parts of the body. Pesticides additionally cause endocrine disruption (Hayes, 2000), and may give rise to growth abnormalities and deformities in amphibians (Ouellet, 2000). With such teratogenic effects, in addition to

Chemical	Dose (g ha^{-1})	Control purpose	Observation (and country)	Citation
ORGANOCHLORINES				
DDT	180	Tsetse flies (Nigeria)	Adult anurans killed	Koeman et al. (1978)
Dieldrin	800	Tsetse flies (Nigeria)	Toads (*Bufo* sp.) killed	Koeman et al. (1978)
	900	Tsetse flies (Nigeria)	Clawed frogs (*Xenopus* sp.) killed	Koeman et al. (1978)
	1800	Tsetse flies (Nigeria)	Frogs (*Ptychadena oxyrhynchus*) killed	Koeman et al. (1971)
	3000	Tsetse flies (Ivory Coast)	Anuran killed	Müller (1989)
Endosulfan	100 (x2)	Tsetse flies (Burkina Faso)	Tadpoles killed	Everts et al. (1978)
	200	Tsetse flies (Nigeria)	Anurans killed	Koeman et al. (1978)
	900	Tsetse flies (Niger)	Frogs (*Ptychadena maccarthyensis* and *P. francisci*) killed	Dortland et al. (1977)
	-	Tsetse flies (general)	Amphibians killed	Müller (1983)
Toxaphene	-	Cattle-dip spill (South Africa)	Tadpoles killed	Brooks & Gardner (1980)
ORGANOPHOSPHATES				
Iodofenphos	-	*Simulium* larvae (Ivory Coast)	Tadpoles killed	Dejoux (1978)
ORGANOCHLORINE/ORGANOPHOSPHATE				
Dieldrin and products, BHC[1] isomers and heptachlor malathion, fenitrothion and diazinon	Spillage; soil contaminated 0.07-3728 ppm (1.0-5180 mg l^{-1})	Locusts - destroyed store (Somaliland), May 1988 with obsolete pesticides	Frogs (*Tomopterna cryptotis*) placed onto wetted soil [0.5 l water: 1 l soil (36% dieldrin and products, 32% heptachlor, 32% ß-HCH isomers and <1% malathion)] contaminated at 3728 ppm were all dead or moribund after 40-65 min	Lambert (1997a)
PYRETHROIDS				
Cyfluthrin	>40	Tsetse flies (Cameroon)	Tadpoles killed	Müller (1989)
Deltamethrin	12.5	Tsetse flies (Burkina Faso)	Tadpoles killed	Everts et al. (1978)
Permethrin	2.5+3(x3)	Tsetse flies (Burkina Faso)	Tadpoles killed	Everts et al. (1978)
SUBSTITUTED DI-ANYL-ALKANE				
GH74R[2] (OMS 1358)	0.2 ppm in water for 10 min	*Simulium* larvae (Ivory Coast)	Amphibians killed	Troubat & Lardeux (1982)

[1]Beta-hexachlorocyclobenzene
[2]1, 1-bis-(para-ethoxyphenyl) 2-nitro propane

Table 1. Records of death from pesticides among non-target amphibians in sub-Saharan Africa.

hatching success, mortality and behavioural defects, tadpoles of the British Common Frog *Rana temporaria* have been used as a bioassay, when placed in cages immersed in water to assess the toxicity to amphibians of pesticide run-off and sediment-borne contamination (Cooke, 1977, 1981). The very sensitivity of amphibians to pesticides and other chemicals renders them useful bioindicators of the levels of contamination in the environment, and their presence without growth abnormalities is generally indicative of pristine conditions. With their link between invertebrate prey and predators higher-up the food chain that in turn ingest them as a trophic resource, amphibians' residue loads can also be biomarkers of the levels of pesticides entering the environment generally via faunal food chains (Lambert, 2001).

Effects of pesticides on amphibians have recently been reviewed by Cowman & Mazanti (2000) and Sparling (2000), while measurement of contamination exposure and its effects in amphibians have been reviewed by Bishop & Martinovic (2000). As part of risk assessment, the threat posed to amphibian populations by chemicals generally have been reviewed by Birge et al. (2000). From these reviews, it was noted that few studies were based on the effects on non-target amphibians of pesticides used for disease vector control and agriculture in tropical developing countries. Although both amphibian and reptile species richness is highest in the tropics (e.g. Mittermeier et al., 1992), most previous studies have been conducted in temperate zones (Devillers & Exbrayat, 1992).

The scanty information available on the effects of pesticides on amphibians in sub-Saharan Africa, based on records in the literature, and observations made during 1993 by Lambert (1997b) in Somalia's North-West Zone (Republic of Somaliland), have already been reviewed by Lambert (1997a). The few reports mentioning death from pesticides among non-target amphibians in sub-Saharan Africa are re-considered here specifically in order to draw attention, within the context of risk assessment, to the potential hazard presented by pesticides to amphibian populations in the region, and in tropical and sub-tropical zones elsewhere.

A range of pesticides causing death among amphibians in different countries of sub-Saharan Africa include organochlorine (OC), organophosphate (OP) and pyrethroid insecticides, used primarily for control of tsetse flies, *Glossina* sp., vectors of trypanosomiasis or sleeping sickness in cattle (Table 1). The majority of observations of death recorded in this work were based simply on the number of animals found dead during ground inspections following insecticide treatment against tsetse flies, or from chemical spills that may involve certain specific sampling and experimental procedures (e.g. Lambert, 1997b). For the last, it was important to show that soil highly contaminated from spillage chemicals from a destroyed store was indeed toxic and presented a threat to common and abundant species in the vicinity, especially a locally occurring amphibian species. The very presence of this species, thus demonstrated to be sensitive and without growth abnormalities, at the bottom of dry river-bed hand-dug wells served by ground water and used by local people, was an indication that ground water below the spillage area remained uncontaminated.

Organochlorines

Quite early on, OC pesticides were recorded to have caused havoc to wildlife (e.g. Carson, 1962).

DDT - Dichlorodiphenyltrichloroethane (DDT) is an environmentally persistent pesticide that in recent years has been banned in many countries. The mechanism for toxicity of DDT, although mainly due to a physiological response, can in part be due to behavioural aberrations, and disruption of glandular development may cause morphological abnormalities. Death among adult amphibians in sub-Saharan Africa was recorded from DDT-spraying against tsetse flies at a concentration as low as 180 g ha^{-1} (Table 1).

Dieldrin - Dieldrin is known to be highly toxic to homeothermic birds and mammals (IPCS, 1989). The primary site of action of aldrin-transdiol (the active metabolite of dieldrin) is somewhere in the central nervous system, with an increase of polysynaptic reflex activity and reduction of orthodromic postsynaptic inhibition, so that excitatory effects were followed by reduced spinal excitability. Many deaths among reptiles resulted from dieldrin-spraying against tsetse flies at the relatively low dose of 200 g ha^{-1} in Zambia (Wilson, 1972), and death was also recorded among anurans (frogs and toads) (Table 1).

Endosulfan - Endosulfan is not known to be persistent (Douthwaite, 1986), and this is an advantage it has over OC insecticides such as DDT. There is a reduced swimming capacity and lack of physical stamina, and a thinning and transparency of the gills were observed symptoms of poisoning. Applications against Tsetse Flies (lowest dose at 200 g ha^{-1}) caused death among tadpoles and adults (Table 1).

Toxaphene - Toxaphene causes behavioural aberrations (mainly hyperirritability and prolonged stupor) and growth retardation. A toxaphene cattle-dip spill entering a river caused death of tadpoles in South Africa (Table 1).

Beta-hexachlorocyclobenzene (technical BHC) - ß-HCH, in combination with dieldrin from heavy pesticide spillage, was especially toxic to frogs (Table 1). ß-HCH residue levels in a toxicity test sample (n = 5) of resultant dead frogs had a geometric mean of 27.09 (range 2.58-322.95) ppm whole body wet weight which was elevated 301.0 times above the 0.09 (range 0-0.43) ppm in controls (n = 7) (Lambert, 1997a).

Organophosphates

Organophosphate insecticides cause inhibition of acetylcholinesterase enzymes, essential for nerve impulse conduction and transmission, which may lead to aberrant behaviour placing the organism at a selective disadvantage and resulting in increased predation.

Iodofenphos - Used against larvae of black flies, *Simulium* sp., the vector of onchocerciasis or river blindness in humans, iodofenphos was recorded to cause death among tadpoles in a river in West Africa (Table 1).

Spillage chemicals (OCS and OPS) - Due to spillage from a destroyed pesticide store near Hargeisa, Somaliland, soil covering an area of 3700 m^2 was contaminated at up to 3728 ppm total insecticides (Lambert, 1997b). Death resulted when adult frogs of abundant *Tomopterna cryptotis* were placed experimentally in contact with the wetted, highly contaminated soil containing OCs (99.6%): dieldrin and products (36.0%), ß-HCH isomers (31.5%) and heptachlor (32.1%), and the OPs (0.4%): malathion, fenitrothion and diazinon (Table 1). No frogs in a first experiment (n = 12) remained alive after 40 min (50 and 80% dead or moribund after respectively 10 and 20 min), and in a repeat experiment (n = 11), all but the two largest individuals — which respectively survived 15 and 20 min longer — were dead after 45 min. Frogs kept alive on uncontaminated mud from hand-dug wells (n = 92 and 81 in the first and second experiments, respectively), from which samples were removed for testing, acted as controls. Total insecticide residue levels in a toxicity test sample of resultant dead frogs (n = 5) had a geometric mean of 30.88 (range 3.69-326.66) ppm whole body wet weight, compared to 0.18 (range 0.01-0.48) ppm in control animals (n = 7), and level at mortality was therefore elevated 167.8 times (Lambert, 1997b). ß-HCH was apparently taken in more readily than dieldrin, and the geometric mean was 15.0 times higher than dieldrin (ß-HCH was only 3.6 times higher than dieldrin in control frogs). With lower residue level at death, dieldrin was probably of higher toxicity to frogs than ß-HCH.

Pyrethroids

Pyrethroid insecticides are recognised as typical neurotoxicants (Vijverberg et al., 1982), acting on the peripheral nervous system, and inducing repetitive activity in sensory nerve fibres, sense organs and the distal portion of the motor fibres resulting in repetition in the motor end-plate. Pyrethroids have high toxicity to insects and a short half life, so that they are non-persistent in the environment. Deaths in tadpoles resulted after treatment with cyfluthrin, deltamethrin and permethrin against tsetse flies (Table 1).

DISCUSSION

Most of the deaths from pesticides among amphibians in sub-Saharan Africa involved OC insecticides, used for control of tsetse flies, the insect vector of trypanosomiasis or sleeping sickness in cattle. DDT treatment at 180 g ha^{-1}, dieldrin at 800 g ha^{-1} (lowest recorded for amphibians) and endosulfan at 200 g ha^{-1} all caused death among adult amphibians.

Amphibian deaths resulting from DDT applications in the field depend on dose, application method, weather at time of application, depth of pond and canopy cover (Power et al., 1989). DDT treatment against mosquito larvae in ponds at 110 g ha^{-1} caused no mortality to tadpoles of the North American Bull Frog *Rana catesbiana* of varying stages and sizes, although 80%

mortality within 48 hr was the result of 1000 g ha^{-1} (Mulla, 1963). Routine spraying of coastal plain ponds against mosquito larvae in Georgia at 110 and 450 g ha^{-1} also caused some deaths among tadpoles and adults of unspecified frog species (Tarzwell, 1950), suggesting that 180 g ha^{-1} used against tsetse flies in Nigeria (Koeman et al., 1978) must be about the lowest dose that causes death in anurans. Dieldrin doses of 110 and 560 g ha^{-1} applied to a pond in California were effective in controlling tadpoles of *R. catesbiana* (Mulla, 1962), and these values are still lower than the lowest at which death was recorded among adult anurans of 800 g ha^{-1} when used against tsetse flies in Nigeria (Koeman et al., 1978). No amphibian deaths from applications of endosulfan are recorded by Power et al. (1989). However, Sanders (1970) estimated median tolerance limits (TL50) - the concentration of endosulfan at which half of the test animals (4 to 5-week-old tadpoles) survived during a specified exposure period (24 hr) - in two North American anurans, and found that in respectively Fowler's Toad *Bufo woodhousei fowleri* and the Chorus Frog *Pseudacris triseriata*, TL50 was at 0.6 (0.3-1.2) ppm and 1.7 (0.5-3.2) ppm.

Tadpoles were also killed by the OP, iodofenphos, used against the aquatic larvae of black fly *Simulium* sp. (Dejoux, 1978). Organophosphate insecticides are toxic to most organisms, causing erratic behaviour that may place the organism at risk of increased predation (Power et al., 1989).

Tadpoles are highly sensitive to pyrethroids, which to a degree have taken over from DDT for control of malaria mosquitoes in sub-Saharan Africa, and deaths have been caused from use of cyfluthrin, deltamethrin and permethrin against tsetse flies. Pyrethroids are a group of insecticides developed from a natural substance (pyrethrum), and are of special interest because of their short half life and their high toxicity to insect pests. However, frogs were found to be highly sensitive to 11 different pyrethroids, and the cis-isomers of deltamethrin, (1R)-permethrin and (1R, aS)-cypermethrin were the most toxic to adults of the North American Leopard Frog *Rana pipiens*; tadpoles of *R. catesbeiana* were especially sensitive to the last (Cole & Casida, 1983).

Pesticide use commensurate with development is still on the increase in sub-Saharan Africa (Sridhar, 1989), and may double within the next decade or so. Recent arguments have, however, been put forward for the continued use of DDT in South Africa (Bouwman, 2000). Pesticides contribute substantially to the alleviation of poverty, especially among rural communities, and have an important role to play in both crop pest control, which increases the productivity of arable land, and in the control of intermediary host vectors of such diseases as trypanosomiasis in cattle, and malaria, onchocerciasis and schistosomiasis among local people. However, this greater use of pesticides is associated with increasing environmental risk. A threat is also thus presented to amphibians, being sensitive to a wide range of pesticides, in both their aquatic oval and larval, and terrestrial adult stages, and such chemicals have contributed to the worldwide decline of amphibian populations (e.g. Wake, 1991; Corn, 2000), and probably to batrachian diversity in general.

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THE EFFECTS OF FLOOD ON AN ISOLATED POPULATION OF SAND LIZARDS (*LACERTA AGILIS* L.) IN WROCLAW (SW POLAND)

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SOUTHWESTERN Poland was flooded by the river Odra and its tributaries in July of 1997. Extensive areas were inundated for 3-4 weeks, with flood waters reaching 4-5 metres in depth. The flood resulted in changes within plant communities and the accumulation of lead and some other elements in plant tissues (Karczewska et al., 2000).

Ogielska et al. (1998) and Ogielska & Konieczny (1999) noted that some amphibians decreased in numbers and the tree frog (*Hyla arborea*) disappeared from one part of the city after the flood, but the reptilian populations remained at the same level. However, their observations are from non-isolated habitats, which allowed the animals to escape and return, and other observations suggest that a few reptilian species may have in fact vanished from some habitats. Maślak (1999) observed a decrease in the numbers of Common Lizards (*Lacerta vivipara*) from one almost completely isolated habitat in Wroclaw (Wojnów, located near the present study area). Najbar (1998) reported an increase in the density of some amphibians, but a significant decrease in the numbers of Slow-worms (*Anguis fragilis*), Sand Lizards (*Lacerta agilis*), Common Lizards, and Smooth Snakes (*Coronella austriaca*) (listed in the order from the most to the least affected species).

The island Wyspa Opatowicka is situated in the eastern part of Wroclaw and for about a century isolated from the mainland by the Odra River and one of its channels (Fig 1). It is covered by deciduous forest (in the northern part) and meadow, bordered by an embankment with a tree belt. The only possible migration route for the lizards is a bridge on the Odra river. However, the bridge is unlikely to be crossed by the lizards because of its considerable length of 250 m and heavy pedestrian traffic in warm weather. In addition, the potential immigrants would have to cross the forest on their way to the meadow and no lizard has ever been observed on the opposite (mainland) bank. Thus the bridge may possibly serve as an emigration rather than an immigration route for the lizards. The footbridge over the channel, built on a sluice, does not seem to be passable for a lizard as its board has a 20 cm wide gap in the middle and its ends overhang the ground at a height of 15 cm.

The present study was conducted for four years (1997-2000). The lizards were captured along zigzag transects at least twice a week from May through September on warm, sunny days, at different times of day. The individuals were marked by toe-clipping (Ferner, 1979; Borczyk, 2000) and every capture was plotted on a map.

The lizards were common in the meadow and on the embankment before the flood. In 1996 it was possible to catch 20 individuals along a 100 metre stretch of the embankment (Robert Maślak, pers. comm.) and for some ten years I occasionally observed a dozen to twenty adult lizards within half an hour. Unfortunately, no precise data on the population density before the flood are available, but it seems nevertheless to have been high.

A significant decrease in the numbers of lizards on the island was observed after the flood. Only two yearling individuals were found and marked there in 1998. Six more lizards, one hatchling, one after first hibernation, three adult males, and one adult female, were marked in 1999. Eighteen new individuals, 11 hatchlings, four males, and three females were in marked in 2000. Altogether, 26 lizards were recorded after the flood.

Nearly all lizards (25) were captured either near the forest or on the embankment. Only one male, which had its hole near an isolated tree, was caught in the middle of the meadow. The distribution of animals after the flood (Fig. 1) suggests that those which survived could only have done so by climbing trees. Young individuals apparently stood the greatest chance of survival, probably because small lizards may be more difficult for predators to find, or are capable of hiding more effectively in bark crevices and climbing trees than adults. I observed young lizards escape into trees more often and also climb higher than the adults. In the western part of the island the lizards are much more common than in the eastern, since the flood wave pushed the escaping animals westwards; the animals in the western and northern parts of the island were driven towards the trees where they could survive, while in the eastern part they were driven away from the trees.

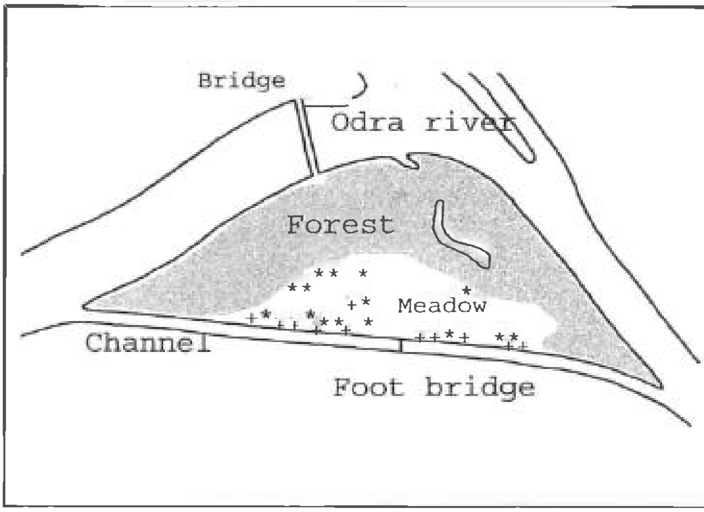

Figure 1.

* Captures and sightings of the lizards after the flood.
+ Single trees.

Atypically coloured lizards were more common on the island after the flood than in other populations from Poland (Maślak, 2000; Borczyk unpublished). The most common colour anomaly was the erythronotus. In 1999 this form constituted 20% of the population. In other populations from Poland the percentages of erythronotus amounted to 2.2% (Kurczewski, 1999), 6.2% (Maślak, 2000), 14% (Pietrzak et al., 1999). Also, two very light-coloured females were captured after the flood. Colour mutants are common in isolated populations (Strijbosch & Verhoeven, 1997; Strijbosch, 1998; Barret, 1999; Maslak, 1999, 2000).

A significant decrease in the numbers of lizards after the flood suggests that both genetic drift and founder effect may have affected the island population. Because the drowning of lizards was probably random, the rare mutants could (1) decrease their frequencies or disappear, (2) maintain their frequencies, or (3) increase their frequencies (Grant, 1991). The high proportion of atypically coloured animals in the island population speaks in favour of the third scenario, which exemplifies a typical bottleneck effect. Secondly, the very low number of lizards that survived the flood, and the apparent effectiveness of rivers as barriers preventing gene flow between lizard populations (Pounds & Jackson, 1981), are both conducive to the founder effect.

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NATURAL HISTORY NOTES

Natural History Notes features short articles documenting original observations made of amphibians and reptiles mostly in the field. Articles should be concise and may consist of as little as two or three paragraphs, although ideally will be between 500 and 700 words. Preferred contributions should represent an observation made of a free-living animal with little human intrusion, and describe a specific aspect of natural history. Information based on a captive observation should be declared as such in the text and the precise geographical origin of the specimen stated. With few exceptions, an individual 'Note' should concern only one species, and authors are requested to choose a keyword or short phrase which best describes the nature of their observation (e.g. Diet, Reproduction). The use of photographs is encouraged, but should replace words rather than embellish them. Contributions are accepted on the premise that they represent a previously unreported observation, and may be edited prior to acceptance. Standard format for this section is as follows:

SCIENTIFIC NAME (Common Name; the abbreviation NCN should be used where none is recognised): KEYWORD. TEXT (there are no constraints on how information is presented but the date, time and locality (with full map co-ordinates if possible) must be included, as should precise details on the nature of the observation with some discussion of its significance, and references to pertinent literature). If the information relates to a preserved specimen, its catalogue number and place of deposition should also be given. REFERENCES. Then leave a line space and close with name and address details in full.

***LACERTA AGILIS* (Sand Lizard): UNUSUAL MORTALITY AT A SITE IN SOUTHEAST DORSET**. I have been monitoring egg-laying sites, mainly in the Wareham and Purbeck area, for a number of years employing passive observation. Early to mid-June is the peak egg-laying period for the Sand Lizard, *Lacerta agilis*, in southeast Dorset and at this time the females are exposed and vulnerable as they venture into open areas in search of suitable egg deposition sites (Phelps, 2000). On 8 June 2001 at Furzebrook, near Wareham, four females appeared to have selected the same patch of sand, an area measuring approximately two square metres. These females were extremely tolerant toward each other and at one stage two were observed digging just a few centimetres apart.

I returned on 10 June to find two females dead, both lying on the same patch of sand. One had been mutilated but the other seemed undamaged and both were still full of eggs. Another dead female was found at the same site the next day, and yet another at a site some five hundred metres away. Again, these were undamaged and full of eggs.

Over the next few days two more dead females were found in the general area. I was quite mystified and suspected Crows or Magpies as the probable culprits, but a predator is supposed to eat its prey! The body count rose to seven and then on 18 June, at the original site, I found a whole nest of eggs scattered over the sand. I was saddened and very puzzled. What could be doing this? The mystery was revealed the very next day, but in fact the clues to the puzzle had been there all the time. Firstly, ants; the one thing each site had in common was that all were in close proximity to ant nests. Secondly, was the presence of a very distinctive feacal deposit. But it just so happened that the culprit was caught in the act. Part of my routine during monitoring is to scan the site with binoculars before making a close approach. On this particular day I was scanning the now infamous patch of sand when I noticed that the sand was being thrown up in the air by something, and it was certainly not a Sand Lizard. As the ground sloped downwards creating a blind spot, I had to get closer.

Edging foward, I took another look through the binoculars, and just as I focused on the spot a crimson head popped up into view; it was a Green

Female Sand Lizard exposed and vulnerable while excavating nest burrow. Purbeck, Dorset, June 2001. Photograph by author.

Eggs of Sand Lizard exposed by Green Woodpecker. Purbeck, Dorset, June 2001. Photograph by author.

Female Sand Lizard killed by Green Woodpecker. Purbeck, Dorset, June 2001. Photograph by author.

Woodpecker (*Picus viridis*). As I now approached the sand patch the woodpecker flew off with that distinctive low undulating flight and at the same time uttering the even more distinctive call. The bird had been busy; the sand patch had been thoroughly worked over. I searched for lizard casualties — there were no dead lizards but in the corner of the patch a tail still twitched vigourously. At least one female had escaped.

I can only conclude that the Sand Lizards were just getting in the way of the woodpecker's normal ant-eating activities, and just one stab from the chisel-like beak would certainly be enough to kill a lizard. Earlier in the year I had found a dead male with a single wound to the throat but otherwise undamaged. It would seem that the cause of this male's demise could also be linked to the woodpecker's feeding behaviour.

The Green Woodpecker is a beautiful bird. They are common enough in the area and have always been a conspicuous part of the local fauna. I suspect that this situation is the work of one or perhaps two individual birds and I have never experienced such behaviour in all the years that I have been working in the area. With respect to the number of lizard fatalities, I felt that some sort of deterrent was highly desirable. My only solution at the time was to place canes with silver foil tied at the top, a sort of bird scarer. I did not feel that this was interfering with nature's plan too much, as this was a unique situation and there were plenty of ants elsewhere. This may well have worked, because later in the year, although it seemed unlikely at the time, two clutches hatched successfully from that sand patch. In addition, seven eggs were retrieved and four were successfully hatched and the young released on site during August 2001.

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EDITORIAL

Erratum

A CASE STUDY IN THE EVOLUTION OF CRESTED NEWT CONSERVATION by Arnold Cooke, *Herpetological Bulletin* number 78, pp. 16-20. On page 19, the final line of data was omitted from Table 2. This summarised counts for the receptor pond in 2001: for 4 counts, the mean number of Crested Newts ±SE was 28.3±7.7. Counts in 2001 confirmed establishment and survival of a translocated population.