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A BREEDING COLONY OF TOADS (*BUFO BUFO* (L.)) IN KENT

By

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(With two figures in the text.)

ABSTRACT

A breeding colony of the toad (*Bufo bufo*) was studied in Kent from 1955 to 1961 inclusive. During this period, recapture data showed that the population of breeding males varied between 900 and 2,000, though on at least two occasions the female numbers were only half to two-thirds those of the males. Only eleven per cent of the males present one year normally appeared during the next breeding season. Toads travel at least one and a quarter miles to their breeding pond, and on this information the local population is estimated as one adult male per two acres, in addition to females and juveniles.

Males from another colony which were released one hundred and fifty yards from the pond were not detected in it that year, although some appeared a year later. Stranger females released into the pond spawned there and some reappeared the next year. Toads are believed to reach the pond as a result of knowledge of local topography. They start to move to the pond when the temperature is about 7°C., spawning at a water temperature of about 9°C. If there is a drop in temperature after they reach the pond, the toads remain in the mud at the bottom, but under severe weather conditions they may even leave the water.

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INTRODUCTION

It is well known that in the spring the Common Toad (*Bufo bufo* L.) migrates to its breeding ponds and is to be found there over a period of days or weeks while it spawns. The breeding period varies from place to place and year to year; normally it follows the time of breeding of the frogs (*Rana temporaria* L.), but sometimes the toads spawn first. Moore (1954) has described the breeding migrations in Dorset, while Savage (1934) has given an account of the oviposition behaviour.

The current research had its origin in a desire to elucidate the factors concerned in the timing of breeding in the toad and in the variation of date in the breeding season in different parts of the country. The first method of approach was obviously one of collecting data on these variations, while the second was purely observational at the breeding sites. This was carried out personally by regular watching over a number of years at

one colony, supplemented by further observation at other colonies in Kent and Surrey. At the same time, certain experiments were carried out on the release of toads from other neighbourhoods into the vicinity of a breeding pond, noting how their "homing instincts" were affected.

METHODS

PHENOLOGICAL RETURNS.

The question of obtaining data was discussed with the late Dr. Malcolm Smith and the Committee of the British Herpetological Society, and circulars requesting information were sent on behalf of the Society to all natural history societies in this country. Those who were willing to help were sent questionnaires to fill in annually about each breeding locality. While there were never more than twenty questionnaires returned from different parts of the British Isles in one year, some of these gave extremely useful information upon which it has been possible to base reasonable amounts of supposition.

GEOGRAPHY OF BREEDING PONDS.

The main breeding pond under investigation is Marlpit Pond (Nat. Grid Ref. TQ 765583), roughly two miles North of Maidstone. The situation of this pond is shown on the map (Fig. 1). It is placed roughly thirty yards from a lane, and is the site of an old marlpit. This was being worked some years ago, but within the memory of the older inhabitants of the district a spring was breached and the pit became filled with water. It is some thirty yards across and of great depth in the middle: although the exact figure for this is not known it is stated to be about twenty-five feet. On the South-West and East sides it is steep—going to a depth of three feet almost at once. On the North there is a very gradual shelving edge. It is surrounded by grass and trees on the North, West and East, and on the South a garden tops the steeply-sloping bank above it. Large amounts of rubbish have been thrown into the pond, where there are also a number of fallen boughs beneath the water, but no waterweed has been found. Egg-laying takes place among the boughs and twigs.

The mode of origin of this pond has resulted in the rather unusual situation of a pond at the top of a hill. One small pond occurs to the South-West of Marlpit Pond but no toads have ever been found in this. Other ponds occur in the parkland half a mile to the East, but toads do not occur in these.

Further bodies of water in the neighbourhood whose toad populations have been studied include the lake in Mote Park, Maidstone, roughly two miles to the South-South-East. This is a lake of some 35 acres, where both frogs and toads spawn. Toads have also been studied at the Mill Pond at Loose, two miles to the South of Maidstone.

Apart from the ponds in the Maidstone district, sporadic visits have been made over 20 years to two at Holmwood Common, South of Dorking, in Surrey. The first of these is the large Four Wents Pond of some two acres, where both frogs and toads breed (Nat. Grid Ref. TQ 184454). This is some nine inches or less deep over a large part of its area, lying at a crossroads, with common land to the North, West and South. About 200 yards to the North lies another, on the opposite side of the road. This pond is a small one, about ten yards across, deeper (about fifteen inches) and colder than the Four Wents Pond: toads breed there, but no frogs.

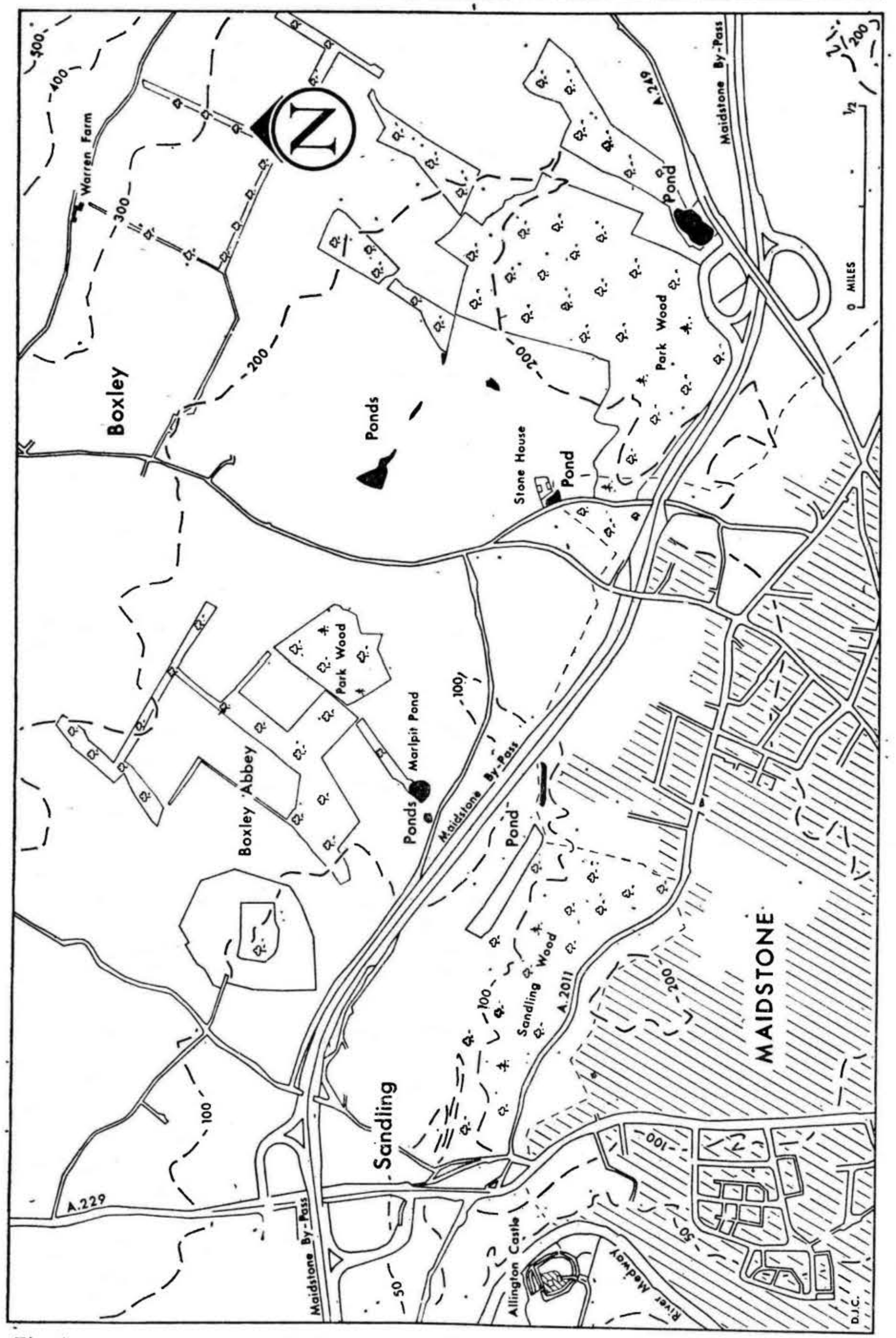

Fig. 1.
Map to show neighbourhood of Marlpit Pond.

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MARKING TECHNIQUES.

One difficulty in population studies has always been that of developing an efficient marking technique in order to identify individuals in the field. Two such methods have been tried. One of these is the time-honoured one of clipping digits level with the web of the hind foot, using different digits for each year. The other is that of sewing small coloured glass beads (one mm. long) on to the toads' backs, permutations of different colours being used. At first, braided nylon was employed to sew these on (as had been originally suggested by G. E. Porter for laboratory frogs), but subsequently ordinary cotton thread was used. Up to five beads could be easily sewn on with one small piece of thread, after making sure that none of the beads lost its colour on long exposure to water.

In order to assess the potentialities of the two marking techniques, in 1956 some males were marked with toe clips and others with beads, and the level of recovery in 1957 was noted.

OTHER FIELD TECHNIQUES.

As soon as reconnaisance on suitable evenings showed that toads were moving towards the pond, as many as possible were collected nightly, marked and replaced either in or by the pond. At the same time it was possible to note how individuals were moving, both in the field, around the pond and on the nearby road. Note was also taken of any toads found dead on the road, as well as of any moving along this.

On a few occasions, toads were collected from Mote Park Lake, Maidstone, and also from the Loose Pond. Collections were made on various occasions at the Surrey ponds. When collected toads were examined, particular note was taken of examples with injuries or anatomical peculiarities.

LABORATORY INVESTIGATIONS.

Weights and measurements of length have been taken on a large number of living specimens both from the localities mentioned here and from others, in particular from Cornwall and Essex. Such figures have been recorded at various seasons of the year. Weights have been taken with a rapidly-acting counterbalanced direct reading balance, using dry toads only. Lengths have been taken, on the advice of the late Dr. Malcolm Smith, generally from nose to tip of urostyle (easily felt beneath the skin), rather than as full body length, which might be expressed rather more variably. Both weight and length figures have been obtained for each individual (the sexes being noted separately), and plots have been made of weight against length.

ESTIMATION OF POPULATION NUMBERS.

This has been carried out by a modification of the Lincoln index method. In the male sex the process is relatively simple, since male toads remain in or around the pond during the whole breeding season. Thus as many males as possible are caught on as many nights as possible and the marks on these recorded. Any not already handled that season are then marked and the captives released. Since there is very scanty ground cover near the pond and the grass is grazed there, it is assumed that the few corpses found on the road or around and in the pond are the only casualties, and that apart from these the death rate is nil during the breeding season. Thus, after the first few nights, as the number of marked males rises, so the total of the males present can be worked out with ever-increasing accuracy. This total will eventually reach a steady figure when the whole population is resident. (Even when some males start to leave after this, the estimate will remain unaltered if marked and unmarked males leave simultaneously, as may fairly be expected; but the fact that males are leaving can be checked both by observation on individuals moving away from the pond and by the fact that it is not possible to catch so many as hitherto.)

The problem of the number of females present is rather more complicated, since no individual female normally spends more than a few days at the breeding pond. One is forced, therefore, to work out the proportion of male to female of those caught, assuming that the same proportion holds good for the uncaught part of the population. Hence, it is possible by simple proportion to estimate the total number of females present on any one night. Again, the number of previously marked females can also be calculated by simple proportion, and hence the total of unmarked females in the pond. This total includes not only those which have come to the pond since the previous occasion of marking, but also females which have previously escaped marking, and allowance must be made for these. Since it is known what proportion of the population of females was marked on the previous occasion, hence from knowledge of the existing number of marked females present it is possible to calculate the number of new arrivals. By adding on the new arrivals in this manner for each occasion, estimation can be made for the total number of females entering the pond.

RESULTS

PHENOLOGICAL DATA.

Results obtained over the earlier years have been published in summary form (Frazer, 1953a, 1954, 1955, 1956). Others have not yet been published. In all cases the original data are available for scrutiny at the Nature Conservancy, 19 Belgrave Square, London, S.W.1. Findings show clearly that toads spawn in ponds, lakes or even ditches, irrespective of the type of bottom to these, in the presence or absence of weed. Toads will spawn in water which is six inches or deeper down to a depth in Windermere (Frazer, 1953b) of fifteen feet at least. Adults in Windermere have been trapped in numbers at a depth of twenty feet. Maximum/minimum thermometer readings have been shown broadly to follow those recorded from thermometers in the grass and in the water of the breeding pond, although any large fluctuations in temperature are smoothed out in the last of these. It is, therefore, possible to use daily thermometer readings from a fixed site as some indication of the extent of changes in the microclimate around the toads. One good example of the kind of findings which can give useful assessments is shown in figure 2, which relates to the toad population of a concrete pond studied for some years by Mrs. A. M. Leadley Brown. It is possible in this habitat to count all the toads present, and these numbers have also been given in fig. 2 (redrawn after Frazer, 1955). The diagram shows that males were migrating to the pond between January 20th and 22nd, immediately after the air temperature had risen to 50°F. (10°C.). There was a falling off in numbers when the water temperature dropped from 45°F. to 42°F. (5.5°C.), and then to 37°F. (3°C.) with the formation of ice. While the ice was on the pond, only one male could be seen below it, remaining in amplexus with the one female. With the rise of air temperature, males started to reappear in the pond four days after the ice had melted, and the numbers were rising above those previously present when the air temperature reached 46°F. (8°C.) or higher. Apart from one lot of

infertile spawn, as soon as the ice covering the pond had melted, spawning occurred when the water temperature was around 45°F. and higher. Neal has studied the breeding behaviour of toads at a lake near Taunton and his findings there are similar. In his 1955 results, spawning started after a fall in water temperature to 45°F. (7°C.) and spawn became abundant as the temperature rose again.

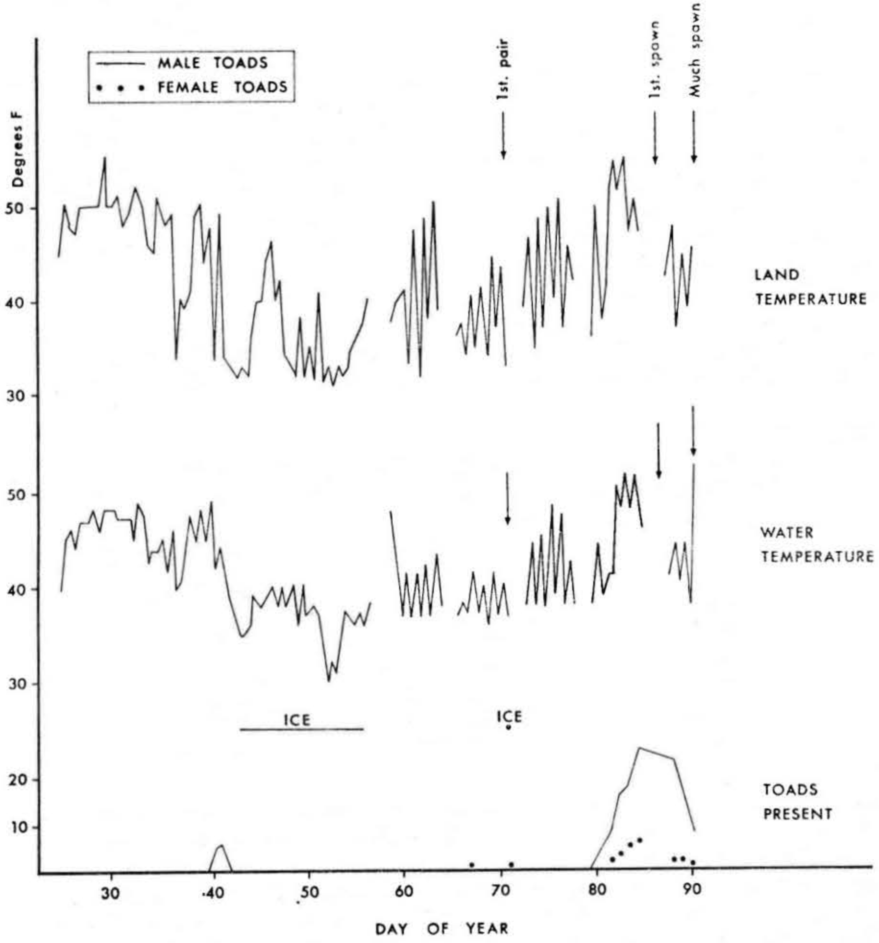

Fig. 2.

Relationship between temperature, toad numbers and spawning in a concrete pond (after Frazer, 1955).

POPULATION STATISTICS.

Assessment of the two marking techniques showed that when nylon thread was being used, the bead method resulted in losses of some or all the beads even before all the toads were released, owing to the knots becoming undone. On the other hand, toads wearing their beads were recovered on two occasions about half a mile from the pond six months after marking. In the case of toe-clipped toads, recoveries were also made in the autumn up to one and a quarter miles off.

In 1956, 178 males were toe-clipped and 271 marked with beads. The 346 males handled during 1957 included twenty-three toe-clipped the previous year, but only seven beaded ones. When it became apparent that the beading technique was less successful long-term than the use of toe-clips, the former method was only used as a short-term means of identifying lengths of time spent by individuals in the pond during one season.

At Marlpit Pond, marking experiments have given the results in table 1. It is seen that the population fluctuates in number between 1,000 and 2,000 males. Furthermore, the results of recoveries of toe-clipped toads show that almost exactly eleven per cent of one year's breeding males are to be found in the pond next year. The sole exception during the period of study was 1959-1960, seventeen per cent of the 1959 males being recovered in 1960. One toad, first marked in 1955, was taken again in 1960. Apart from this one very few have been seen more than two years after they were first marked.

As part of the experiments on transposition, in 1956 ninety-five males from Mote Park Lake were liberated roughly 150 yards from Marlpit Pond. This was towards the end of the breeding period, and the only

TABLE 1.

Population numbers of male *Bufo bufo* at Marlpit Pond, 1955-1961 inclusive. Where data are sufficient for assessing female numbers, these are given in brackets.

	Population total	*Number handled*
1955	1,500 (750)	569 (187)
1956	1,500-2,000	449
1957	960	346
1958	1,300	561
1959	1,700-2,200	632
1960	1,600	517
1961	1,000 (660)	468 (198)

ones recovered that year were two males found the next night at the site of release and another one which by then had gone eighty yards away from Marlpit Pond, but which was now returning towards its place of release. However, one of these was found amongst the breeding community at Marlpit Pond in 1957, and four during 1958. In contrast, forty-two ripe females were released actually into Marlpit Pond in 1956 and three of these were found two days later after spawning in it; two of these Mote Park females turned up again in Marlpit Pond during 1957. In 1957, also, fifty-seven females received from Devon were released on February 15th (a month before the Marlpit Pond breeding season) by another pond at Stone House, roughly three-quarters of a mile West of Marlpit Pond. None of these was captured again.

The toads from Marlpit Pond are of large size, and this becomes particularly noticeable if those from Loose or Mote Park are compared with them. Experience at Four Wents Pond has shown that males are found there as small as seven grams in weight, while a large proportion

of the population are less than twenty grams; at Marlpit Pond on the other hand, very few males are below twenty grams in weight, and the average dry weight of 125 males taken on March 9th, 1957, is 28.4 grams ± 5.4 (S.D.). Only three of these were less than twenty grams weight, while the largest weighed forty-five grams. A sample of 274 from Four Wents Pond in 1950 and 1951 had a mean weight of 19.0 ± 4.0 grams. The females at Marlpit Pond are also larger than those elsewhere in Britain, and in fact the largest noted there (in 1957) weighed 148 grams and measured 87 mils. from nose to urostyle, with a total length of 99 mm.—some 12 mm. longer than the biggest British female known to Malcolm Smith (1951).

OTHER STUDIES.

In the course of observations upon toads both at Marlpit Pond and Four Wents Pond it was possible to study questions associated with migration, amplexus and spawning, as well as the effect of temperature on behaviour. As had been found in the questionnaire results, toads started to move and be noticed on the roads during the first suitable warm nights, but no large numbers were seen until a temperature around 45°–50°F. was reached. Movement to the pond took place from two directions, but some toads certainly travel along roadways. Both sexes have been seen on their migrations to or from the pond, travelling on tarmac roads half a mile or more from the water. The actual distance they travel in this way has not been checked, but in October, 1960, a dead marked male was found at Warren Farm on the Pilgrim's Way, approximately one and a quarter miles from Marlpit Pond.

Individuals of both sexes may travel singly or in amplexus. Previous writers usually imply that travel in amplexus only occurs following a fortuitous meeting on route between the sexes. However, examination at night shows that not only are males floating on the surface of the pond in the typical spread-eagled posture, but that many are congregated in the shallow water at the edge of the pond, and that others are to be found in the surrounding grassland as far as ten yards or more from the edge of the water. Many of these are facing away from the water and give the impression that they are awaiting the approach of females. Supporting evidence comes from the fact that toads which have been replaced in the pond after marking have been found amongst those here.

When there is a drop in air temperature, the first effect is that of stopping the approach of further migrants when the critical minimum migrating temperature is reached. However, at this time toads are still moving in the water, and some males are still to be found on the surface. A further drop in temperature will cause these to disappear. This was well shown in March, 1953, when a visit to Four Wents Pond on a cold morning led first of all to belief (based on a circuit of the bank) that no toads had yet arrived. However, wading in the pond showed that the toads were hidden in the mud of the bottom. At about 11.30 a.m. the sun came out and the air temperature was appreciably higher. From this time on toads were appearing in some numbers from the bottom of the pond and the males were croaking audibly. A marked contrast to this took place at Marlpit Pond in 1958, when practically all the males had reached the pond by March 31st, but the first spawn was only noted on April 2nd. On the 5th a cold spell started which lasted until the 15th. During this, toads were not seen, and only a maximum of twenty-five males and three females were taken on any of the succeeding nights, in contrast to the 202 males and forty-two females taken in two hours on March 31st. Although the few females taken after this cold spell were all paired, no more spawn was noted, and by April 22nd only a few males could be found on the surface of the pond.

It has been noted as a regular and consistent finding from year to year that not only spawning, but also the migration of toads to the water occurs roughly a week earlier at Four Wents Pond than at the second pond 200 yards away.

At Four Wents Pond, toads have been found in some numbers crushed on the road to the East of the pond, but not on that to the South. Those crushed on the road by Marlpit Pond have been noted each year. It has been noticeable here that large numbers of toads were seen on this road in 1955, when their presence drew attention first of all to the breeding pond. In 1956 as many as forty males and three females were taken on the roadway in one hour, but since that year never more than eight have been seen in the lane in one night.

INCIDENTAL FINDINGS.

Among the 3,074 males and 625 females from Marlpit Pond handled during a period of six years, two males have been found with six toes on each hind foot. Ten males and three females have occurred with a foot or greater part of a leg completely missing, as well as one with a club-footed appearance, which had lost all the toes and lower part of the left foot. On one occasion predation occurred to some slight extent, when in 1957, five males and three females were found dead one night on the verge of the pond, bearing some puncture wounds on their under surface. This phenomenon was only noticed on the one occasion.

DISCUSSION

The results of marking studies have shown first of all that the use of beads is not sufficiently rewarding to be practicable after a period of years. Various snags have been met. In particular, certain beads lose their colour, and must not be used; others become detached from the toad too soon. When braided nylon was originally used, the difficulty of knotting this material resulted on at least one occasion in the beads being lost even before the toad was liberated. Even with cotton, the results have not been commensurate with those obtained by the use of the more permanent toe clip. On one occasion in 1957, a female was captured wearing a piece of thread which did not even bear a knot. Although the use of beads is not considered practicable for studying recoveries on a year-to-year basis, they have proved their worth in association with toe clips (to show year of capture) on females as indicators of actual dates of capture, so that the period spent in the pool by one individual during one season could be studied.

The use of toe clipping has also got disadvantages. In the first place, there is the possibility of doing permanent harm to the toad, though generally this is not noticeable, and toads recovered in subsequent years seem to be capable of normal activities. However, toes or even feet may be damaged by other agencies, so there is a possibility of some degree of inaccuracy here—though the figures for individuals with feet or legs missing show that this is only very slight.

The marking results have demonstrated that the number of males present at the breeding pond from year to year keeps relatively constant,

while a large fluctuation on one occasion is evened out in the long run. Since only eleven per cent of the toads recur from one year to the next, the numbers present at any time are mainly those which are newly adult—despite their large size, which is probably a measure of their good feeding as youngsters. Toads caught several years after their original capture have still been found to weigh somewhere in the region of twenty-six grams. The larger size of the Marlpit Pond toads is a further pointer showing that they do not spread to other ponds in successive years. The fact that only eleven per cent are found to return the next year might possibly have been explained by their survival either without returning at all to breed again (as Malcolm Smith, 1952, believed to be the case for large females), or because they bred subsequently in some other pond. The latter is most unlikely, both on the grounds of size levels (as already mentioned) and because although a number of apparently suitable ponds are present in the parkland a quarter to half a mile eastward, no toads or toad tadpoles have ever been detected there. The nearest known breeding pond to Marlpit Pond is Mote Park Lake, roughly two miles away (see figure 1). The point about large females not breeding is also disproved by the exceptionally large females found in Marlpit Pond.

The actual number of toads present at Marlpit Pond is known with a fair degree of accuracy for the males, but the data for the females are not so complete, and only for 1955 and 1961 can one say with a fair degree of certainty that in those years the number of females was only half the number of males present. This may well hold also for other years, but there are not enough data to determine the point. If such is always the case, then there must presumably be some selective force destroying females at a higher rate than males between the time when the spawn is deposited and when the survivors from this spawn reach the breeding pond. In view of the large losses which result in some 1,500 eggs giving rise in due course to two breeding adults, it is apparent that very slight imbalance in the factors leading to maturity can bring about this effect. On the other hand, one should not lose sight of the possibility that losses of the two sexes may be comparable, but the males may reach sexual maturity before the females (as is claimed by Ting & Boring, 1939, for *Bufo bufo* in China), so that greater losses occur among the latter before they come to the breeding pond for the first time.

If one takes the mean number of breeding males at around 1,500, it is possible to get a rough idea of the density of the toad population outside the breeding season. Marked toads have been found far from Marlpit Pond in different directions, but the one farthest away was found one and a quarter miles from the pond. If toads can be considered to be evenly spread over a circle of this radius centred on the pond, then that circle will cover an area of approximately five square miles. There will thus be an average of 300 males per square mile, or one per two acres. In addition, there are adult females and at least three times as many immatures which may be expected to survive to sexual maturity, apart from any which fall by the wayside. The terrain is mainly cultivated land, with a certain proportion of houses and roads, possibly one-tenth of it woodland. Hardly any hedges are present, except along the roads, and much of it is open grass fields or orchards. It is, therefore, not particularly suitable for toads, and the population is probably not heavy as compared with other areas.

The evidence seems to be conclusive that toads emerge from hibernation as the result of a rise of environmental temperature. The exact temperature at which hibernation ceases is not easy to assess, since the temperature gradient between the outside air and that inside the hibernaculum is not known. Findings on the Common Frog (*Rana temporaria*) from hibernating quarters at Mote Park (Tynan, 1955) show that this emerges when the surrounding temperature is 46°F.

Toads may be found on the road leading to the breeding pond when there is an appreciable rise in the surrounding temperature. Again, it is hard to be precise, for a very good reason, since different communities of toads are shown to have different threshold temperatures. The results given here show that at St. Ives migration occurs with a land temperature rising to about 45°F. (7°C.), although at Exmouth the number of arrivals does not show a steep rise until a few degrees higher. The data given by Moore (1954) show a similar picture, with peaks of movement at a temperature around 13°-14.5°C. Similar findings come from the particulars given for Cheam in 1955 (Frazer, 1956). The important thing is to realise that the threshold temperature varies not merely between two colonies which exist many miles apart, but also between colonies only a few yards away from one another. Examples are the one at Four Wents Pond and the second pond 200 yards to the North, and the deep water and Lazy Bay colonies in Windermere (Frazer, 1953b). In each case, not only does the colony inhabiting colder water spawn later than its neighbours, but the toads comprising it migrate to the water a week or two later. It is comparatively easy to understand how natural selection can allow for this deviation in response, so that over a large number of generations the temperature threshold of the cold-water toads becomes raised. All, however, that can be said authoritatively is that when a particular threshold (which will vary from one breeding colony to another) is reached, then the toads emerge from hibernation and move purposefully towards their breeding pond.

The next point for consideration is what gives rise to this purposeful movement. How do the toads find their way to one particular pond or part of a pond? Various theories have been put forward about this, even that it may be a chance wandering until the right habitat is reached. Unlike the case of the frog, which seems to wander in this country (Savage, 1934), the toad goes towards the correct spot, and certainly avoids other ponds and pieces of water which it may pass within a few yards on its way to the correct place. Suggestions have been put forward that the guiding sense may be auditory, olfactory or visual. The idea of an olfactory stimulus has been put forward for *Rana temporaria* by Savage (1935), who suggests that the smell emanating from algae in the water may prove attractive. Moore (1954) has given an account of inconclusive experiments where the nostrils of toads have been blocked with vaseline, which, however, the toads removed in a few minutes. He has pointed out, though, that toads may converge radially on a pond (as they definitely do at Marlpit Pond) irrespective of the direction of the wind. The auditory stimulus theory has been based upon the conception that later toads hear the first males at the breeding site as they croak and home on these. This fails to take account either of the manner in which the first individuals reach the water or in which toads travel up to one and a quarter miles along roads with a number of right-angled turns in them. In fact, Moore has recorded one toad which was two and a quarter miles away from the breeding pond and apparently travelling towards it. Bogert (1947) marked a number of *Bufo terrestris terrestris* and found that many of these returned to their home area from

distances up to one mile away. He suggested that the toads were attracted back by calling males in the breeding pools adjacent to the site of recapture. There is, however, no real evidence in support of this hypothesis, except that some of the toads had been removed across terrain apparently unsuitable for them, where no toads had been detected. Since some percentage of toads reappeared, whether liberated to East, North or West, it is hard to believe that any auditory stimulus can have attracted them; it is felt that in *Bufo bufo* a topographical knowledge fits better as a means of reaching the breeding site, which is fixed over a number of years, in sharp contradistinction to sites used by the American toads, of which Bogert (1947) says: "Most toads, unlike the majority of frogs, utilise temporary pools".

The evidence in favour of local knowledge seems incontrovertible: in the first place toads (which are notoriously among the more intelligent amphibians) must in some fashion have traversed terrain between the breeding site which they first left as newly-metamorphosed animals, and the hibernaculum from which they emerged at the start of their first breeding season. Secondly, the experiments in transplanting males from a breeding community in Mote Park have not shown any to travel 150 yards to the Marlpit Pond site that year, although foundation members of that community were coming from further afield. At least one of the transplanted toads had travelled 150 yards in the wrong direction when seen a night later, while three others were remaining close by the site of their liberation. On the other hand, the same proportion as amongst the natives present that season found their way into the breeding pond a year later—by which time they may be assumed to have acquired some familiarity with the neighbourhood. The females deposited in the pond both spawned there that year, and also returned the next year—suggesting that where a female spawns one year is likely to be her spawn site the next. On the other hand, none of the Devon females liberated by a non-breeding pond half a mile away were ever recorded again. Negative evidence suggests this could be interpreted in any one of many opposing senses. There is also the incontrovertible evidence from the toads in the different communities near Dorking and in Windermere. In each case the fact that spawning toads in the two adjacent sites arrive at two different times and that there is no overlap, shows that the two communities remain as quite separate entities. There is a regular absence of toads from certain ponds, while they arrive regularly at adjacent ponds or pass close by the unused ones on their way to the spawning site.

One question of interest here relates to the way in which a new site is colonised. This may be merely a new part of a particular pond. Thus, at Four Wents Pond in 1940 the toads spawned along the Western side and the frogs along the Northern one. But ten years later the toads were spawning throughout the pond and the frogs were nearly all contributing to a vast mass of spawn some six feet by four feet or more across, to a level of six inches deep. This re-orientation of the amphibians in the pond can easily occur after their arrival there and be due to purely local conditions. On the other hand, where conditions are stable in a large volume of water (as at Windermere), the toads move not merely to the water, but to that part of it which comprises a spawning site, and do not leave this until spawning has taken place.

The build-up of a new breeding colony of frogs has been watched over the past few years in a small part of the South-Eastern side of Stone House Pond at Boxley. In 1955 and 1956 no frogs at all were seen in this pond, nor were any spawn or tadpoles noted. In 1957, one clump of spawn was deposited, but in 1958 as many as six females deposited spawn, and the next year the colony had risen to something over thirty pairs. In 1960 probably double this number of pairs bred there. This increase in spawning individuals each year seems hard to explain, since the survivors of the off-spring from 1957 would not reach sexual maturity until 1959, or more probably 1960. However, if one stray pair of frogs spawned in the pond in 1955, some of their offspring might have fed well and reached sexual maturity in 1957 (see Smallcombe, 1949), in contrast to the majority of survivors doing so in 1958. Even this still leaves the difficulty of the sharp build-up in 1959, and further in 1960, to add to the problem, if one considers a fresh colony of frogs to be tied to one pond; Savage (1935) has shown that in one spawning season frogs may move from one breeding pond to another. In some species of toads it has been shown that migrations from one breeding pond to another may occur (e.g., Blair, 1943, in *B. americanus*), although in other localities they behave more like *Bufo bufo* in this country (Piatt, 1941).

While *B. bufo* may perhaps found a new colony, as has been described for frogs, there has been no evidence of this here, where it breeds in permanent standing water, in contrast to the more peripatetic *B. americanus* and *B. fowleri*, noted by Blair (1943). On the other hand, Rostand (1955) has stated that in France it breeds in almost every piece of water, so possibly our race may have more restricted insular habits. In this case, there remains the problem of how a new colony is started—the way in which toads began to breed in Marlpit Pond some time in the last fifty years, between its first existence as a pond and the present day. Unfortunately, we have no definite evidence of the exact or even approximate date when toads started to breed there. However, there are certain occasions when conditions become unsuitable for spawning at an existing site. An example of this was noted at Chilham Castle in Kent (Stainer, 1952) where toads spawned in an artificial lake, probably of Seventeenth Century origin. In 1949, this lake was nearly dry, and Stainer described it as a "great expanse of mud seething with toads, all croaking". In 1950, 1951 and 1952 it is noted that there was a marked drop in the numbers of breeding toads resorting to the lake. If they behave there in a manner comparable with the Marlpit Pond toads, then only eleven per cent. of the breeding stock would anyway have returned in 1950, while the surviving toadlets would not yet have reached sexual maturity. Similarly, the 1951 population would have been mainly the survivors of the 1948 spawn, and only the 1952 ones mainly related to the presumed poor breeding stocks in 1949. However, the Marlpit Pond results in 1957 and 1960 suggest that a low breeding population one year is not reflected either in the figures for the next year or for the population three years later, when the offspring from this generation reached the breeding pond.

The experimental transposition of ripe females from Mote Park Lake to Marlpit Pond in 1956 showed that they not only remained to breed in suitable surroundings, but also returned in subsequent years to this breeding ground, hitherto unknown to them. If, therefore, one breeding ground becomes untenable for any particular reason, and another suitable one is nearby, this might be expected to be used instead. In the case of Marlpit Pond, this may well be what has happened. It is known (Philp, 1957) that tadpoles could be found some ten years ago in a pond in Sandling Wood, lying at the foot of the valley, some 200 yards to the South of Marlpit Pond. Some time between this occurrence and five years later, the penstock of this pond was drawn, with the result that hardly any water was to be found in it thereafter, and tadpoles no longer occur. It could be significant that in 1955 there were large numbers of toads to be found on the road between this pond and Marlpit Pond, whereas since then the few seen have borne very little relationship to the actual number reaching the pond. The distance between the two ponds is well within the migrating capacity of toads, and in fact one marked in Marlpit Pond in 1957 was recovered that summer from the garden of a house on the other side of Sandling Wood. However, both toads and tadpoles were seen in Marlpit Pond in 1948 (Philp, 1957).

One further possible way of starting a new colony might perhaps be considered here. It is known that when a new pond is dug and left without any fish being placed in it, fishes such as Sticklebacks (*Gasterosteus aculeatus*) soon appear therein. It is generally assumed that these arrive because their eggs have been carried attached to the legs of water birds. Such a mechanism might well account for toad spawn as well as tadpoles finding their way to certain new ponds, and it might be that survivors from such spawn or tadpoles would go to breed eventually at the pond where they spent their life before metamorphosis.

Once the toads have reached the pond, the males await the arrival of females, the majority of which will not yet have got there. In suitable weather the males are seen floating spread-eagled on the surface, or even waiting on shore for any unmated females which may arrive. If the weather is cold, migration stops, but the threshold for activity in the water is a few degrees lower than that for migration, so the males are still active in the water and even on the bank around the pond. Such activity is more marked at night, but toads in the water are also active on warm days and may even venture ashore then, if there is a certain amount of cover present near the verge. Examination of the phenological data shows quite clearly that water temperature is the important factor in the spawning of toads. When the water is cold, they remain in hiding at the bottom, or if it becomes very cold (as the Leadley-Brown results show) even leave it for hiding places elsewhere. When it is warm they become active, and in particular come to the surface of the water, while greater warmth leads to oviposition. The actual details of this have already been described by Savage (1934). Although odd lots of spawn may be laid at lower temperatures, the main body is not laid until a water temperature of about 45°F. (9°C.) or higher is reached.

It has been frequently noticed that although in any one locality frogs (*Rana temporaria*) normally spawn before toads (*Bufo bufo*), this order of procedure is sometimes reversed. In fact, normally the temperature threshold for emergence, migration and spawning is rather lower for the frog than for the toad, but the frog is known to require two or three days for the ripening of the ova before the female can oviposit. If the temperature rises sharply so that the toads emerge from hibernation at the same time as the frogs, then they can be in the water and spawning (without waiting for egg ripening) before the frogs have all oviposited. Examination of the data for ponds where both species breed has given this simple explanation.

Once spawning is completed, the males release the females (Savage, 1934) and the spent females may be found leaving the water the same night. Marking experiments showed that under the usual weather conditions females did not stay in the water more than three nights, but when severe weather set in they were found to remain for a fortnight or longer. This is in distinct contrast to the males, which stay until nearly all the females have left, while a number of them remain for up to a week after the last female has gone. The mechanism responsible for their departure is not known, but it is apparent that gonadotrophin is being put out (presumably from the pituitary) in all males during their time in the breeding pond when females are present, since at this time sperms can be found in the cloacal urine of the males, and spermiation is known only to occur under the action of gonadotrophin on the testes; if males from the breeding pond are isolated from the females, they are found to have ceased spermiation in a week or less. Possibly the presence of the females is necessary as a stimulus to the male pituitary and serves as a factor inducing the male sexual behaviour. The effect of cold weather on the spawning has already been noted, with special reference to Marlpit Pond in 1958 when a prolonged cold spell started just as spawning was commencing, the toads remained for a matter of weeks in the pond without spawning and eventually left without doing so. It is probably significant that in the same year a dozen or two pairs of toads were found spawning in September in a pond in Wales, where certainly some toads had spawned earlier the same year (Thomas, 1958). As the males have sperms in their testes throughout the year, their coming into breeding condition at this season would not offer any difficulties, but the females are a different matter. Normally after spawning there is an interval of some time before fresh follicles start to develop in the ovaries. In those fish where during ovulation corpa lutea develop, degenerating ova probably act as a source of nourishment to those which continue to develop: possibly the same thing has happened in this case. It is suggested that although certain toads managed to ovulate and oviposit in time, the generally severe weather caught the latter part of the spawning period and therefore many females failed to ovulate and their eggs were eventually resorbed, or that the earlier stages of their next sexual cycle came to be speeded up, thanks to the nourishment thus provided for the developing eggs. Once the right stage of the cycle had been reached, then the temperature being sufficiently high, migration to the water took place. The one difficulty lies in trying to explain why the males were attracted to the water; possibly weather conditions may have played an important part in this.

The above argument could also account for the occurrence of unhatched spawn in Sussex towards the end of July in certain years (Shrubsole, 1936), but it may be significant that toads were again heard croaking in the welsh pond in September, 1960 and 1962 (Thomas, 1963), while a single pair spawned near Ludlow in September, 1961 (Hurrell, 1961).

Two six-toed males seen were not deformed to anything like the extent shown by Rostand for frogs (Rostand, 1955). By analogy with human cases and by consideration of the rarity of their occurrence, this may well prove to be a genetically controlled condition, rather than one dependent upon the environment, such as Rostand has suggested for amphibians.

The cases where loss of a foot or leg had taken place are probably the result of predation, whose source can only be speculative. As there was a tendency for these cases to occur suddenly in one season, possibly some fish predator might have been the cause, but as there are no pike (*Esox lucius*) in Marlpit Pond, this seems unlikely. Predation of some other kind must

certainly have been the cause of the dead toads found on the bank in 1957. Most predators will not eat toads, although hedgehogs and some Grass Snakes (*Natrix natrix*) will do so. It has been suggested that possibly a rat may have been responsible for this case. I have received information about other instances; one was at Ashurst, Hampshire (Hook, 1958) where in 1958 heaps of partly-eaten dead toads were found, one pile containing as many as 22 bodies and others less. In addition, numbers of corpses were seen also in 1958 near Midhurst in Sussex (Sankey, 1958), one group alone containing at least 34. These were lying on their backs with the intestines protruding. Loveridge's (1913) account of rats eating the flesh of toads is suggestive, but the piles or collection of bodies leave one to wonder whether a heron (*Ardea cinerea*) was responsible, or even members of the crow tribe. The verdict here must remain unproven, but observations from a number of areas suggest that such predation is unusual.

ACKNOWLEDGEMENTS.

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SUMMARY.

1. A breeding colony of the toad (*Bufo bufo*) has been observed in Kent from 1955 to 1961 inclusive.
2. Recapture data show that the breeding males in the population vary between 900 and 2,000.
3. On the two occasions when firm figures for the female population were obtained, these were only half to two-thirds of the male total.
4. Only eleven per cent. of males present one year appeared during the next breeding season.
5. In individual size, the toads making up this colony are exceptionally large.
6. Males from another local breeding colony released 150 yards from the pond were not detected the same year, although some entered it a year later.
7. Females from the second pond released actually into the breeding pond spawned there and some returned the next year.
8. Toads marked at this breeding pond are found as far as one and a quarter miles away at other times of year.
9. The local toad population is estimated as one adult male per two acres, in addition to females and juveniles.
10. It is believed that toads find their way to the breeding pond as a result of topographical knowledge.
11. Phenological records of their colonies show that toads move towards the breeding ponds as soon as the temperature is high enough (about 7°C.).
12. If there is a drop in temperature after they reach the pond the toads remain in the mud at the bottom, or in severe conditions they may even leave the water.
13. Spawning occurs when the water temperature is around 9°C. or higher.
14. Spawning at abnormal seasons is discussed.

REFERENCES

Blair, A. P. (1943). Population structure in toads. Amer. Nat. **77:** 563-568.

Bogert, C. M. (1947). A field study of homing in the Carolina toad. Amer. Mus. Novitat. **1355:** 1-24.

Frazer, J. F. D. (1953a). Frog and toad breeding records for 1952. Brit. J. Herpet. **1:** 139-146.

(1953b). The breeding habits of toads (*Bufo bufo*) in Lake Windermere. Brit. J. Herpet. **1:** 153-158.

(1954). Frog and toad breeding records for 1953. Brit. J. Herpet. **1:** 161-170.

(1955). Frog and toad breeding records for 1954. Brit J. Herpet. **1:** 228-236.

(1956). Frog and toad breeding records for 1955. Brit. J. Herpet. **2:** 24-29.

Hook, O. (1958). Personal communication.

Hurrell, H. G. (1961). Personal communication.

Loveridge, A. (1913). Enemies of *Bufo vulgaris*. Zoologist. **17:** 233-234.

Moore, H. J. (1954). Some observations on the migration of the toad (*Bufo bufo*). Brit. J. Herpet. **1:** 194-224.

Neal, K. R. C. (1956). The breeding habits of frogs and toads, Broomfield Lake, near Taunton, 1952-4. Brit. J. Herpet. **2:** 15-23.

Philp, E. G. (1957). Personal communication.

Piatt, J. (1941). Observations on the breeding habits of *Bufo americanus*. Copeia: 264.

Rostand, J. (1955). Les crapauds, les grenouilles et plusieurs grands problèmes. Gallimand (Paris). 7th ed.

Sankey, J. (1958). Personal communication.

Savage, R. M. (1934). The breeding behaviour of the Common Frog, *Rana temporaria temporaria* and the Common Toad, *Bufo bufo bufo*. Proc. Zool. Soc. Lond. 55-70.

(1935). The influence of external factors on the spawning date and migration of the Common Frog (*Rana temporaria temporaria*). Proc. Zool. Soc. Lond. 49-91.

Shrubsole, G. (1936). The spawning of the Common Toad. Nature (Lond.). **138:** 835.

Smallcombe, W. A. (1949). Albinism in *Rana temporaria*. J. Genetics. **49:** 286-290.

Smith, M. (1951). The British amphibians and reptiles. Collins (London).

(1952). Personal communication.

Stainer, D. E. (1952). Personal communication.

Thomas, N. B. (1958, 1963). Personal communication.

Ting, H-P & Boring, Alice (1939). The seasonal cycle in the reproductive organs of the Chinese toad (*Bufo bufo* and the pond frog *Rana nigromaculata*. Peking nat. hist. bull. **14:** 49-80.

Tynan, A. M. (1955). Personal communication.

NOTES ON THE EGGS, INCUBATION AND YOUNG OF THE BEARDED DRAGON, *AMPHIBOLURUS BARBATUS BARBATUS* (CUVIER).

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INTRODUCTION

A gravid female *Amphibolurus barbatus barbatus* was collected on the 8th November, 1963, in south-east Queensland six miles from Inglewood on the road to Warwick. Unlike many agamids which the author has kept in captivity (unpublished observations) this female deposited her eggs readily in a small foam plastic cold box used to transport reptiles during the summer heat. Examination of the literature showed that egg incubation had not been described in detail. The sole reference located was in a brief popular article by De Rover (1960). De Rover hatched ten of twenty-one eggs after two months at 27-28°C. He placed the eggs in a saucer with damp cotton

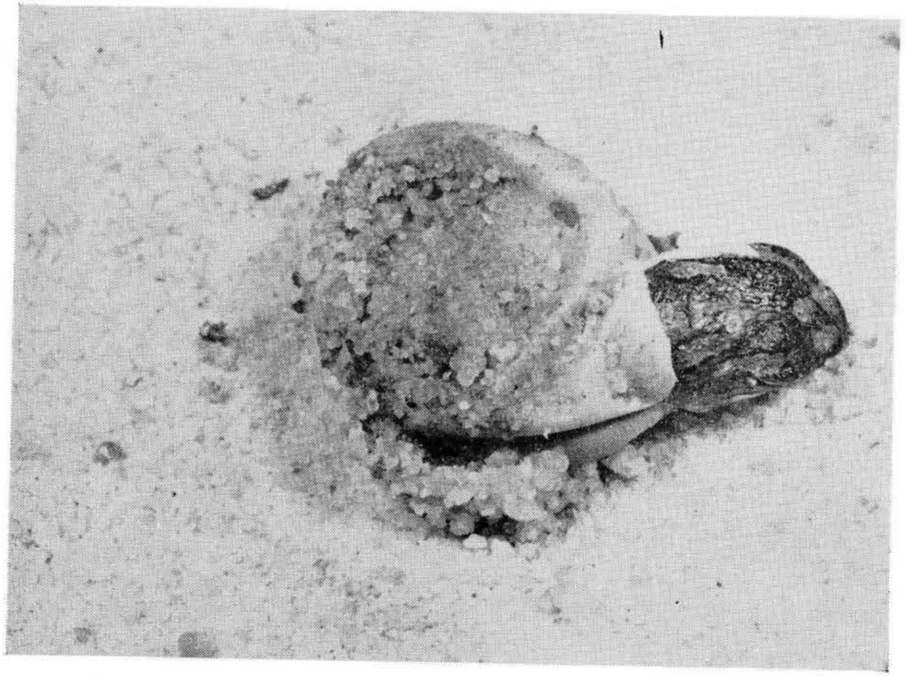

PLATE 1. *Amphibolurus b. barbatus* hatchling with head protruded; a posture which was maintained without movement for over seven hours.

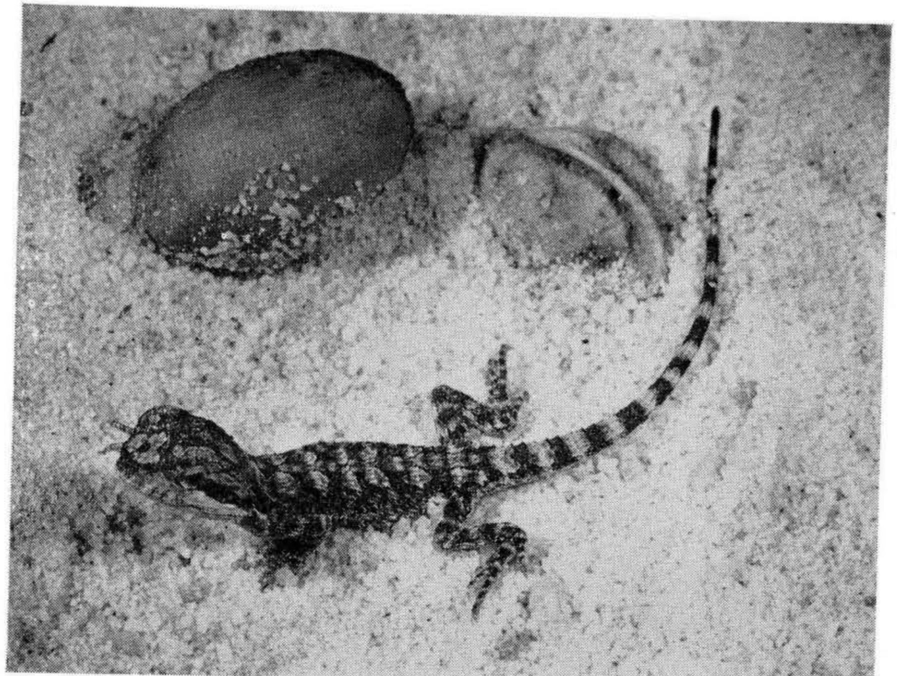

PLATE 2. Emerged *Amphibolurus b. barbatus* hatchling with egg-shell and unhatched egg.

wool, contained in a larger saucer with water so that the cotton wool remained moist. These were then enclosed in a container with a lid.

INCUBATION TECHNIQUE.

The author's eggs were incubated in eight inch diameter petri dishes. Each dish contained two inches of sterilized sand which was uniformly moistened with distilled water. A standard technique was adopted. Water was added until the sand would absorb no more, then the petri dish was tilted and all excess water drained off. A volume of dry sterilized sand equal to one-third of the original was added, followed by the eggs and a second petri dish placed on top to prevent evaporation and the dishes placed in an incubator at 25°C.

This method has proved ideal for incubation of many parchment-shelled lizard eggs, Bustard (in press). In the last year eggs of six species have been successfully incubated using this technique.

The nineteen eggs were split into three groups. The eggs of group I (1-7) and group II (8-13) were placed *on top* of the sand. Those of group III (14-19) were carefully buried in the sand so that they were completely covered. Groups I and II differed in their water relations. Both started out with identical conditions but during the incubation period the container of group I was allowed to partially dry out whereas group II was remoistened as necessary.

RESULTS.

(*a*) *Weight changes during incubation.*

Initially the weight gains of groups I and II were similar. Group III showed a more rapid increase in weight. As can be seen from Table 1 the eggs in group I lost weight considerably during the second half of the incubation period, due to the partial drying out of their container, whereas the eggs of groups II and III gained weight continually. Egg 11 desiccated and was removed; examination showed it to be infertile.

Unfortunately, since they hatched first, and the author was absent on field work, no record of the weights of the eggs of groups I and II were recorded after the 51st day. During this absence no water was added to any of the containers. It can be assumed that the weights recorded on the 51st day of incubation provide a relative guide to the three groups. The eggs of group III were weighed and measured for a fifth time after 78 days of incubation. As is shown in Table 1 they had continued to increase in weight linearly.

Egg 19 was the last to hatch (it hatched on 24th February) and it was weighed and measured for a sixth time on 22/2/64. It had continued to increase in weight during the last week prior to hatching and during these last few days the rate of weight increase was markedly greater than at any previous time during the incubation period.

The weights of the eggs during incubation and the dimension changes are recorded in Tables 1 and 2.

(*b*) *Size changes during incubation.*

Considerable gains in length and breadth of the eggs occurred during incubation. Percentage increase in breadth is greater than length increase, but length increments are also highly significant in increasing the egg volume.

(*c*) *Appearance of the eggs.*

On 16/12/63, after fifteen days' incubation, it was noted that the

Number	1/12/63	16/12/63	% age change	7/1/64	% age change	22/1/64	% age change	18/2/64	% age change	22/2/64	% age change
1	2.47	3.49	+29	5.49	+122	5.03	+104				
2	2.42	3.06	+27	4.32	+87	2.95	+22				
3	2.12	3.13	+48	4.93	+133	3.95	+86				
4	2.18	2.79	+28	4.23	+94	3.19	+46				
5	2.14	2.83	+33	4.20	+96	3.57	+67				
6	2.40	2.66	+11	3.82	+59	3.07	+28				
7	2.48	3.21	+30	4.64	+87	3.36	+35	Hatched 13-14/2/64			
8	2.41	3.43	+42	4.41	+83	5.09	+111				
9	2.43	3.10	+27	3.64	+49	4.36	+121				
10	2.49	3.39	+36	4.39	+76	5.05	+103				
11	2.39	2.62	+10	—	—	—	—				
12	2.31	3.12	+35	3.56	+54	4.03	+74				
13	2.64	3.46	+31	4.10	+52	5.43	+106				
14	2.64	3.68	+39	4.98	+89	6.15	+133	8.74	+231		
15	2.57	3.69	+44	5.16	+101	6.32	+146	9.11	+254		
16	2.31	3.34	+45	4.65	+97	5.41	+134	7.51	+225	Hatched 21-22/2/64	
17	2.41	3.43	+42	4.89	+103	5.73	+138	8.0	+232		
18	2.46	3.63	+48	5.16	+110	6.02	+145	8.57	+248		
19	2.68	3.91	+44	5.46	+104	6.43	+140	8.87	+231	9.62	+259

TABLE 1. Wts. (g.) of ***Amphibolurus barbatus barbatus*** eggs during incubation.
% age changes are based on original weight.

Number	1/12/63	16/12/63	7/1/64	22/1/64	18/2/64	
1	24 × 14	29 × 16.5	27 × 20	26.5 × 19		
2	23 × 14.5	23 × 15.5	29 × 18.5	29 × 15		
3	22 × 14	22 × 16	29 × 19.5	23.5 × 18		
4	22 × 14	21.5 × 15	23 × 18.5	23 × 16.5		
5	22 × 14	22.5 × 15	23 × 18	23.5 × 17		
6	23 × 14	22.5 × 15.5	23 × 18	23 × 16		
7	24 × 14	23.5 × 16.5	24.5 × 19	24 × 15.5	Hatched 13-14/2/64	
8	24 × 13	24 × 16.5	25 × 18	26 × 19		
9	24 × 14	24 × 15.5	24 × 16	25.5 × 17.5		
10	24 × 15	24 × 16.5	24.5 × 18	26 × 19		
11	23 × 14	22.5 × 15	—	—		
12	23 × 14	23.5 × 15.5	24 × 16	24 × 18		
13	25 × 14	25 × 16	25 × 17	28 × 19		
14	24 × 14	26 × 16	28 × 18	30 × 20	34.5 × 22	
15	22 × 14.5	24 × 16.5	26.5 × 19	28.5 × 20	33 × 23	
16	22.5 × 13	24 × 16	26 × 18.5	27.5 × 19	31.5 × 21	Hatched 21-22/2/64
17	23 × 14	25 × 16	27.5 × 18	29 × 19	32.5 × 21	
18	24 × 14	25.5 × 16	28 × 18	30 × 19.5	34.5 × 22	
19	23.5 × 14.5	25 × 16.5	26.5 × 19	29 × 20.5	33 × 22.5	

TABLE 2. Dimensions (mm.) of *Amphibolurus barbatus barbatus* eggs during incubation.

eggs which had been completely buried in sand had harder, more leathery shells. By 7/1/64 this difference had become more noticeable. The shells of eggs 14-19 (completely buried) were soft and extremely flexible despite their greater distension. Eggs 1-14 had developed comparatively hard shells which were of a white chalky colour in contrast to the more colourless shells of the buried eggs.

(*d*) *The hatching process.*

The hatching process was observed for egg 19. At 9.15 a.m. on 24th February, 1964, a small slit was seen in one end of the egg. The author's attention was drawn to the egg by its deflated appearance and a small pool of viscous liquid on the sand adjacent to it. During the following hour the young lizard succeeded in enlarging the opening and protruding its head. This posture (plate 1) was maintained from 10.20 a.m. without movement until at least 5.45 p.m. When touched it usually failed to move and quite violent prodding elicited little or no response. It seemed as if the young lizard had died as respiration was not observed. At 10 a.m. respiration was laboured and could be detected by the expansion and contraction of the egg-shell. From shortly after 10.30 a.m. until 5.45 p.m. respiration could not be detected and must have been extremely shallow and/or infrequent. After 5.45 p.m. I was unable to observe it until 7 p.m. when the young lizard had emerged. This specimen was healthy and active, like the rest of the brood, and the following day ate a fly and a mealworm. It is suggested that this resting behaviour following rupture of the shell may be normal before emergence takes place. A newly emerged hatchling is shown alongside its eggshell and an unhatched egg in plate 2.

Group	Total length	snout-vent	tail	wt. (g).
I	89	39	50	2.05
	87	38	49	2.17
	89	40	49	2.07
	85	39	46	2.10
	83	38	45	1.91
	101	41	60	2.24
	99	39	60	2.29
II				
	99	41	58	2.41
	96	41	55	2.15
	92	40	51	2.13
	94	40	54	2.17
	95	40	55	2.10
III				
	95	41	54	2.20
	94	41	53	2.23
	90	40	50	2.02
	98	42	56	2.30
	92	40	52	2.09
	94	41	53	2.10

TABLE 3. Sizes and weights of young *Amphibolurus barbatus barbatus* at hatching.

(*e*) *Weights and dimensions of newly emerged young.*

The weights and measurements of the young at hatching are given in Table 3.

The hatchling lizards ate flies, gentles and mealworms. At the end of the first week they were all preserved together with the female and presented to the British Museum (Natural History). They are BM. 1966. 166-184.

(*f*) *The ovary and clutch size.*

A gravid female *Amphibolurus b. barbatus* with a snout-vent length of 185 mm. was collected during December, 1963, near Canberra. On dissection this female was found to contain 15 eggs in the right oviduct and 16 eggs in the left oviduct, a total of 31 eggs, all of which were ready for deposition. Examination of the ovaries showed that ova of two markedly different sizes were present. In each ovary a number of eggs measuring 6-8 mm. in diameter occurred together with a larger number of much smaller eggs, the largest of which measured about 2 mm. in diameter. The large ovarian eggs were counted and there were 15 in the right and 16 in the left ovary. Undoubtedly these ova constitute the following year's eggs. It is interesting to note that not only the total number but their disposition between the ovaries was identical with the current year and, furthermore, that before egg laying takes place the ova for the following year have undergone marked increase in size.

The female which deposited the 19 eggs was also examined. The left oviduct contained a large egg (24 x 15 mm.). The left ovary contained 8 ova measuring 4-5 mm. and a large number of small ova of which the largest did not exceed 2 mm. in diameter. The right oviduct held 10 ova measuring 4-5 mm., many smaller ova and 2 of an intermediate size (2-3 mm.). It was not possible to state the precise brood size for the following year, but it can be said to lie between 18 and 20.

These two observations suggest that a given female is likely to produce clutches of a relatively constant size at least during part of her adult life.

DISCUSSION

The results show that considerable variations in the weight of the eggs, and hence their water content (Cunningham and Hurwitz, 1936), do not prevent normal hatching. The ability to withstand considerable desiccation has obvious survival value, which is backed up by field observations. Blair (1960), working on *Sceloporus olivaceus*, found that drying up of the top-most eggs (which are those most subject to desiccation) was the most common cause of failure to hatch in undisturbed nests and Mayhew (1963) on *Sceloporus orcutii* concluded that one of the major causes of variations in abundance appeared to be reproductive success which might be greatly influenced by seasonal rainfall.

Egg 19 increased in weight from 8.87 to 9.62 g., an increase of 28% of its original weight during four days in the last week of incubation. Data on weight changes of parchment-shelled reptile eggs during incubation is extremely sparse. The little published information is contradictory. Gordon (1960) on *Anolis* said that eggs increase in weight within the twenty-four hours before hatching. Blanchard on *Diadophis* (1926), Cunningham and Hurwitz (1936) on *Sceloporus* and Shaw (1963) all recorded actual decrease in size and/or weight of incubating eggs prior to hatching. There is insufficient data as to when this takes place. Shaw agrees with Gordon that there is a very noticeable loss of moisture from the egg and consequent shrinkage just prior to hatching. Blanchard noticed that the eggs either ceased increasing or declined in size, "a week or so before hatching", and Cunningham and Hurwitz noted a decrease in weight within a two week period preceding hatching. Shaw, however, recorded weight loss for a clutch of snake eggs (*Boulengerina*) during the first sixty days. The eggs were viable and commenced hatching on the 78th day. Shaw mentions a clutch of *Varanus* eggs which had gained an average of only 11.7% in weight after 124 days of incubation and which commenced hatching on the 170th day.

Legler (1960) working on *Terrapene ornata* observed eggs to increase at a fairly steady rate from the first week until hatching when in moist surroundings. He added, "Increase in weight and size seemed to reach a peak in the middle of the incubation period and again immediately before hatching." Two workers who, like the author, studied agamid lizards also recorded weight increase prior to hatching. Asana (1931) recorded that weight increase took place especially between the 4th and 18th day in *Calotes versicolor* but that about three days prior to hatching the eggs showed a slight additional increase in length and breadth. Harris (1964) states that eggs of *Agama agama* weigh about 1.2 g. when laid but that after one week they may weigh up to 3.0 g. and at hatching 4.5-6.0 g. Harris mentions a slightly more rapid increase in size before hatching, as was observed in egg 19 of *Amphibolurus barbatus*. He suggested, "The slightly more rapid increase in size shortly before hatching may help loosen the earth above the egg, and so facilitate the young lizard's escape." The increase in weight recorded for *Amphibolurus barbatus* of 225-250% in those eggs which were buried in damp sand is high. Shaw (1960) referred to two eggs of a clutch of *Chamaeleo basiliscus* which, "showed the rather astonishing increase of 142-185% over their weights at the time of laying". However, it is below the lower end of the range of the increase mentioned above for agamids.

This would appear to be a field where a valuable contribution could be made by recording size and weight changes during incubation in captivity. Unfortunately in most instances data on the eggs is only recorded once, usually shortly after deposition.

The change undergone by the *Amphibolurus* egg membranes in the eggs placed on top of the sand may be an adaptation to reduce water loss by reduced permeability. It should be stressed that parchment-shelled reptile eggs kept at high humidity conditions often desiccate unless at least part of the egg is in actual contact with a moist surface, as has been pointed out by Clark (1946).

The young *Amphibolurus* resting for at least seven hours with its head protruding from the shell is paralleled by observations on snake hatchlings which often appear to remain for some time with only the head protruding. There are a number of records, for instance Fitch (1963) on *Coluber constrictor*, of the head being withdrawn into the shell if they are disturbed. It contrasts with two oviparous skinks (*Leiolopisma* spp.) studied by the author which dashed out of the egg as soon as rupture had been effected (unpublished observations).

The finding that the amount of available moisture can influence size at hatching has interesting ecological implications. Gordon (1960) showed that intermittent wetting of *Anolis* eggs which were allowed to partially desiccate in between, produced significantly larger hatchlings than eggs which had been kept continuously moist. Gordon's observation provided a close parallel with the situation existing in nature. *Anolis* lays its eggs superficially where they are subjected to a cycle of daily rain and drying which characterises the Gulf Coast of the U.S. *Amphibolurus* possesses strong, clawed limbs well adapted for digging. Gradual decrease in availability of water (as produced in group I) is likely to occur in nature during dry years or in marginal nesting sites. It is unlikely that the eggs meet rapid alterations like *Anolis* since their position below the soil protects them from extreme conditions.

References.

Asana, J. J. (1931) The natural history of *Calotes versicolor* (Boulenger) the common blood sucker. J. Bombay Nat. Hist. Soc. **34**, 1041-1047.

Blair, W. F. The Rusty Lizard. University of Texas Press.

Blanchard, F. N. (1926) Eggs and young of the eastern ringneck snake, *Diadophis punctatus edwardsii*. Pap. Mich. Acad. Sci., Arts and Letters. **7**, 279-292.

Clark, H. (1946) Incubation and respiration of eggs of *Crotaphytus c. collaris* (Say). Herpetologica **3**, 136-9.

Cunningham, B. and Hurwitz, A. P. (1936) Water absorption by reptile eggs during incubation. Amer. Nat. **70**, 590-595.

Fitch, H. S. (1963) Natural history of the racer *Coluber constrictor*. Univ. Kans. Publ. Mus. Nat. Hist. **15**, 351-468.

Gordon, R. E. (1960) The influence of moisture in the eggs and hatchlings of *Anolis c. carolinensis* Voigt. Nat. Hist. Miscell. No. **173**, 1-6.

Harris, V. A. (1964) The life of the Rainbow Lizard. Hutchinson. London.

Legler, J. M. (1960) Natural history of the ornate box turtle, *Terrapene o. ornata* Agassiz. Univ. Kans. Publ. Mus. Nat. Hist. **11**, 527-669.

Mayhew, W. W. (1963) Reproduction in the granite spiny lizard, *Sceloporus orcutti*. Copeia (1), 144-152.

Rover, W. De (1960) Het Kweken van reptielen. Aquarium Den Haag **30**, 222-223.

Shaw, C. E. (1963) Notes on the eggs, incubation and young of some African reptiles. Brit. J. Herpetol. **3** (4), 63-70.

BIRTH OF ALBINO SLOW-WORMS

By

Maxwell Knight

On September 4th, 1965, a girl member of The Grosvenor Young Naturalists' Society—a thriving and keen group in Surrey—was given two female slow-worms (*Anguis fragilis*). These were two from a batch collected from Branscombe, S. Devon, and Brockenhurst in the New Forest; it is not possible to say from which of these two places the females in question came. On September 14th both these females gave birth to young. One litter numbered 11 and one 10. The larger litter included no less than 5 albinos.

The proud owner, Mary Toneri, noticed that five of one litter did not have the normal appearance and colour of newly-born slow-worms. On closer examination she noted that they had ruby-red eyes and pink tongues—the general body colour being pinkish-grey, almost the colour of a small earthworm.

On September 29th, I gave a talk to this enthusiastic Society, and some of these albino young were shown. I was very kindly presented with two which are still in my possession and feeding well. The remainder are reported as being safely in hibernation. The two I have were photographed (colour transparencies) by Mr. Michael Lyster of the Education Department of the Zoological Society of London. The transparencies display all the features very well indeed.

I subsequently showed these albinos and gave an account of their history at one of the Zoological Society's Scientific Meetings where they aroused some considerable interest. So far as I have been able to ascertain there is only one record of an albino slow-worm (an adult); this is in a report of the Essex Field Club. It would be useful to know if any of our members have knowledge of a similar occurrence.

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REVIEWS

BIBLIOGRAPHY OF SNAKE VENOMS AND VENOMOUS SNAKES:

by FINDLEY E. RUSSELL *and* RICHARD S. SCHARFFENBERG. Bibliographic Associates, Inc., West Covina, California. Price : cloth $9.80, paperback $8.80.

Major bibliographies are almost always a welcome addition to the rapidly growing fields of science. This publication is no exception.

The book is divided into 20 major headings, with sub-divisions under most: I. Articles prior to 1850; II. General biology of venomous snakes; III. Venom apparatus; IV. Collection and control of venomous snakes, including prevention of snakebite. Extraction, yield and storage of venom; V. General biological effects of snake venoms; VI. General chemistry of snake venoms; VII. Enzyme chemistry of snake venoms; VIII-XI. Physio-pharmacology and toxicology; XII. Immunology and antivenin; XIII. Snakebite; XIV. Pathology and bacteriology; XV. Complications of snake venom poisoning and treatment; XVI. Snakebite or poisoning in animals other than man. Immunity or lack of immunity in animals; XVII. Experimental therapeutics; XVIII. Uses of snake venoms; XIX. Folklore, myths, superstition, and primitive treatment and uses; XX. Appendix.

Sections V-X and XXII are subdivided into: A. Elapidae and Colubridae; B. Crotalidae; C. Viperidae. In V and XII an additional section D. Hydrophiidae is added. Sections II and XIII are broken down into geographic regions.

Section II is undoubtedly the weakest and most inconsistent part of the entire volume. This is not surprising since it is the least related to the authors' field of specialization. This section, as stated by the authors, deals with taxonomy, ecology, habits, defence, toxins and venoms when either are related to taxonomy. One wonders why a reference such as Jan and Sordelli's "Iconographie generale des Ophidiens" is included when such an important work as Boulenger's "Catalogue of the Snakes" is excluded. Under the heading "North America" a brief paper by Bogert on the "Hopi Snake Dance" is listed whereas a large paper by Klauber on the same subject is omitted. A brief paper by Fitch and Glading, "A field study of a rattlesnake population", is included, but Fitch's monograph on the life history of *Agkistrodon contortrix* is not listed. Certainly a major omission in this section is Stejneger's "Poisonous snakes of North America". Examples of other pertinent titles missing are: Gloyd's, "Snake poisoning in the United States : A review of present knowledge", and Stickel's "Venomous snakes of the United States and treatment of their bites", to mention only a few. In the section on South and Central America, again there are numerous inconsistencies of inclusion and omission. Klauber's "A new species of rattlesnake from Venezuela" is included, whereas other original descriptions of venomous snakes are omitted. A major omission is the bulk of Schmidt's papers on coral snakes—one is cited under the North American section. I assume West Indies titles are included in this section but find no reference.

One could continue the same criticism through the other sub-divisions of Part II. However, this section is a minor part of the total publication, and an evaluation of the book should not be based on it alone.

The real contribution of the book starts with section V and continues throughout. One can obviously find omissions in any section, but they are minor and would for the most part be picked up through the listed references. The usefulness of the book would have been increased if complete pagination as well as the figure and plate numbers had been given, especially since these data were very likely available to the authors and would not have increased the size of the book appreciably. In most cases, a given publication is cited only once, with the authors determining which subject category is the most appropriate for it. The appendix is a list of papers which the authors were unable to see, or verify. An author index is included.

It is gratifying to witness active researchers taking the time from their studies to make available such a useful amount of material as is presented in this book.

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FESTSCHRIFT ZUM 70 GEBURTSTAG VON PROFESSOR DR. ROBERT MERTENS. (Memorial issue on the occasion of the 70th birthday of Prof. Dr. R. Mertens) Published by Senckenbergiana Biologica 1.XII.1964. Frankfurt a/M W. Germany.

Contemporary with the great German poet Goethe there lived, in his home town Frankfurt, an eminent physician, Dr. Johann Christian Senckenberg, who was not only tirelessly devoted to healing the sick but who used his considerable mental gifts and his not less considerable fortune for the study of every conceivable branch of natural science. Towards the end of his life he endowed the building of a general hospital and when, unfortunately he was killed by falling from the builders' scaffold while the hospital was being built, he left this institution endowed with 95,000 gold gulden, a considerable sum in those days. The impetus given by Senckenberg found an echo in the minds of wealthy merchants and scientists of the Town who, in the course of time, endowed the Foundation with funds of such magnitude that the Senckenberg Society of Natural History has, in our days, become one of the most important bodies outside the universities, which is wholly devoted to pure research and to the publication of the results obtained in six different journals and a large number of books.

One of these Journals: "Senckenbergiana biologica" devoted its issue of December 1st, 1964, to the commemoration of the 70th birthday of a man whose name ought to be well known to every member of the Herpetological Society. Robert Mertens joined the staff of the Senckenberg Museum in 1947 and although officially retired in 1960, he is still tirelessly engaged in the study of reptiles and amphibians in all parts of the world. He was born in Petersburg (now Leningrad) and speaks Russian fluently. This enables him at present to study herpetological collections in Western and Southern Russia. For 50 years Mertens has made journeys to all parts of the Earth to study the herpetological fauna and the number of his publications gives a good image of the energy devoted to this pursuit.

The 32 contributions to the Mertens Memorial Volume have been written for the occasion by well known collaborators in the field of herpetology, some in German, some in English, some in French. As may be expected, they all deal with highly specialized subjects and those who are interested will have to read the volume to obtain an impression of the high scientific standard obtained by modern herpetology. Professor Mertens should be well pleased by this testimony to his popularity in the world of scientific herpetology.

E. ELKAN.

THE AMPHIBIANS OF SOUTHERN AFRICA: by J. C. POYNTON. Ann. Natal Museum, Vol. 17 pp. 1-334, Pietermaritzburg, November, 1964.

This comprehensive work represents the greatest effort to date to bring order out of the chaos of African amphibian taxonomy, at least as far as the southern half of the continent is concerned. It gives a description, photograph (useful but not always definitive) and distribution data with map for each of the species and sub-species found in the area covered. A very welcome effort has been made to cover not only morphological, but also ecological and other aspects, which to some extent have been taken into account in the revisions. A detailed key is added (with a warning from the author as to its inherent limitations), as well as extremely interesting chapters on evolutionary background and various ecological and zoogeographical aspects.

No price is indicated, but Wheldon & Wesley charge £3. This may seem a lot of money for a paper-back volume, but the contents justify the cost and make the book indispensable from now on for any study of the African anurans.

J. W. STEWARD.

REPTILES AND AMPHIBIANS OF THE WORLD: by HANS HVASS, translated into English by Gwynne Vevers. Methuen, London, 1964. 125 pp. 21s.

A small "popular" book cannot do justice to a large subject, but this volume comes near to being an exception. A great deal of practical information, covering all the major groups and an admirably large number of individual species, is packed into its slightly more than pocket format.

A few of the coloured drawings are inadequate but most are well-executed and suitable aids to recognition. The author is out of date in his taxonomy in places, so that some of the scientific names are no longer valid and in one or two cases the wrong name is applied to the information.

Recommended for the general herpetologist.

J. W. STEWARD.

ILLUSTRATED GUIDE TO THE VENOMOUS SNAKES OF HONG KONG, By J. D. Romer. Government Press, Hong Kong, 1965. A concise guide to identification of the sea-snakes, kraits, coral snakes, cobras and vipers found in Hong Kong, with beautiful colour illustrations. Text is printed in Chinese as well as English.