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SOME OBSERVATIONS ON THE MIGRATION OF THE TOAD (*BUFO BUFO BUFO*)

By

H. J. Moore

Since 1938 toads squashed by motor-traffic have been noticed by the writer on a stretch of the main Blandford-Shaftesbury road running North-South through the village of Iwerne Minster in Dorset. At the same times toads have appeared in the swimming pool in the grounds of Clayesmore School adjacent to this road. The concrete pool at this time of the year is empty, but a trickle of water runs intermittently down the floor of the pool. The appearance of these toads, which were used for dissection in the biological laboratory, led the writer to start making regular counts of the number of toads in the pool, and also on the section of main road, and to examine the figures in relation to the time of the year and to the weather conditions. Intensive observations were made in 1950 and 1951, while in 1952 and 1953 particular lines of enquiry were followed up. Throughout the investigations the writer has received the greatest stimulation and help from Dr. Malcolm Smith and many of the lines of enquiry were suggested by him.

The work has been accomplished largely through the enthusiastic help of the boys at Clayesmore School, in particular the members of the Natural History Society, and I wish to express my gratitude for their readiness to help study toads at any time of the day or night under almost any weather conditions.

The toads migrate to breed in a small artificial lake situated in the school grounds. The lake is now considerably overgrown with weeds. Swamp conditions prevail over much of its $1\frac{1}{2}$ acres, and it is evidently a hydrosere rapidly approaching its climax. The estate in which the lake is situated lies at 200-220 ft. altitude on the junction of chalk, greensand and clay. To the East the chalk rises sharply to 600 ft. forming the West escarpment of Cranborne Chase. A series of dry valleys running East-West cut into the chalk at Iwerne Minster, Sutton Waldron and Fontmell Magna (Fig. 1); and roads lead steeply up the spurs between the valleys. Springs emerge from the water table at the junction with the greensand and drain westwards to join eventually the R. Stour. There is no inlet to the lake, but water arises from springs and leaves the lake through a sluice to join the westward running brooks. Up this brook toads migrate under certain special conditions. South of the estate are two other lakes in the grounds of two country houses. Toads do not visit these lakes to breed. They congregate in the Clayesmore lake from an area of between 7-8 sq. miles. Until recently the area was largely parkland, but since the 1939 war more arable has appeared. It is well treed and there are many small copses. The lake itself is surrounded by copse except on the north shore where a fringe of alders is rapidly filling the gaps.

Methods of Investigation.

At first *road counts* were made of dead toads, on the stretch of main road between the Lodge by the school gates (referred to hereafter as Jennings Lodge or J.L.) and a lane leading past the south end of the lake (known as Marshy Lane = M.L.), a distance of nearly half a mile. In 1950, the previous day's corpses were not removed, so that although corpses are usually washed away in a day or two, absolute figures were not obtained. In 1951 and since, the corpses were removed, counted and sexed each morning at 8 a.m. during the months from January to the beginning of April. The possibility of removal by scavenging animals or by road cleaners was borne in mind. The road carries moderate traffic, with a minimum between 2330 hrs. and 0600 hrs. during which hours the minimum temperatures also occur. The male corpses generally appear pink however badly squashed, and those of the females black. It was not possible to determine how many were squashed as pairs. Towards the end of the season a complication arises as the incoming migrants are crossed by an outgoing stream of dispersing toads. The corpses of these "spent" females were pink, and so extra care was needed.

Simultaneously, *Swimming Pool (or S.P.)* counts of live toads were made each morning. The exit drain grating was blocked with gauze and bricks. As however it was not evident whether a toad was a newcomer or had been in residence for some days, methods of marking these toads were tried. At first coloured elastic bands were placed round the hind-limb, but these were only partially satisfactory. An energetic female especially if on the move would soon wriggle it off. Tying little numbered "running shorts" on to migrating toads was tried, but the process of tying the shorts on in the dark, often in heavy rain, proved impracticable. One run of migrants was marked with dabs of blue oil paint. This lasted sufficiently long for them to be traced a day or two later, but was only satisfactory for identifying that stream of migrants, and did not identify the individual toad. Eventually we resorted, with some reluctance, to the amputation of terminal digits, which appears to be the standard practice.

This proved satisfactory, affording as it does a wide range of combinations, and apparently not affecting the animals; though combinations involving amputation of the largest of the hind toes of females were avoided, as the toes tend to become inflamed.

Recoveries too of toads marked by this method are not 100 per cent. satisfactory, since toads do meet with similar injuries very frequently in their natural lives.

At the lake breeding site, counts were also made at suitable dates, but the difficulty of obtaining reliable estimates here is that toads on reaching the lake often disappear into the deeper waters or lie buried in the depths

of the swamps, particularly when a snap of cold weather follows on a period of movement. One might well count some 200 toads moving towards or on the banks of the lake during the night, and the following morning a search would reveal not a single individual. In 1952 the toads spawned in deeper water than hitherto, which added to our difficulties. During the period of these counts on the roads and at the pool, bicycle and car patrols were made throughout the neighbouring countryside in order to gauge the extent and degree of concentration of the migration lines.

In the next phase of investigation we extended our activities considerably. Night patrols were made especially in weather suitable for movement. Individuals were patiently followed, the routes they took plotted. Their behaviour on the march was studied and the speed of movement estimated. Patrols on foot were extended to all points of the compass around the lake. Migrants were dissected to establish at what stage ovulation took place, and samples of testes and nuptial pads were preserved for the Department of Zoology at St. Bartholomew's Hospital, where the endocrine calendar and breeding cycle is being investigated. The plant ecology of the lake was studied.

At this stage it should be made clear that none of the main problems of toad migration have been elucidated. To the questions: What starts them off from their hibernacula? How are they guided to the breeding site? How and to where do they return when breeding is accomplished? Where, in fact, do they all hibernate?—we have provided no answer. But it is hoped that the detailed observation of one particular community will provide material data and the stimulus to other observers to make comparable studies.

Hibernacula.

The story should start from the hibernacula, but unfortunately we have found none, apart from a few under old timber in a wood near the lake, and there is a report that a good number used to use the drain pipe leading away from under the Swimming Pool. My opinion is that many of the hibernacula are quite close to the lake in the many small copses encircling the breeding area. This view is supported by the early emergences being on a narrow front and within range of a march to the lake in one night at the first incidence of "releaser weather" (q.v.). At such times none have been found further off. It also seems probable that they bed down in copses and deserted chalk pits near the roads leading up on to the chalk. Toads from such sites provide the regular migrant "streams" down Tower Hill and Sutton Waldron Hill.

Further efforts to locate the hibernacula will be made.

The distance travelled to the Breeding-Site.

A migrant stream in March has been traced $\frac{3}{4}$ mile up a road on to the chalk, and these have been proved by blue-paint markings to reach our

estate. Pairs were among the furthest recorded. Other toads have been found at distances of a mile and 1¼ miles along lower roads, and one toad marked the previous March was found among others 2¼ miles away in March, 1952, moving down a lane off the chalk. On the other hand, many roads have been traversed by day and night at migration times with negative results, so that it is likely that they do not come from much greater distances than those instanced.

The Time taken to Complete the Journey.

Observation of blue-marked toads have shown that an individual may take nearly 24 hours to march ¾ mile as a minimum, and my opinion is that many toads take more than one night to complete the journey, and that they lie up and halt in woods *en route*. This is likely to happen anyway if they do not get a sequence of nights with suitable migration weather. Individual toads followed on migration have been seen to go to ground in copses on entering the estate even in weather suitable for continuing the journey.

All our records strengthen the belief that they travel mainly by night. If they do move by day it is only rarely that they appear on the roads. On one very suitable night for migration (16/3/51) at the peak of the migration period when the weather was warm and humid, none were found on the roads before 1800 hours despite the suitability of conditions. Toads travelling by road routes would be at a disadvantage if they set out in the hours when daylight was approaching, as they seem more easily to get lost in the day and are more likely to get run over. This point was supported by observations.

Mode of Progress.

In all except two of the cases observed, the males moved by walking while the females, single or paired, may hop as well and always do so when alarmed. They also kick vigorously with their hind legs. Progress by hopping might be of survival value for the females. The sex-ratio of corpses is discussed below.

In walking the forearm when raised exerts a pressure on the ground before being elevated. This hoists the body up on that side. The limb then moves forward and just before it is carefully placed on the ground the toes are spread so that the webbed hand exhibits a large surface area in contact with the substratum. Like Agag they walk delicately. When migrating the head and back are roughly parallel with the ground. They take six or seven hind-leg paces and then pause. If a toad is picked up and placed elsewhere, its first reaction prior to moving is to sit well up with the head pointing up and the forearms slightly extended as props. Anthropomorphically one would say they were getting their bearings.

Speed of Progress and Migration.

Individuals have been followed, especially when moving along the kerbstone which is marked with chalk and later measured, care being taken not to shine any torches directly on the individual being observed. It was found that the males travelled the fastest, the females more slowly and the pairs still slower. Few pairs have been weighed, but one ripe female of 70 gm was carrying a male who weighed 23 gm. The following are the data obtained :

Males. 4 followed, with average rates of from 95-192 yards per hour (yph), three of these over distances from 11-20 yards and one over 512 yards.

Females. 7 followed, with average rates from 65-133 yph, mostly over distances from 75-205 yards. Some of these were on roads, others on gravel paths or on grass. The mean rate over these different surfaces was 99 yph with a maximum burst of 204 yph.

Pairs. 3 followed with average rates from 48-87 yph, over distances of 14, 40 and 116 yards.

Toads are essentially individuals and not too much attention must be paid to averages and estimates based on so few data, but the observations give an idea of the order of magnitude of their speeds and define approximate limits.

Pairs, it is seen, are at a disadvantage, though the males are more certain of their mate. No direct correlation with the sex ratio of corpses can be obtained as pair-corpses cannot be distinguished regularly. Would we be far out in expecting a female to do 90 yph, that is to say a mile in about 20 hours? If she had to travel this distance to the breeding site, she could not do it in one night, and the behaviour of watched individuals supports the opinion that they "stop in" en route. Though the figures are inconclusive I have the impression that toads move more slowly on grass. One female with two males on her back was seen staggering over a wet hummocky field with great difficulty.

The Community on the Move.

The migration of toads being an individual affair, there are neither parties nor processions. I have no details of their emergence from the hibernacula. Is there a social psychological factor or do they sneak off quietly one or two at a time, every toad for him(her)self? Are there separate hibernacula for the sexes? We have no direct evidence. The frequency of females on the road running south of the estate is suggestive, as are the early small runs of males. In the artificial hibernaculum provided by dead leaves in the empty swimming pool, both sexes bed down together in huddles to be described below.

TABLE 1

Period of Movement.

Year	Movement	Peak(s)	Spawn	Notes
1950	19/2–25/3	19/2–25/2 17/3–23/3	12/3	
1951	17/2–27/3	12/3–23/3	24/3	Might have spawned earlier in deep water.
1952	4/3–24/3	4/3–10/3 16–17/3 22/3–25/3	11/3	New breeding site.
1953	17/1–1/4+	22/2–23/2 23/3–30/3	24/3	Exceptionally dry spell in March. New breeding site.

or if the day of the year is taken :—

TABLE 2

Year	Days	Peaks	Spawn	Migration Period
1950	50–84	50–56, 76–82	71	35 days
1951	48–87	71–82	83	39 days
1952	64–84	64–70, 76–77, 82–85	71	21 days
1953	17–91	53–54, 82–83	83	75 days

An estimate of the size of the migrant community may be made from the daily road-counts on a selected stretch of road. There does not appear to be any constant relation between the size of the community and the period of movement.

TABLE 3

			Quotient
1950	34 days.	500 corpses (a few counted twice)	6.8
1951	39 days.	439 corpses	8.9
1952	21 days.	138 corpses	14.5
1953	75 days.	184 corpses	4.1

In 1952 there was a long spell of unsuitable weather from 19th February to 3rd March, while in 1953 there was an even longer spell and the main migration did not travel by road.

Forerunners or Early Toads.

Each year there are usually small movements quite early.

TABLE 4

Year	Road Count	S. Pool	Others
1950	JAN. —	—	—
	FEB. 19th, 28	17th, 15	17th pair
1951	JAN. —	—	—
	FEB. 17th, 15	17th, 7	—
1952	JAN. 15th, 1	14th, 1	—
	FEB. —	11th, 1 female	—
	MAR. 4th, 6	—	3rd (frequent, main movement)
1953	JAN. 27th, 1	17th, 6	17th, 1
	30th, 4	—	—
	FEB. —	—	8th, 1

SEX-RATIO OF MIGRATING TOADS.

(a) *Sex of Early Migrants and First Appearance of Pairs.*

Males, females or pairs may be met with from the very start. If anything there are more males at first (vide graph 1). The 1951 Swimming Pool records show from 17th February to 2nd March a single pair, and from 4 to 9 single males, females arriving being soon paired.

The first pairs observed in that year on the roads were 7 pairs on 12th March, four days before the peak movement, nearly a month after those at the pool had paired; and pairs were most numerous on the roads on 16th March, a week before spawning. Details of early toads seen are :—

1951. Small males at S.P. on 17th February.
Mostly females on road, 17th February.
1952. An odd male (14th February), and female (11th February) at S.P.
Both sexes and pairs on first night of movement, 3rd March.
1953. 4 small males, 2 females at S.P., 17th January.
4 large males on road, 31st January.

(b) *Sex-Ratio in the Total Movement.*

On 13th March, 1951, of 204 toads on the move on the roads and in the estate there was a ratio of 66 per cent. males to 34 per cent. females, 24 pairs being noted; on 16th March, at the peak of migration, of 235 counted alive, there were 58 per cent. males and 42 per cent. females, a significant increase in the number of females, single and paired. There were 42 pairs. On the 19th March counts at the breeding site totalled 170 with 66 per cent. males and 34 per cent. females, 39 pairs being noted. Thus the ratio of males/females is in the neighbourhood of 2 : 1.

On the other hand the figures for total casualties on the road for the whole season were :—

1951. 38 per cent. males, 62 per cent. females. 391 toads.
1952. 30 per cent. males, 70 per cent. females. 135 toads.

From this it appears that the slower movement of the females may result in more females than males being run over. This of course would accentuate the predominance of males at the breeding site. Counts of sexes entering the Swimming Pool do not give a true picture of what is going on, although they do reflect a change in sex ratio as the season progresses (vide graph 2). Taking 1951 as the year in which we obtained most data, between 17th February/12th March there were mainly males in the pool, with an odd pair and a small wave of females on 3rd March who were soon paired off. By the 17th March there were many pairs (13), 10 single females and 4 single males, while on the day spawn was first found, 24th March, no

males remained unpaired in the empty pool, though 14 pairs were still present. Thus our early suspicion that in this community the males did not, as described in most texts, outnumber the females was not a sound appreciation. The more likely explanation is that the females set off later, crossed the road in greater concentrations and were more easily slain by motors.

In 1953, an exceptional year when the main visible migration took place in a short period, there was a great preponderance of males both on the move and in the water at the breeding site. The road corpse counts showed more even figures, but had observation continued into April, it is probable that figures more akin to those of 1951 and 1952 would have emerged. The details for 1953 were :

(i) *On the Move.*

On 22nd March. 94% males, 6% females. 163 toads with 6 pairs.
On 24th March. 89% males, 11% females. 239 toads with 16 pairs.

(ii) *At Breeding Site in Water.*

On 24th March (spawn date). 85% males, 15% females. 86 toads with 13 pairs.

On 27th March. 73% males, 27% females. 226 toads with 60 pairs.

(iii) *Total Corpses on Selected Road Stretch.*

53% males, 47% females. 184 toads.

TOTAL NUMBERS INVOLVED AND ESTIMATES OF SIZE OF COLONY.

The sources of data are : The individuals counted on the move inside the estate, on roads and fields outside; the number at the empty Swimming Pool; estimates at the lake breeding site and the corpse counts on the N-S road sector. For example, on 13th March, 1951, there were :—

In grounds	93
At Swimming Pool	17
Live on roads	129
Dead on road sector the following morning	60
	299

Bearing in mind that some will have been counted on the roads and later in the estate, and that some corpses will have been counted live on the previous night, a minimum estimate of toads on the move on that one night, a busy one, might be about 250.

On the 16th March in that year, the peak night, the figures were :—

Live and on the move	235
Dead on road sector the following morning	86
	321

Say about 275 on the move

On 17th March the attention was concentrated on the Lake and its shores. 124 were counted, and these were a mere fraction of those present; while there were 90 dead on the road the following morning. On 19th March there were 170 around the lake, and 20 dead on the road. Thus we have three nights with about 250-300 on the move on each night, and these were primarily from the North-East-South sectors where owing to roads, counts were facilitated.

In 1953, on 24th March, the date of spawning, 255 were counted, only 15 of which were on the roads owing to the special conditions of migration obtaining in that year. Is it a fair guess that the minimum number of toads involved was of the order of 2,000?

Counts at the breeding site did not prove satisfactory. An estimate in 1950 was of about 200 on 13th March, the day following the first spawn; but two factors militate against getting a reliable figure : (a) the migration to and from the site is spread over a fair period and we know that abmigration overlaps with migration to the breeding site after first spawn.

(b) the presence of extensive *Typha latifolia* swamps in which the toads hide; and the fact that in cold weather, both in the daytime or at night, they may nearly all disappear from view.

The problem can be approached from another angle, that of the actuary, by considering the total known deaths per annum, and guessing the percentage mortality, and thus arriving at a figure.

TABLE 5

SUMMARY OF DEATHS 1950-1953

Year	*Rd. count Sector*	*Rd. count Other rds.*	*Predators*	*Died*	*Total*
1950	500	15	12	6	533
1951	439	66	58	—	563
1952	138	13	—	8	159
1953	184	20	—	9	213

Taking the 1951 figures, if about 500 were killed on roads, and if that number is 40 per cent. of toads coming from N, NE, E, SE and S points, 1,250 might have set out.

If that total represent two-thirds of those converging from all point of the compass then the grand total estimate would = 1,875, say about 2,000. If our prediction of percentage road casualties, however, is too high, then the total would be even greater.

The small numbers for 1952 (a maximum road count of 22, whereas it was 92 in 1950 and 90 in 1951), might be due to a poor breeding season after the hard winter and spring of 1947, with a consequent lean generation of four-year-olds.

The small numbers for 1953 were definitely due to the long dry period which precluded the use of road routes.

Pairing en Route.

This has occasionally been observed. One pair which joined in the middle of the main N-S road immediately made for the side of the road away from the breeding site and remained in the grass. Struggles between unpaired males and paired males have also been seen en route, the tenant kicking the challenger over backwards with his free legs. It is well known that balls of scrimmaging toads may accumulate round a lady at the breeding site. The stimulus for the competitors may be the sight of the rough-house as the following note suggests: "4th March, 1952. In order to measure certain migrating males, I gathered them together and one or two were entangled on the ground. The others approached the scrum and joined in the fun, everyone kicking and croaking."

Moulting en Route and at Arrival at Breeding Site.

This is a common phenomenon and introduces complications when dabs of paint are used for marking.

Feeding en Route.

Freshly run-over, though not too badly damaged toads were dissected, and of 25 males, 22 had empty stomachs. The others had arthropod remains and a little fibrous vegetable matter. Of 35 females, 34 had nothing, and one a millipede and some fibrous plant tissue. Two males at the breeding site had empty stomachs and reduced fat bodies.

We could not induce toads to feed en route. Wriggling worms were dropped before 8 males and 6 females one night. The toads either hopped or clambered over them, and showed no inclination to sup. In this context it may be mentioned that migrant toads always clamber over obstacles, such as dead leaves, and never pass under them, even where this would be the easier course.

Routes.

The routes to be described are best followed by referring to the district and school sketch maps (Figs. I and II). None of the toads travelled uphill on the spring migration. Most travel along the level, but one main stream comes down the quite steep Tower Hill road, which is sunken, with steep hedges and banks. Observations on corpses and migrants suggest that roads, especially sunken roads, are followed where possible. These would be easier going, and they tend to canalize down easier routes as they approach the breeding area.

Observations made on the night of 13th March, 1951, when intensive investigations were made, present the general picture of toads moving to the lake chiefly from the higher ground on the east. They probably originate from the chalk valleys and copses in them. They then strike the N-S road at a limited number of points (vide marked routes on map). Some may also drop straight into this road from woodland bordering the east side. Smaller movements were detected from the South, along the road, and also along farm tracks; from the NW across fields; and later investigations revealed toads approaching the lake across fields and along streams from the west. The original concept of a unilateral invasion from the east gave way to that of radial congregation from most points of the compass. Inevitably more information has been collected about the eastern toads which move primarily on roads. When this easterly stream reaches the main road they cross and then proceed either N or S under the kerb until a convenient way up is reached. Then they move along until they reach one of the several entrances to the school grounds. Here their routes diverge, some going straight across grass plots, most proceeding further along the many gravel paths, later to cut across the field to the lake. Once on the grass they do not necessarily go straight, as individuals followed have shown.

Thus small barriers can deflect them, and despite their reputation for climbing, individuals have been seen to try to mount the kerb without success, and then to be deflected at right angles to travel north or south. When by chance a temporary new entrance occurs they are quick to take advantage of it. One night when a wall had been temporarily opened 26 toads flowed in and got badly lost in a small garden. On another occasion a master who left his door open found the toads moving into his sitting room.

Once in the grounds many individuals lose their way and the sketch (Fig. III) shows how they may go to ground in a garden or copse. Those deflected north to the Lodge entrance then move SW and this probably accounts for their appearance in the empty Swimming Pool. The regular increases in the Pool population correspond well with heavy movement on the roads, while there is no evidence of their reaching it from the north or north west. However, they do leave the ' Pool and proceed to the lake, as marked toads have shown.

One particular route is worthy of special mention. On the west margin of the lake (Fig. IV) a stream runs out through a sluice. Piped for a few yards, it descends a small waterfall to run out as a brook over the farmland to the west. Up this brook toads were found to be migrating in considerable numbers in March, 1951. The nights in question were cold and dry, unsuitable for normal migration, and there was little or nothing on the roads on those nights. When they reach the grotto hollowed out in the greensand by the fall they must perforce scramble out and make through the wood to the lake margin. On entering the water they often find themselves behind a grating, which explains the appearance of a small quantity of spawn there in some years. The migration up this brook was particularly conspicuous in 1953. Two days before the spawning of 165 toads in the grounds and approaches 155 were in this stream and its tributaries, and of those, 142 were males. On the evening following spawning, of a grand total of 246 on the move on all routes, 139 were on this stream, again with a vast preponderance of males (121 males, 9 pairs). On the road there were only 6 corpses the next morning.

They also move along the dry floors of the numerous copses in the estate. Many of these contain yews with little carpet layer.

CONDITIONS UNDER WHICH MIGRATION TAKES PLACE.

When toads are found out at night they may be engaged on a breeding migration or on a temporary emergence in search of food. If their awakening from hibernation and emergence is initiated by an internal threshold of sex hormone accumulation, it may be thought that after December such feeding forages would not take place and that all movement then is promoted by the reproductive urge. To the night observer the overall impression of their movement at such a season is its purposiveness; of a silent steady flood of slowly moving animals. The "conative element" of E. S. Russell (1934) is evident. On my present observations I consider all movement from January to March to be reproductive. In the autumn movements to be discussed in a further paper, one must be more cautious in arriving at an evaluation of the nature of such behaviour.

It is common knowledge that amphibians in Britain are more likely to be seen during and following on a rainy night. Our evidence points overwhelmingly to the occurrence of mild wet weather favouring movement. Records of maximum and minimum temperatures so far have not proved very helpful. It has not been practicable to record temperatures at intervals during the night throughout the breeding season. A short spell of cold at night can halt a movement already in progress. Conversely, there may still be movement on a night which is only partially cold and dry. Again I have not had access to sufficiently detailed data of relative humidity. However, the general impression of weather conditions noted down in a

diary each day have tallied sufficiently well with observed movement for us to be able to say that on such and such a night we will expect and prepare for movement on the strength of the afternoon weather conditions. On the other hand, nights that seem promising may show no movement particularly if early in the season. This fact in itself hints at the probability that an internal environmental factor also is operative.

The converse movement-forecast is more reliable. On cold dry nights we do not anticipate any movement and there have been numerous occasions when this has been borne out in fact. Similarly, where the weather has changed abruptly during the night, migration has been halted. On such occasions I believe the toads to "bed down" and "lager". The chart (Table 6) presents some of our data on the relation of weather to movement.

The persistence of the migration already mentioned suggests a "drive" from within. In considering the weather we may think that there are external conditions which initiate or allow movement to take place; and there may be conditions which may cause the pituitary to secrete a gonadotropic hormone and stoke up a "drive".

Following Tinbergen (1942) it may be that the degree of external stimulus necessary to release migratory behaviour may have to attain a lower threshold as the internal factor of hormone accumulation becomes more intense. This would explain a season such as 1952 where suitable weather conditions early in the season did not precipitate movement. Conversely, weather conditions too severe to allow migration early in the year would not prevent it as the season developed to its climax when the animals were brimming with the internal compelling juices. This was particularly evident in 1953 when after a preliminary wave of movement about the 22nd February, a long spell of cold dry fine weather ensued and no movement was detected until a month later. Then, although it was still dry though warm, the main migration took place quite rapidly in a few days and a note of urgency was detected. Toads could not use the roads, movement was by copses and particularly up-streams, and quite a few toads were travelling, contrary to their usual practice, by day.

I would summarize the influence of weather on migration thus: The releaser mechanism in the toads is a threshold of internal conditions varying with communities and with individuals, and this becomes operative when suitable weather conditions including humidity directly and temperature indirectly are "right" as they often are.

That other external factors may start off the "pituitary clock" is also likely; but of these conditions we have no information.

THE REPRODUCTIVE STATE OF MIGRANT TOADS.

The investigation of this lies outside the scope of the present paper. However, a small quantity of material is being collected for other investi-

gators who may be able to find a correlation between hormonal condition as shown by the lipoid content of interstitium and of nuptial pads and the observed behaviour of the animals. Toads for this purpose are being collected in all months of the year. In the spermatogenetic cycle of the male, sperms are maturing again from March onwards, with a peak of activity between July and September, well in advance of the season of movement (Champy 1913).

The differences in timing, in dates of movement and of spawning between toads from neighbouring communities might be explicable if genetical physiological constitutions and their hormonal cycles were found to differ.

We have some data on the timing of ovulation. Of 18 toads examined which were crossing the road-sector none had more than one or two eggs in the oviduct, nor had those which in 1952 were delayed for a long time in the empty Swimming Pool.

With the discovery of a neighbouring colony at Tarrant Gunville in 1953 the following interesting comparison emerged.

The Tarrant Gunville colony probably started spawning on the morning of 24th February in a relatively small pond. The number of toads present was estimated at about 300, and the temperature of the water was 51°F. at a depth of 1 ft., 50° at 2 ft., and 50° on the ground by the pool. Five pairs were brought to the laboratory and placed in the aquarium also at 50°F. Three of these had commenced spawning. The following morning no fresh spawn had been shed, until one recommenced at 1100 hrs. This contrasts with toads brought in from the Clayesmore Lake, which spawned readily when placed in the aquarium. The two females which did not spawn were found not to have ovulated.

The Clayesmore colony situated only four miles away did not spawn until 24th March, a month later. Of four pairs inspected on that day :—

1 female had ovulated.
1 female was well on with ovulation.
1 female was just beginning.
1 had not started.

In summary it seems certain that ovulation takes place only a short time prior to oviposition, and may immediately precede it. A technique by which an ovulated female could be recognized without dissection would be worth discovering.

SENSE OF DIRECTION IN MIGRANT TOADS

How the toads find their way unfailingly to the one water and do not deviate to breed in other pools remains a separate and fascinating problem. No answer will be found in the present paper. The possible theories come under the headings of :—

Auditory stimulus.
Olfactory stimulus.
Visual Memory.

To deal first with the *auditory stimulus*. This can hardly operate for the first arrivals at the breeding site. In 1951 none were croaking at the empty Swimming Pool on 12th March, and on the 13th, the day of peak movement, only three were croaking between 2010-2030 hrs. at the Lake. On the 25th, when spawning was in full swing nearly all the males were croaking, but by then the migration was practically over. On the 28th and 29th very little song was heard. These were cold nights. It is likely that the degree of song is related to temperature. I do not believe that the males' song is a prime stimulus. They generally only call when frightened, when fighting, at the height of the spawning season or when put together with consequent fights. It appears to be a social reaction. That this small sound could carry up to distances of a mile, seems unlikely, especially on noisy windy nights.

OLFACTORY STIMULI.

It has been suggested that the wind may carry the smell of weed from the Lake to the migrating animals. Toads from different communities, however, move towards ponds with very different vegetation, and indeed to different sub-communities in the one pond in successive years. These, however, are communities of the higher plants. Whether the planktonic and other encrusting algal communities are more constant has not been investigated. Experiments in which dishes of water from the breeding site have been placed in the empty swimming pool at a time when many toads have found their way there have given no results.

Acting on the suggestion of Dr. Malcolm Smith, we tried in 1952 blocking up the nostrils of migrating toads. The experiments were carried out on a small scale but were inconclusive. In particular toads were found to wipe off vaseline used in a matter of minutes. Dr. Maxwell Savage (in litt.) has suggested that we might anæsthetize migrant toads by spraying their throats, or go further and dissociate the olfactory bulbs by operation. The trouble here is that, as he points out, we are then not dealing with a natural animal but with a laboratory product. The waywardness of individuals holds out little hope for us being able to follow them thereafter and large numbers would have to be so treated if we were to hope to get any recoveries by later samples at the breeding pool.

If wind played much part in carrying olfactory stimuli, the direction of the wind would be significant. The prevalent wind in wet conditions is S-W, but many toads approach the lake downwind. Here Dr. Maxwell Savage suggests that due attention should be paid to ground air currents, which might well vary in direction from the wind. But the simultaneous

radial congregation that we have observed seems hard to explain on this hypothesis, unless toads only moved on still nights, which is not the case. I have noticed that on foggy nights which are also still nights toads seem more prone to get lost, but have insufficient data to support this observation.

I have received an impression—an anthropomorphic one it is true—that there is a process of orientation. Toads move along a lane which runs from E-W, South of the breeding lake. When approaching from the east, and when clear of a copse on their right they have been seen to pause, and to sit well up with the head raised in a manner, suggestive to the human observer of tense concentration. But on what? In this position they have always faced towards the lake, and between them and the water has been clear ground. On the other hand in these fields surrounding the breeding lake and on its banks males have often been facing away from the lake sitting propped up; a torch beam level with the ground will light them up conspicuously. They may here be awaiting the approach of females with whom they can couple, and are placing themselves as it were at the head of the queue. This posture is similar to that adopted when waiting for females in the water itself. The data so far gathered are insufficient for valid conclusions, and further speculation at this point would be out of place.

Now that we have a second breeding colony separated from us by only four miles there opens up the possibility of interesting experiments in transferring marked samples of populations and discovering if their directive sense operates under such experimental conditions. Preliminary transfers of quite small numbers have so far given no recoveries, nor indications. One difficulty is that the members of the two communities are obviously in a different phase of their breeding cycle at the same time. Also the chances of recovery are small even if they did complete the longer journey, as of 95 toads examined at the 1952 Clayesmore breeding site, none bore our previous markings.

DEFLECTED MIGRANTS : THE TOADS IN THE SWIMMING POOL.

As mentioned already, a proportion of each wave of migrants find their way to the empty swimming pool in the school grounds. It was hoped that a study of events there might throw light on problems of their migration, and in particular help in solving the problem of how they find their way. There seems no doubt that those who get into the pool have lost their way. Conditions are undoubtedly abnormal for them. There was not at any previous time any pond or stream in the immediate area of the present outdoor pool.

How do they enter the pool? At first we thought that they might emerge from an exit drain, especially as another old drain nearby was said by the gardener to be inhabitated "by all the toads in the neighbourhood". So

a wire mesh was placed over the grating and toads continued to turn up in the pool. It is probable that most of them come down the two sets of stone steps at the west end of the pool. They can drop straight in, either by accident or design, since a boy saw one female fall the 9ft. on to the concrete at the deep end one night, without apparently sustaining injury.

EXIT FROM THE SWIMMING POOL.

That they can leave the pool is certain as with regular daily counts an individual or even a pair may leave it for a day or two and then turn up again.

On the other hand some individuals we have watched climbing the steps (7″ high) were remarkably incompetent as the following extract from the journal indicates :

"I watched a female trying to negotiate these precipices. She would extend an arm, get a grip, stand on tip toe, extend the other arm, scrabble with feet, fail to make it, and then topple over. She then paused and moved along the step to try again. She then left those steps and moved across to try the others. I then placed some half bricks in the corner of each step and watched. Their efforts were not intelligent and they were not very persistent. The lady toad would approach the brick which was on her right. She would then place her right hand on it, get a leverage and then place the left hand in space and try to get a leverage on that. When leaving as pairs, the males do not assist their climbing spouses."

FROM THE POOL TO THE BREEDING LAKE.

Of the first six males marked by clipping at the pool, two were subsequently found in the lake near the breeding site. The first was marked on February 17th and stayed at the pool till March 7th. It appeared at the lake on March 13th. The second, also marked on February 17th was at the pool till March 11th, and in the lake by 18th March. A third marked on February 17th was placed that day on the edge of the pool and was not seen until March 12th when it was found migrating south along a path towards the lake at night. The distance to the lake is about 512 yards direct.

No systematic homing experiments have been carried out on the pool dwellers, but a banded male and female removed to a shorter and longer distance did not return. A pair which were helped out at the height of migration in 1951 moved 8 yards in half an hour, and then turned into a copse and settled under the root of a Yew tree.

BEHAVIOUR IN THE SWIMMING POOL.

This varies with the amount of water trickling over the floor and with the degree of cold and with the wind direction. In cold, dry weather they form huddles usually in the NW corner when the prevailing wind is north. Here

they lie buried under dead leaves. With other wind directions they form smaller huddles of 5-6 in other corners, preferring those which are damp. The numbers in the huddles may reach 49. The males, who have a proportionately larger surface area are often beneath. There is no fighting in the huddles. They are probably warmer there. Body temperatures were taken of some females in the forenoon on March 30th, 1950. The air temperature in shade was 7.7°C. Those in the shade had body temperatures between 7.5-8.5°C.; while those in the sun were 20-21°C. One from under a huddle in the sun was 16°C. In mild damp weather they move round the edge of the floor of the pool attempting to get out. Before moving off they do not show any particular orientation, spreading out to face in all directions. In cold weather they stay all night in their huddles. Chunks of wood, etc., are often used for shelter. They can put up with frost but may eventually succumb. When frozen into an icy lump the limbs are extended, the hind femora at right angles to the body. This hard clear weather eventually killed 3 males and one female.

Some toads from the Tarrant Gunville colony placed temporarily in the pool were seen to climb vertically in the corners. One reached a height of 3ft. before peeling off. Our own toads have never been observed doing this.

PAIRING AT THE POOL.

Pairs enter the empty swimming pool, and toads at the pool pair up both by day and by night. Where toads have been marked on the forelimbs, difficulties arise in checking, as the fists, particularly the two innermost toes with black pads, are screwed up in amplexus, and it becomes necessary to separate the pairs. After such separation they do not necessarily re-unite, and when placed together in a huddle take no immediate notice of each other, and one partner may stroll off. This is in striking contrast to behaviour at the breeding site where a male will grip anything from a stick to a frog, or in the aquarium where they will mount an axolotl. The bond is weaker in the artificial *cul-de-sac* of the empty pool. The problem of how the sexes recognise each other has not I believe been tackled. But Dr. Savage (1934) has shown conclusively how in water a male which mounts another male discovers its mistake by the second male chirping, whereon the first toad leaves go.

An early formed pair (February 17) was removed to the vivarium in the laboratory, and a bowl of water placed at one end and one of plant detritus and algae from the pool at the other. The pair soon broke up and a few hours later were found buried just below the surface of the sand. On dissection the female was found not to have ovulated. In 1953 two early migrants, a male and a female, entered the pool during a mild spell in mid-January and were introduced into the vivarium on February 3rd. They were then carefully observed by one of the boys and daily temperatures

noted. To summarize the observations, the toads in captivity, at a higher mean temperature with less extreme diurnal swing than that experienced by a control batch at the swimming pool, paired earlier and spawned nearly a month ahead of the rest of the colony. The male's first reaction was to burrow, which was probably a defensive reaction to a strange situation. The female did not burrow. The male did not feed in captivity, but the female took a worm one week before spawning, and fed more often afterwards. There was an unsuccessful first amplexus, suggesting that the male was ready but the female had not reached the appropriate stage in her breeding cycle.

Many of the pairs separate naturally at the pool particularly after the spawning date, the female kicking the male out of the way. In 1952 pairs which had been together in some cases 14 days mostly separated, the tendency to divorce increasing with the cold, dry weather. There is no doubt that the empty swimming pool is an unnatural environment and does not allow the breeding behaviour to proceed.

NUMBERS AT THE SWIMMING POOL.

The general picture of toad numbers at the pool is shown by Graph 2 of the figures for 1951. Influxes correspond with migration on the roads. Maximum numbers present were :

1950, 83. 1951,40. 1952, 39.

The maxima preceded the spawning date in 1951 and 1952, and followed it in 1950. The sex ratio has been discussed above.

With the waves of toads entering the pool there are usually small numbers of Smooth Newts (*Triturus vulgaris*), of which 11 were counted on one occasion, and Warty Newt (*Triturus cristatus*) occurs. They join in the huddles with the toads in the colder weather. Never have juvenile toads been found with them. The pool is surrounded by copses containing yews with little carpet vegetation. When the population has increased, and no toads have been seen on paths, it is likely that they have travelled through or from these copses.

THE LAKE BREEDING SITES.

As the spawning date approaches the bulk of the migrants are to be found all round the lake, in the water, perched on decaying *Typha,* on the grass banks, and on paths in the woods. But at first they are only visible by night, and then only if the weather is not cold and dry. The next phase finds them concentrating near the selected breeding site, and fewer are found round other sectors of the shore. During spawning they will be visible in the water during the day time as well, especially if it is warm. The movement of toads away from the lake will overlap with the arrival of fresh

migrants. Following the peak of spawning activity they disperse to all quarters of the lake again, and then presumably most leave. Their presence all round the lake margin before concentrating makes it unlikely that they are guided by the olfactory stimulus of a particular plant.

They enter the water where there is a gentle grassy slope or gully, rather than through wood litter, and males wait in open patches of water near the shore at night. As Maxwell Savage has described, the males float with the head up and hind legs parted, facing the bank, no doubt awaiting the arrival of the females. I have noticed that in this position the lungs are fully inflated and act as hydrostatic organs, giving either sex a bulging appearance. If they are alarmed, both sexes will crash dive slantingly, forcing the air out of their lungs.

When we transported the population of the empty swimming pool on March 21st, 1952, to the lake in the afternoon, several toads paired there and then as they entered the water, and most had disappeared in a few minutes. Some climbed back, up the bank.

They do not always seem able to recognize partners. Of three single females who were brought from the Swimming Pool and placed in the water at the breeding site, one swam off and was pursued by two males, one of which mounted. The other two swam right through the perimeter of waiting males, none of which took any notice. Similarly a male on the bank placed in the water on or near a female did not embrace her, and the female crash dived. This occurred before the spawn date.

PREDOMINANCE OF MALES.

Despite the misleading statistics from the swimming pool discussed above, the males have been consistently more abundant at the breeding site, as is usually the case. On March 25th, 1951, in the evening, a count at one point gave about 100 males, with about 20 pairs and no single females. At this stage the males were mostly croaking.

HIDING BY DAY AND IN COLD WEATHER.

Following a night of intensive migration, not a toad may be seen in the lake on the following day, until spawning actually begins. Following a count of 124 on the night of March 17th, 1951, only one pair was visible on the following afternoon. They appear to lie low in the *Typha latifolia* swamps. Their behaviour at this stage appears to be influenced by temperature. In cold weather they lie deep and out of sight, although there is not more that a degree of difference of temperature between surface water and a foot down. This may be a protective device. At the height of spawning they swarm near the surface regardless of danger. Prior to spawning it may pay them to lie low. On March 24th, 1953, the spawn date, when 86 were counted at the lake and 246 that evening on the move towards the

lake, there were few in view at the surface at 0930 hrs. the next morning in fine, sunny weather, but following a slight ground frost. Most were below in 2-2½ ft. of water, just below the top layer of willowmoss. Others dived out of sight when approached. By 1120 hrs. however they were swarming at the surface.

CHOICE OF SWARMING SITES.

The accompanying map of the lake (Fig. IV) shows where the toads have bred. In 1939-40, and from 1946-1951 they spawned in shallow water between 6 ins.-1 ft.; in 1952 they moved to a more typical area in deeper water up to 3 ft., while in 1953 they moved again and spawned in a site of depth 2-2½ ft. Thus they have spawned in shallower water than that usually described. They change their sites over the years. This no doubt can be correlated with changes in the vegetation of the lake, which is being silted up and is a typical *Typhetum* hydrosere, which has been advancing rapidly towards its climax in the years since the war. The weed around which the spawn has been laid has been different in each case, indicating no especial preferences. Details of the site are given below.

Between 1939-51 they spawned in a restricted area in shallow water on the bank side of a *Typha* patch. The dimensions in 1950 were about 30 ft. x 6 ft., with a depth from 6 ins.-1 ft. The area was clear of *Typha* and *Iris pseudacorus,* which had been grazed back by horses especially during years with dry summers. In this year the vegetation consisted mainly of *Ranunculus aquatilis,* some *Callitriche,* a few *Alisma* and much floating *Typha* debris. The latter which is an important micro-habitat in this lake formed the main anchorage for the tadpoles on emergence in that year.

In 1951 they occupied a strip a little to the west. It was also clear of *Typha,* and the first spawn was on *Callitriche.* They also spawned in the *Iris* with little spawn on the *Typha* debris. The area occupied in that year was 10 ft. x 8 ft. During these years there has been no spawn in other parts of the lake, apart from that from a few pairs trapped behind the grating by the sluice exit stream.

In 1952 the old spawning site was deserted and they moved into deeper water off shore from an island. The area was 24 ft. x 30 ft. and was carpeted with abundant *Myriophyllum, Ranunculus aquatilis,* and some *Fontinalis* moss. After the main spawning a small group (7 males, 5 pairs) occupied yet another site not far from the site to be used in 1953.

In 1953 after a long, dry spell in March, when the water level was unusually low they moved to another site in mid-water of a channel. This was densely covered with willow moss, which reached to the surface, and heavy rains brought the level to 3 ft. There were also some water lilies here.

Prior to 1952 horses had watered at the old breeding site, and the swans on the lake had kept away from this channel. In 1952 with the departure

of the horses, three swans had taken to using the channel. In 1950 toads had been severely mauled when spawning, possibly by a dog. This factor and the general development of the swamp to drier margins may account for their changes of plan.

SPAWNING DATES AND PERIODS.

1950. March 12th (71).
1951. March 24th (83).
1952. March 11th (71).
1953. March 24th (83).

In each year except 1953 the corpse count on the road sank to a minimum shortly before the date of spawning. The late dates of 1951 and 1953 spawning are I think due to weather conditions. In 1951 there were a few cold days from 20th-23rd before the date of spawning, while the drought in February and March, 1953, was undoubtedly the cause of the late date in that year. Mid-March would seem to be the typical spawn-date for this community, but records from future years will need to be accumulated to establish whether this is so. The accompanying graph (III) show the spawning date in 1953 relative to the water, ground and air ttmperatures taken daily at 1400 hours. Water temperature reached 16°C. for the first time on the day before spawning began while the air temperature rose sharply from 10-16°C. four days beforehand. This matches the apparent pattern found for Frogs (Frazer, 1953).

Toads spend some time at the lake before conditions, physical or biotic, precipitate spawning. In 1951 they were present at the lake for 23 days (minimum), of which 11 days was prior to spawning. In that year pairs were recorded at the lake before spawning thus :

March 13th. 1 pair.
March 17th. 12 pairs.
March 19th. 25 pairs.
March 24th. Spawning commenced.

None were visible that year after March 28th, their disappearance being accentuated by a cold snap, but no doubt they were there.

Actual periods during which spawn was shed have been :

1950. circ. 9 days.
1951. minim. 4 days.
1952. circ. 9 days.
1953. minim. 8 days.

while at the Tarrant Gunville Colony in 1953 it was 8-9 days.

SPAWNING DATES DIFFERING IN SEPARATE COMMUNITIES.

As Dr. Malcolm Smith records in his book, toad communities separated geographically by only 20 miles may commence pairing on dates over a fortnight apart. Whether their spawning date also differed was not stated. We hoped to produce some evidence on this point, and in 1953 were fortunate enough to discover another colony only 4 miles away which did in fact spawn a month earlier on February 24th. If we refer back to the temperature graph III it will be seen that, if temperature is significant, two suitable periods for spawning occurred in the last two weeks of February and of March. It is possible that the Tarrant Gunville colony had a shorter distance to travel to breed and moved in time for the earlier date.

If these neighbouring communities were in fact isolated from each other and there was no inter-change, genetical isolation would probably emphasize differences in behaviour. At any rate the difference in the behaviour of the two colonies shows that temperature alone does not cause migration.

If the spawn dates of the two colonies are customarily separated by any substantial number of days, it will be interesting to follow the behaviour of marked migrants brought from the roads or swimming pool at Clayesmore and placed in the Tarrant Gunville community at the onset of spawning activity.

Within the community frequenting a given breeding locality there are of course individual differences in timing. The evident waves of migration, though at first sight explicable by the periodic nature of suitable migrating weather, are just as likely to represent emergences from separate hibernacula. Evidence in 1952 strongly suggested that the first toads came from copses situated not far from the road sector, and the absence of corpses on outlying routes in the early stages of migration precludes the explanation that the different waves correspond to varying distances travelled by toads which emerged simultaneously.

PERIOD OVER WHICH MOVEMENT TAKES PLACE.

Dr. Malcolm Smith writes that the migration in some colonies from first to last arrival may go on for a week to ten days. In our colony this was true of the small scale migration of 1952 when they moved in seven days. Corpses were found on the road :

1950, over 16 days.
1951, over 34 days, but the main movement was in 20 days.
1952, over 7 days.
1953, over 65 days, but the main features were a movement of 7 days in February and of 12 plus days in March.

In each case I have only considered the period of movement up to the date of spawning. In fact these figures are minimal as in 1952 and 1953 we

established that the inward stream and outward stream of spent toads did in fact cross each others' paths. Evidently with large colonies migration may be spread over a longer period than was hitherto suspected.

DISPERSAL AFTER SPAWNING.

This takes place in two stages. The toads spread out again around the shores of the lake, and then actually move away from it, some of them indeed being killed on the road. In 1950 nine days after spawning began only a few were in sight at the breeding site, but toads could be heard croaking in various swamps of *Typha,* though no spawn was found in them. Evidence of the return movement across the road was as follows :

March 27th, 1951. Several pink "spent" female corpses on the road sector, three days after spawning commenced.

March 16th, 1952. With a view to studying return movement 21 males, 4 females and 35 pairs were marked from the spawn site in the afternoon. That night there was movement including among others spent females going eastwards. Of 9 live and 13 dead females, none had our marks which suggests either that they had set off before we marked them in the afternoon, or that they had previously moved to the margins of the lake as suggested above. This eastward movement was traced a short distance up Tower Hill but above the inner village only females migrating to the lake were found, and fresh ripe females arrived at the empty swimming pool by the next morning.

The absence of males was what would be expected, since, being in a majority at the breeding site, they stay on for further fertilizing.

The dates for return migrants are :

1951. 9 days between road count peak and first spent females.
3 days between spawn date and first spent females.

1952. 9 days between road count peak and first spent females.
5 days between spawn date and first spent females.

1953. 4 days between spawn date and first spent females.

The possibility that a female might return from the lake without shedding her eggs must be considered, though it is unlikely owing to the predominance of males. This return migration takes place under similar weather conditions to the breeding migration, as do in fact all toad movements. Some males at any rate are in no hurry to stir far from the lake since male toads were disgorged by Grass Snakes (*Natrix*) from the lake on May 12th and 25th, 1953.

There is also a well-marked autumn movement which it is hoped to describe in a later paper.

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SUMMARY

1. The relative daily numbers of toads on their breeding migration have been obtained by morning corpse-counts on a selected stretch of road in Dorset, near to the breeding lake, over a period of years.
2. Overnight weather has been recorded and the possible correlations of numbers migrating with weather conditions have been explored. These include both initial movements and peak periods.
3. A distinction is drawn between the external conditions stimulating physiological readiness to move and conditions allowing of such movement.
4. Other methods utilized in studying the migration are described and tentative conclusions for this community are put forward on the location of hibernacula, the distance travelled, the time taken over the journey and the speed of the migrants.
5. The duration of the movement and the time of the year chosen are tabulated for four seasons.
6. No relation between the extent and the duration of the movement has been perceptible.
7. Behaviour *en route,* differential sex behaviour and the sex ratio of migrant toads are discussed.
8. Estimates as to the size of the colony are made.
9. The routes used by toads are described and a picture of radial congregation emerges with confinement to an aquatic approach in weather unsuitable for normal migration.
10. The seasonal physiological condition of the toad in relation to inception of migration is briefly considered. Weather conditions allowing migration to continue are evaluated and the ability of the toad-watcher to forecast a good night for movement is noted. The lowering of the threshold of external stimuli as the breeding season advances and as the internal drive gains strength is described.
11. The reproductive state of migrant toads is discussed and some details of the timing of ovulation are given.
12. The different timing of reproductive behaviour of two colonies closely situated is described and considered.
13. Observations (largely negative) on the stimuli guiding toads to their breeding waters are made. The possible value of observations on a deflection of some migrants each year into an empty swimming pool in elucidating the nature of such stimuli is suggested.
14. Observations confirming what others have described at the breeding site are given. The breeding sites, which occupy different areas of the lake in different years, are described.
15. Spawning dates and spawning periods are given.
16. Preliminary observations are made on the dispersal after spawning.

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RELATION OF OBSERVED NIGHT WEATHER & TOAD MIGRATION AS INDICATED BY CORPSE COUNTS THE FOLLOWING MORNING ON A SELECTED STRETCH OF ROAD.

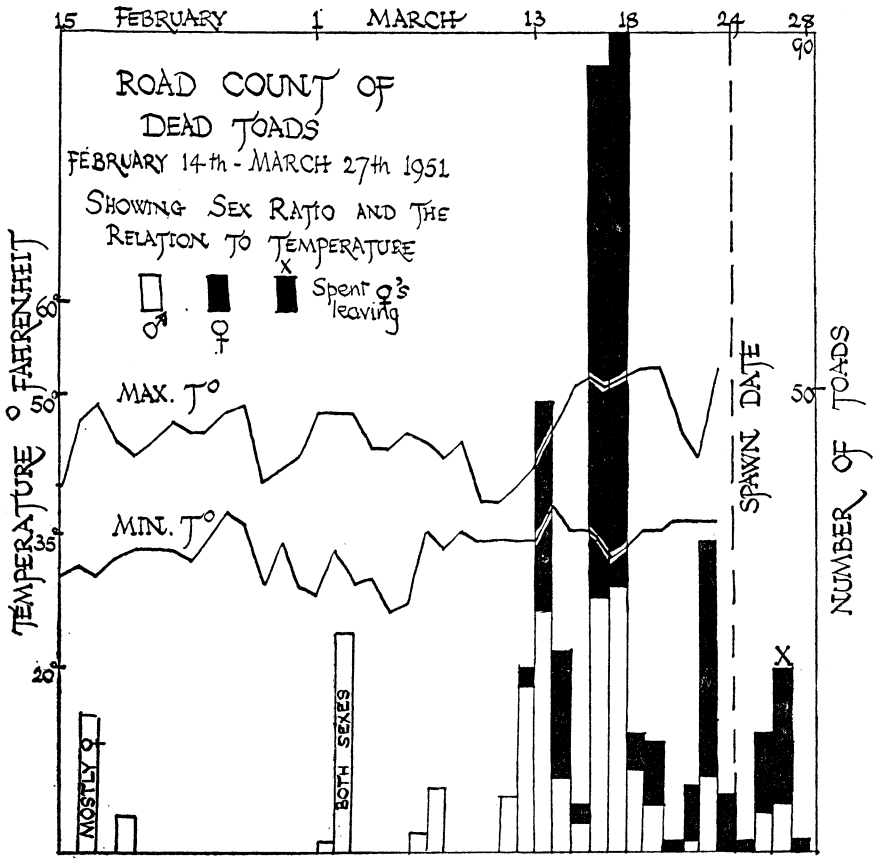
NOTES: THE DATE FEBRUARY 20th REFERS TO THE NIGHT OF 19/20th.
THE FOLLOWING SYMBOLS ARE USED TO DESCRIBE THE WEATHER:

MW = MILD WET
W = WET
CW = COLD WET
CD = COLD DRY
D = DRY
MD = MILD DRY
C = COLD

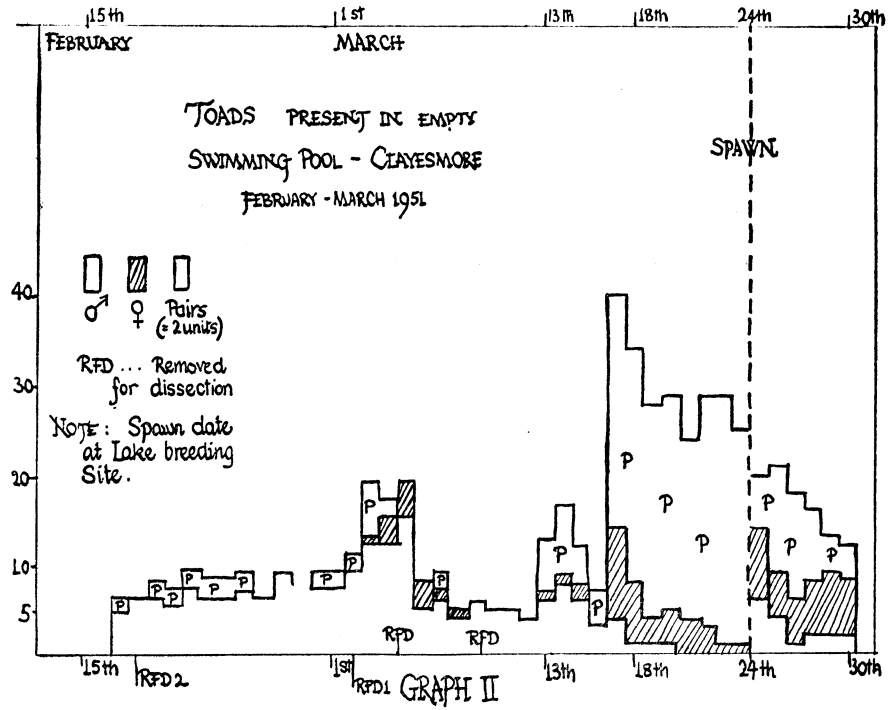
IF THE WEATHER CHANGED SHARPLY OVERNIGHT, TWO SYMBOLS ARE SIGNIFIED.

	1951			1952			1953		
	DATE	WEATHER	TOADS	DATE	WEATHER	TOADS	DATE	WEATHER	TOADS
JAN.	14	MW	0	14	CD	0	17	MW	0
FEBRUARY	17	W	15	15	MW	1	20	CD	0
	18	CD	0	16-28	C	0	21	MD	0
	19	CW	4	30-31	CW	0	22	MW	0
	21	C	0	1	CW	0	26	CD	0
	22	C	0	2-3	CW	0	27	MW	1
	23	CW	0	4-6	CD	0	28	MW	0
	24	CW	0	7	MW	0	29	CD	0
	25	CW	0	8	CD	0	30	MW-C	4
	1	C	0	9-10	CW	0	31	CW	4
	2	MD	1	11	MW	0	1-7	CD	0
	3	MW	24	12-14	CD	0	8	CW	0
	4	CD	0	15	CW	0	9	MW	0
	5	CD	0	16	W	0	10	MW-C	0
	6	MD	0	17-18	MW	0	11-18	CD	0
	7	CW	2	19	D	0	19	MW	5
	8	CW	7	20	MD	0	20	CD	0
	9	CD	6	21-29	CD	0	21	MW	5
	10	CW	0	1-3	MD	0	22	MW	19
	11	CW	0	4	MW	6	23	MW-C	22
	12	CW	6	5	MW	11	24	MD	6
	13	MW	20	6	MW	8	25	CD	2
	14	MW	49	7	MW	22	26	CD	0
	15	MW	22	8	MW	11	27	CD	0
	16	MW-CW	5	9	MW	15	28	CD	0
	17	MW	86	10	MD	6	1-12	CD	0
	18	MW	90	11	CD	1	13	CW	2
	19	CW	13	12	CD	2	14-20	CD	0
	20	W-CD	12	13-15	CD	0	21-22	MD	2
	21	CD	1	16	MW	2	23	MD	4
	22	CD-D	7	17	MW	18	24	MD	19
	23	D	34	18	MD	1	25	CD	6
	24	CW	6	19-20	MW	0	26	MW	10
	25	CW	1	21	MW	0	27	MW-C	9
	26	W	13	22	MW	16	28	MW	7
	27	W	21	23	MW	5	29	W-MD	15
	28	CD	1	24	MW	9	30	MW	29
	29	CD	0	25	MW	4	31	MW-C	8
	30	CD	0	26-27	CD	0	APR 1	MD	5

Table 6

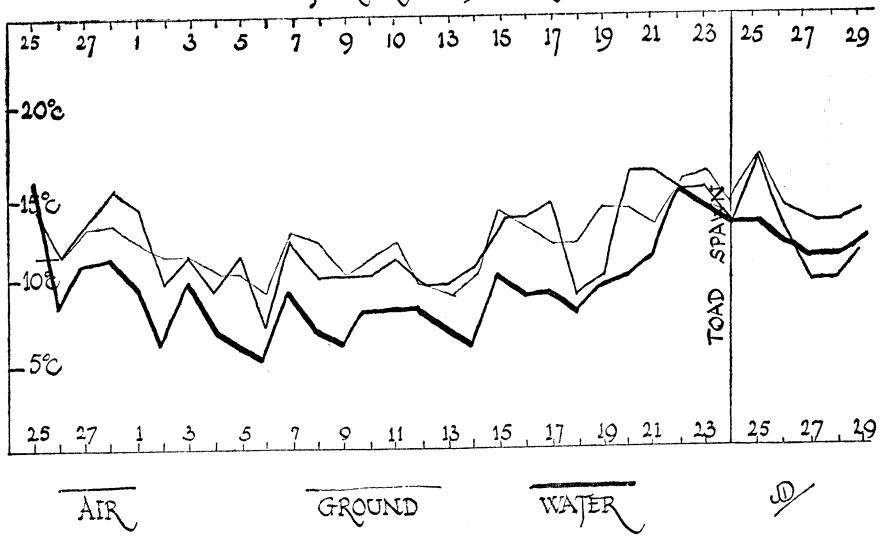


Graph I



GRAPH II

GRAPH III : TEMPERATURES AT THE LAKE DURING 1953
25th FEBRUARY — 29th MARCH



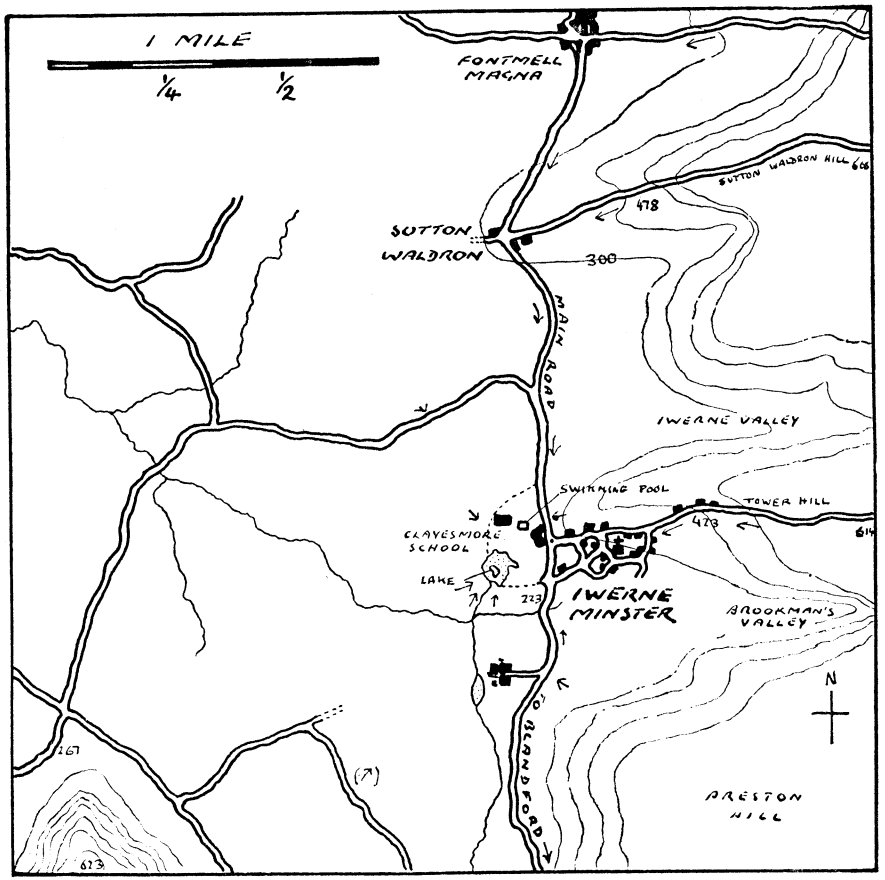


Fig 1.

Fig. II CLAYESMORE SCHOOL GROUNDS WITH TOAD MIGRATION ROUTES.

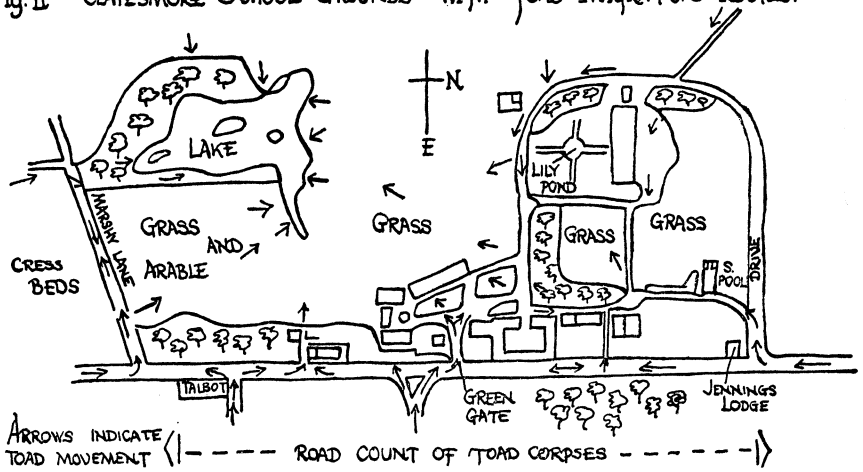
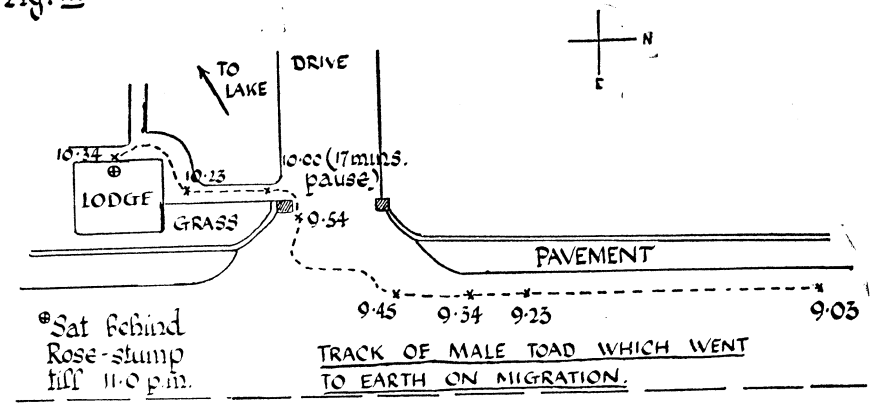


Fig. III



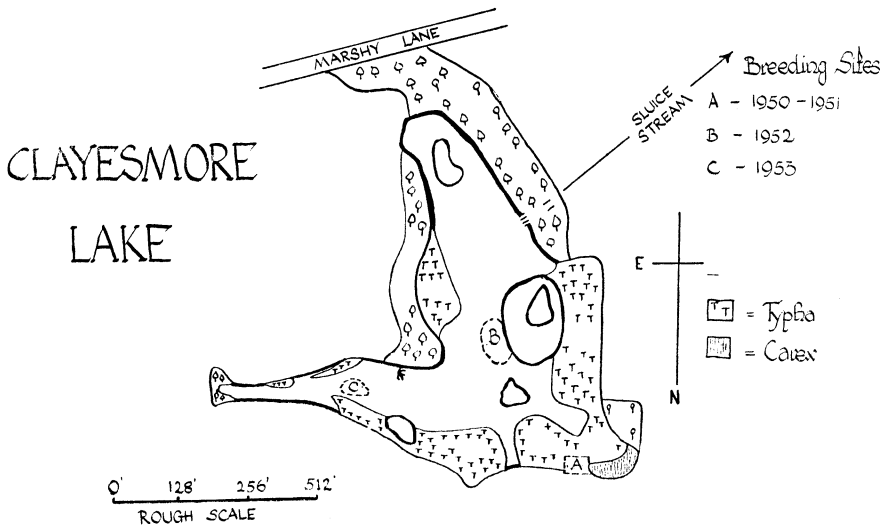


Fig IV showing Toad Breeding Sites 1950 - 1953 JD 54.

CORRESPONDENCE

Sir,

On January 15th, 1954, my tame Leopard Snake was coiled round my neck when I was in the kitchen. I opened the door of a small safe and to my intense surprise he dived forwards and siezed a small cheese rind which was instantly swallowed—and not disgorged. He had eaten two pink mice on Monday, January 11th, and took a larger mouse on January 17th.

I have tried him with a cheese rind dangled in front in his vivarium, but he ignores it.

With the exception of this peculiarity, he is eating well and normally.

FRANCES L. PERRY.

Ann's Cottage, Little Baddow, Nr. Chelmsford, Essex.
January 26, 1954.

Sir,

I have been greatly interested in the discussion on herbivorous snakes and am now in a position to add something to the argument. I pass over an old note of the eating of some yellow flowers by a "Skaapsteker", as memory and observation may have been at fault, in favour of a more recent case. This month I received a letter from a Kenya correspondent, Mr. Alastair Graham, which stated that a native on the farm had told him that a python had been seen three times to take tomatoes from a bush which he pointed out. One knows the proneness of natives to tell you what they think you wish to hear, but in this case the man was not questioned and did not think there was anything unusual in the circumstances, nor did my correspondent think that I would be interested save as in a curious native belief.

I do not think that we need take much notice of the contention that a snake's teeth are "not particularly suited for a vegetable diet," for it is only by their adaptation for prehension and deglutition that they may be deemed suitable for an animal diet; and would assist the ingestion of a mango as readily as of a frog. My own belief is that fruit may be taken by snakes far more often than has been suspected. The chances of this being observed in the field are exceedingly remote and herpetologists have not hitherto thought of supplying captives with fruit. In a dry, hot country a juicy tomato would surely be attractive to a thirsty python.

If a snake can swallow a fowl's egg, the putrefying vomit of a cannibalistic fellow, and other unlikely items, I think both it and we can 'swallow' a mango or tomato.

WALTER ROSE.

"Oaknook," Protea Road, Newlands, C.P., South Africa.
August 30th, 1954.

Sir,

AGAMA SPECIES EATING SCORPIONS

The following remarks might be of interest to you :

Recently we were watching some thatch being removed when a scorpion fell out of the thatch (probably *Buthus* sp.). A large lizard (*Agama* sp.) rushed out at a terrific speed and, before we realised what had happened the scorpions sting gland had been bitten off. No other segments had been removed. The lizard then sat back and gulped and possibly chewed a little before he finally swallowed the sting-segment. Meantime the scorpion was futilely trying to sting at nothing.

The lizard then rushed in again and caught the scorpion round the cephalothorax and abdomen and crushed it with one bite. It then slowly and with evident enjoyment masticated. The whole scorpion was finally swallowed. The scorpion was about $2\frac{1}{2}$ in. in length, the lizard about 8 in.

There are numerous lizards of this genus about the house; they live mainly on flies and other insects. This is the first time I have seen them attack a scorpion. It is apparent from the speed and sureness of attack that it was not, however, the first time it has been done.

They feed with evident enjoyment on bits of chicken thrown to them, and have even been known to eat a lighted cigarette end. Although this was not favoured the lizard never learnt and was burnt by each successive one thrown to him.

As I mentioned above we have numerous specimns of these lizards round the house. Are they wanted by anyone? I have a British Museum Alcohol tank here and, if necessary, lizards could be put into it for anyone interested.

E. T. M. REID, B.SC., F.R.E.S.
Veterinary Entomologist, Yirol, Sudan.
25th March, 1954.

Sir,

I have heard this morning from Dr. P. B. Stones, who is probably the expert on Nigerian snakes.

He was most interested in my letter in your Journal and writes :—

". . . I have never had any live specimens of *Dasypeltis scaber*, I have, however, examined several recently killed specimens and in the stomach of

one I too found seeds which appeared to be those of *Momordica foetida*. I have never found any other seeds in snakes, nor have I been able to persuade any of the various live species kept in Lagos to take a vegetable diet." (P. B. Stones.)

F. R. IRVINE.

32 Tavistock Square, London, W.C.1.

28th May, 1954.

EDITOR'S NOTE

The recent correspondence shews the wide variety of feeding behaviour in snakes. Some of the events may seem unusual, but Dr. Rose's belief that the events may be more common than are suspected brings out the point that the fraction of the total life of a wild species which is ever reported by a human observer is minute. Any *accurate* observation, however bizarre, would probably be multiplied by thousands if we had the complete picture, and would then be an undoubted part of the general life of the species. The Journal is open for such observations, but, of course, the difficulty of repeating the observation puts a heavy srtain on the observer of any event which could have an alternative explanation.

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