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A thermal function of the envelope of the egg of the
Common Frog, *Rana temporaria temporaria* (Linn.)
with observations on the structure of the egg clusters.

By

R. MAXWELL SAVAGE

INTRODUCTION

The different species of the genus *Rana* have several types of egg masses. Some, for example, *R. temporaria*, Linn, *R. sylvatica* Le Conte, *R. pipiens* Schreber and *R. palustris* Le Conte, lay their eggs in compact, roughly globular clusters. Others, for example *R. esculenta* Linn, *R. clamitans* Latreille and *R. catesbiana* Shaw, lay their eggs either in small masses or in a film which floats on the surface of the water. Moore (1940) and Douglas (1949) have suggested that the globular cluster is an adaptation to cold weather, since all the species which have it breed early in the year and inhabit relatively cold climates. The species with the other types of egg masses breed in warm weather. It had been previously suggested that the egg jelly itself might possess the properties of a heat accumulator (Savage 1939). The present paper describes experiments and observations which confirm these suggestions.

SOME CHEMICAL AND PHYSICAL PROPERTIES OF THE ENVELOPE

Chemically and physically the envelope is a very remarkable material. It contains about 99.7% of water (Savage 1937, p. 250), and yet has the properties of a solid. There are very few, if any, other materials, solid at ordinary temperatures which have as high a percentage of water. The jelly of the Coelenterates, for example, is commonly considered to be an exceptionally dilute solid, but because of the salts in the sea water, it has much less water in it than the jelly of the frog's egg. Most of this water comes not from the parent frog, but from the pond, for when the eggs are first laid, their envelopes are but a small fraction of the size which they attain when they are fully swollen. As a means of producing the largest possible mass of solid material with the least possible expenditure of matter and energy this jelly is possibly unmatched by artificial gels, although similar products of other fresh-water organisms may equal it.

Since it has this very high proportion of water, it shares with water many exceptional properties. For example, it has possibly the highest specific heat of any known solid. That is to say, there is perhaps no other solid which, once heated, will cool down so slowly. Yet, at least in the early stages, it is transparent. Light energy will pass through it without being much absorbed. At the centre, there is a black body, which will absorb nearly all the radiation falling on it, and convert it into heat. Because of the high specific heat of the surrounding jelly, the rise of temperature will

be small, but so will be the drop in temperature when the source of heat is removed. There are no convection currents, because the water has, so to speak, been immobilised. The conductivity is low, so that little heat escapes from this cause. In short, the whole arrangement looks like a heat trap. Moreover, the clump itself is approximately spherical, the ideal shape for minimising heat losses, and the habits of the parent frogs ensure that many clumps are laid together, commonly in actual contact.

EXPERIMENTAL

In order to see whether these effects were sufficiently marked to be confirmed by experiment, the following tests were made.

An egg cluster was divided into two equal parts. One part was heated in order to kill the eggs. Each was then left for a day in a 250 ml. beaker alongside a third beaker containing water to the same volume. The three beakers were left side by side near a window, exposed to the daylight as evenly as possible. After a day, both egg masses had a temperature of 8.85° C., but the water was only at 8.60° C. This showed (1) that metabolic heat from the living eggs was not sufficient to produce a difference of temperature, under these circumstances, which was measurable with a thermometer graduated in 1/100ths of a degree, and so could be neglected in subsequent experiments, (2) that the eggs were 0.25° C. higher in temperature than the water.

A 60 watt electric lamp was then arranged at an equal distance from the beaker with the killed eggs and from the beaker of water. The light was switched off and on at irregular intervals, and the results are recorded in Table 1. They show that the eggs heated up in one case more quickly than the water, but in another experiment they heated more slowly. On both occasions, the eggs cooled down more slowly, the difference between the water and the eggs being 0.4° C. Left overnight with the light switched off, the eggs were still 0.3° C. warmer next morning.

Ink was then added to the water in order to absorb radiation. Both beakers then warmed at the same rate, but when the light was switched off, the eggs remained warmer than the water.

An artificial jelly (15% gelatin in water) behaved in very much the same way as the eggs.

Experimentally, therefore, there is evidence that a mass of frog's eggs exposed to intermittent radiation is, on the average, warmer than a similar mass of water.

FIELD OBSERVATIONS

Table 3 shows the results of a series of field observations, carried out in many ponds and over a number of years. It can be seen that in general, the eggs in a pond are warmer than the surrounding water, by an average of 0.63° C., the temperature being measured in both eggs and water at about the same depth below the surface. This point is important, because if the temperature of a pond is explored with a thermometer, parts may be found which are warmer than the eggs. This is so, for example, among the

weed mat at the bottom of clear shallow water in bright sunshine. In such circumstances, the radiation is converted into heat when it strikes the bottom, and the pond warms from the bottom upwards, just as it would if it were to be heated from below. Convection currents tend to equalise the temperature in time, but do not work fast enough to abolish the differences. These locally warm places are not representative of the main part of the pond, but because of these and other variable factors, it is not to be expected that the eggs will always be warmer than the water. All that this paper shows is that they generally are. The differences persist after dark and are to be found soon after dawn.

DISCUSSION

The differences in temperature which have been found may not seem very large. They are, however, larger than were expected when this work was planned. Much smaller differences would have been regarded as significant in the life of the frog.

Rana temporaria seems to be well adapted to breed in cold weather. Of all the European Anura, it breeds the earliest, and may spawn before the ice has left the ponds. In England, most of the spawn is laid in the late winter, and in some places it may often be found in February, or even in January (Savage, 1935). It thrives in the Alps, not far below the snow line, where it breeds in June, soon after the snow has uncovered its breeding pools. Both tadpoles and frogs grow there to an unusual size.

An animal which thus exposes its eggs and early tadpoles to temperatures little above those which are lethal is peculiarly sensitive to small differences of temperature. For a summer breeding frog, it can matter little if the temperature drops, say 0.2° C. For a winter breeding animal, this may be all the difference between a lethal temperature and one allowing survival. It is not necessary that an event should occur often for it to be of critical importance for the survival of a species in an area. If for example, a catastrophic drop in temperature occurred only once in a century, re-colonisation of the area thus deprived of frogs might have to take place over distances of hundreds or even thousands of miles, and a century might be all too short a period for this to happen. Were some eggs in the area only a degree or so warmer than the water, some might survive, and spreading would take place from many points within the area.

Besides the stark alternatives of survival or extinction, there may also be lesser advantages in these differences of temperature. The warmer the eggs, the earlier they will hatch. Work which is not yet complete suggests that it may be an advantage for tadpoles to hatch early.

Moore (1940), Douglas (1949) and the writer are in agreement that the globular cluster is an adaptation to cold conditions. Moore and Douglas do not discuss in any detail why they think that this shape is better for cold weather, presumably basing their opinion on the obvious fact that this is the shape which presents the least surface for cooling. The temperature measurements in this paper show that this is only one part of the effect, and that heat generation and storage take place as the result of the physical properties of the jelly, when it is exposed in a natural environment.

Douglas (1949) described the distribution of this and other species of European Anura, including some measurements of the thermal tolerance of the eggs. He concluded, as did Hertwig (1898) that *R. temporaria* is not only adapted to cold conditions but that it is unable to colonise warmer places, because the eggs cannot withstand such high temperatures as are quite suitable for *R. esculenta*. Moore (1940) came to similar conclusions about the North American species which lay their eggs in globular clusters, for example, *R. sylvatica*, *R. palustris* and *R. pipiens*. Unlike Douglas, however, Moore ascribes the inability of the eggs to survive warm conditions to insufficient supplies of oxygen, considering that the embryos inside the cluster have to receive their oxygen by diffusion through about two inches of jelly. When the oxygen requirements are raised by the accelerated development which is induced by the high temperatures, insufficient oxygen diffuses through and irregular development or even death of the embryos is the result. Douglas, on the contrary, specifically states that oxygen requirements were not of importance in his experiments on *R. temporaria*, although it should be noted that he divided up his clusters.

Since the laboratory aspects of this problem have also been studied by chemists, the zoological literature is not a complete guide to the available knowledge. Needham (1931) discusses in detail temperature tolerances, and reactions to abnormal conditions for gaseous exchange, and gives many references to relevant work. In a footnote to Table 68, p. 502, he states, "Hertwig's and King's figures are interesting because *Rana fusca* and *temporaria* lay early in spring when the water is often freezing; *Rana palustris* and *esculenta* later, and *Bufo lentiginosus* later still. Giglio-Tos has emphasised the importance of this in ecology." The figures to which he refers show that '*Rana fusca*'* has a lower optimum and a lower maximum temperature for development than the other species. There are many other parts of this book which have a bearing on the laboratory aspects of this problem. For example, it appears (p. 678) that the irregular development observed by Moore has had much attention, and that although the question is not yet settled, the balance of opinion seems to be that carbon dioxide excess rather than oxygen deficiency may be the responsible factor. There is general agreement that an abnormality of gaseous exchange is involved. Why, then, does it not occur in the field, for clusters in their natural environment are almost always evenly developed? According to Moore, it is because the temperatures in the field at the relevant season are sufficiently low for diffusion of oxygen to be sufficient at the reduced rate of consumption, even for the inner embryos. But Moore did not describe any experiments at low temperatures. In 1938, however (Savage, 1938, p. 474) details of an experiment were described, in which for purely technical reasons eggs were retarded by being kept every night in a refrigerator at about 4° C. and during the day at about 10°-15° C., temperatures rather below those usually prevailing in the ponds. It was found that irregular development occurred unless the egg clump was torn apart. Moreover, the following experiments make it appear doubtful if, under natural conditions, even the centre of the clusters is likely to be short of oxygen, or to accumulate carbon dioxide.

**R. fusca* = *R. temporaria*

An egg cluster of *R. temporaria* was examined under a binocular microscope. It could be seen that there were spaces, roughly triangular in section between the separate envelopes, as would be expected from the fact that the cluster is an assembly of spheres. If these spaces were closely watched, debris, or sometimes swimming animals, could be seen to emerge. It appeared possible that the egg clumps contained channels through which water could circulate. If about one ml. of indian ink is placed on an egg clump with the aid of a pipette, while the clump is floating freely in water, and the subsequent events followed with the microscope or even with the naked eye, the ink can be seen to flow through a network of anastomosing channels. In a very short time, usually about thirty seconds, the ink goes right through, collecting in a pool on the bottom of the vessel, vertically under the point where it enters. It is therefore evident that the clump is freely permeable to currents of water, provided that the conditions are such that these will be induced. If the American species of *Rana* which have egg clusters like those of *R. temporaria* in outward appearance, also resemble this species in the possession of these "intercapsular channels," then Moore's conclusion that the inner embryos may be two inches from a supply of oxygen is incorrect—the real distance is 2 or 3 mm. And yet the conclusion that embryos in thermostats often suffer from lack of sufficient gaseous exchange is, as previously stated, accepted. What then is the explanation of the irregular development in thermostats? It is probably that the conditions in a thermostat do not allow the intercapsular channels to function. Moore used a thermostatically controlled room for his experiments. The better a thermostat, the more completely is convection abolished. He covered the eggs with "just sufficient water." This may have hindered the circulation of the water by closing the lower ends of the channels. He makes no mention of mechanical agitation, yet in a pond, wind action is usually sufficient to agitate the surface of the water, and thus impart an oscillation to the clumps, which seems likely to produce a bellows action within the clump, sucking and expelling water from the channels. Unless the clumps were irradiated, differences of temperature produced by the effect described in this paper would not be set up, and convection from this cause would not be present. On the whole the experimental conditions departed very much from those of the natural environment. The most probable explanation of the irregular development of frog's eggs in a thermostat is that it is a laboratory artefact caused by the cessation of water currents through intercapsular channels.

If this is the correct explanation, then it is possible that in the natural state, even the inner embryos in the globular clusters always have enough opportunities for gaseous exchange, in spite of the occurrence of higher temperatures than normal. In the 1949 season, the temperature of some ponds exceeded 21° C. for a time, but the eggs developed normally. Eggs collected and placed in a small dish at temperatures of between 16° and 21° C. developed irregularly. It seems doubtful if the southern limits of distribution are set by difficulties in gaseous exchange, a direct thermal effect being more probable.

SUMMARY

It has been shown that the jelly of the egg of *R. temporaria* is a substance having remarkable properties. It consists almost entirely of water, and so has many of the unique properties of water, but being a true solid, altogether lacks convection currents. The result is that radiation falling on the black embryonic body at the centre is converted into heat which is dissipated with exceptional slowness. Natural egg masses, together with artificial jellies, when they are exposed to intermittent radiation, are maintained at a higher average temperature than similar masses of water. Field observations confirm that the egg clumps are generally warmer than the water which surrounds them, a difference of 2° C. being sometimes observed. The average difference is 0.63°. It is suggested that in a species of animal which breeds so early in the year that temperatures below freezing point may sometimes occur after the eggs are laid, quite small differences of temperature may be of great importance to the species, enabling some eggs to survive what would be otherwise catastrophic climatic conditions. *R. temporaria* inhabits the colder parts of Europe, and ranges up to the summer snow line in the mountains. The heat conserving jelly, the globular egg cluster and the habit of mass spawning may all contribute to the ability of the frog to survive in these places.

It has been found that the egg cluster contains a system of anastomosing channels, which may be called the "intercapsular channels." Ink placed on the upper surface of a clump rapidly flows vertically through the mass, and in a few seconds, appears below. It is suggested that the existence of these channels explains how it is that in the field, the embryos in different parts of the mass develop at the same rate, but that in thermostats, where the currents of water are prevented from circulating in the intercapsular channels, irregular development often occurs. It is probably through these channels that the tadpoles make their way to the surface so soon after they hatch.

The results of Moore (1940) are considered in the light of these observations. He concluded that the globular cluster is an adaptation to cold weather. It is thought doubtful, however, in view of the existence of the intercapsular channels, which appear not to have been observed before, whether lack of oxygen sets a southern limit to the distribution of those species of *Rana* which have this type of egg mass. It is thought that a direct temperature effect, such as is suggested by Douglas (1949) is more likely. Irregular development is probably a laboratory artefact.

TABLE 1

Temperatures in two beakers, one filled with water, and the other with an equal volume of eggs, killed by heat. Intermittent exposure to radiation from a 60 watt lamp.

Time	Light on or off.	Temperatures °C.		
		Eggs.	Water.	Difference.
07.00	On	8.90	8.75	+0.15
07.50	On	9.95	9.25	+0.70
08.30	Off	9.85	9.60	+0.25
06.50	On	9.35	9.15	+0.20
07.50	Off	9.95	9.85	+0.10
10.45	Off	9.55	9.15	+0.40
Ink added to water.				
18.45	On	8.35	8.30	+0.05
13.45	On	9.70	9.70	+0.00
18.00	On	11.25	11.30	-0.05
18.45	Off	11.65	11.75	-0.10
19.45	Off	11.65	11.95	-0.20
22.10	Off	11.05	10.75	-0.30
22.35	Off	11.00	10.70	+0.30
08.15	Off	10.75	9.95	+0.80
20.00	On	12.60	12.50	+0.10
20.15	On	12.60	12.60	±0.00
20.30	On	12.70	12.80	-0.10
20.45	On	12.85	12.90	-0.05
23.10	On	12.45	13.40	+0.05

TABLE 2

Temperatures, measured by two thermometers, each with the bulb blackened and immersed in a 15% gelatin gel, and in water respectively, contained in boiling tubes, having the same volume. Illuminated by a 100 watt lamp.

Time	Light on or off.	Temperatures °C.		
		Jelly.	Water.	Difference
19.47	On	9.70	9.65	+0.05
19.52	On	11.20	11.05	+0.15
19.57	On	12.15	11.90	+0.25
20.02	On	12.95	12.65	+0.30
20.07	Off	13.55	13.20	+0.35
20.12	Off	12.25	12.95	+0.30
20.17	Off	12.90	12.60	+0.30
20.22	Off	12.55	12.35	+0.20
20.27	On	12.30	12.15	+0.15
20.32	On	12.95	12.70	+0.25
20.37	On	13.60	13.30	+0.30
20.42	On	14.30	13.90	+0.40
20.47	Off	14.85	14.40	+0.45
21.07	On	13.20	12.95	+0.35
21.27	Off	15.45	14.85	+0.60
21.58	On	12.80	12.60	+0.20

The experiments were repeated with similar results.

TABLE 3

Temperatures in egg clusters and in the water alongside. Field observation.

Pond.	Date	Time	Temperature °C.			Notes.	
			In eggs	In water	Difference		
Green Street	19.3.39	15.30	7.9	7.2	+0.7	Cold north wind, occasional showers dull.
				8.3	7.2	+1.1	
				7.8	7.8	±0.0	
				8.0	7.2	+0.8	
				8.1	7.1	+1.0	
West Railway, Ditch ...	West ...	19.3.39	16.00	6.5	5.9	+0.6	Isolated clump.
				6.1	5.9	+0.2	
				6.4	5.9	+0.5	
				6.6	5.95	+0.65	
				5.2	5.4	-0.2	
Battlers Green	19.3.39	—	5.9	5.5	+0.4	New laid clump.
				5.9	5.7	+0.2	
				6.0	5.3	+0.7	
				5.6	5.2	+0.4	
				5.0	4.9	+0.1	
Green Street	21.3.39	21.15	5.3	5.2	+0.1	A night visit. Temperature at top of clump, 3.4, at bottom 6.0. Water, 5.2 at bottom among weed, 4.7 at top. Soon after dawn. Heavy rain at dawn, clear with sun when readings were made.
				5.2	4.9	+0.3	
				5.5	5.2	+0.3	
				5.9	5.0	+0.9	
				5.9	5.0	+0.9	
Green Street	22.3.39	08.15	6.7	5.6	+1.1	3 clumps. Windy. Air, 5.8.
				6.3	5.9	+0.4	
				6.1	6.1	±0.0	
				6.2	5.9	+0.3	
				8.7	7.8	+0.9	
Garden	25.3.39	—	8.3	7.8	+0.5	
				9.0	7.8	+1.2	
				10.25	10.4	-0.15	
Palmate newt	26.3.39	—	10.25	10.15	+0.10	
				9.75	10.10	-0.35	
				9.90	9.90	0.0	
Green Street	25.3.39	—	13.0	12.7	+0.30	9.5 under weed mat at bottom.
				12.90	12.7	+0.2	
Garden	25.3.40	15.45	14.5	14.0	+0.5	
				18.10	13.6	+0.5	
Garden	16.3.41	—	9.0	8.85	+0.15	Water cloudy.
				8.6	8.75	-0.15	
				8.7	8.7	+0.0	
Garden	17.3.41	—	6.7	6.2	+0.5	Water cloudy.
				5.9	6.0	-0.1	
				5.9	5.8	+0.1	
Garden	18.3.41	—	1.1	1.0	+0.1	Water cloudy.
				1.0	1.4	-0.4	
				1.5	1.4	+0.1	
				6.6	6.9	-0.3	
				12.8	12.5	+0.3	
Bentley Heath Village	—	—	12.8	12.5	+0.3		
Bentley Heath Church	—	-19	19.0	17.0	+2.0		

Pond.	Date	Time	Temperature °C.			Notes.	
			In eggs	In water	Difference		
Lower Parkfield	...	—	11.0	11.0	+0.0	In shade.	
Lower Parkfield	...	—	11.75	11.5	+0.25		
Dagger Lane	3.4.48	16.00	12.5	10.5	+2.0	Some spawn hatched. Sunny, cold wind.
				12.0	10.5	+1.5	
				12.0	10.5	+1.5	
				12.5	10.5	+2.0	
				15.0	15.0	+0.0	
Bluebell Wood	3.4.48	—	14.0	13.0	+1.0	
				14.0	13.0	+1.0	
				9.2	9.6	-0.4	
Bentley Heath Village	...	5.4.48	19.00	9.6	9.6	±0.0	The first two clumps had been almost destroyed by moorhens, The third was freshly laid.
				9.6	9.6	±0.0	
				10.0	9.6	+0.4	
Bentley Heath Church	...	5.4.48	19.30	10.5	10.5	±0.0	Spawn completely destroyed by moorhens, and a mere film on the water.
Upper Parkfield	...	5.4.48	—	9.6	9.5	+0.1	Spawn deep owing to recent rain after drought.
Lower Parkfield	5.4.48	—	9.6	9.3	+0.3	The first four were under duckweed cover. The last two were not.
				9.6	9.2	+0.4	
				9.3	9.1	+0.2	
				8.5	9.0	-0.5	
				7.6	7.2	+0.4	
Bentley Heath Church	...	26.3.49	—	8.6	7.5	+1.1	The last entry is from the centre clump.
				21.2	19.5	+1.7	
				20.5	19.8	+0.7	
				20.6	17.8	+2.8	
				21.5	19.5	+2.0	
Bentley Heath Village	...	26.3.49	—	19.2	17.5	+1.7	
				21.5	—	—	
				16.5	14.5	+2.0	
				14.5	13.5	+1.0	
				16.0	14.5	+1.5	
Hospital Pond	...	26.3.49	—	15.5	15.2	+0.3	An exceptional number of clusters estimated at 2000. All on the bottom, not floating.
				14.6	14.5	+0.1	
				13.8	13.5	+0.3	
				14.5	15.5	+1.0	
				14.0	13.6	+0.9	
				13.5	13.2	+0.3	

Mean difference in temperature between spawn and water: 0.63° C.
Number of positive differences: 63. Number of negative differences: 10.

BIBLIOGRAPHY

- (1) Douglas, R. (1949). Temperature and Rate of Development of the Eggs of British Anura. *J. Anim. Ecol.* 17. 189-192.
- (2) Hertwig, O. (1898). Ueber den Einfluss der Temperatur auf den Entwicklung von *Rana fusca* und *Rana esculenta*. *Arch. Mikr. Anat.* 51. 319-81.

- (3) Moore, J. (1940). Adaptive differences in the Egg Membranes of Frogs. Amer. Nat. LXXIV 89-93.
- (4) Needham, J. (1931). Chemical Embryology. Cambridge Univ. Press,
- (5) Savage, R. M. (1935). The Influence of External Factors on the Spawning Date and Migration of the Common Frog, *Rana temporaria temporaria* Linn. Proc. Zool. Soc. 49-98.
- (6) Savage, R. M. (1937). The Ecology of Young Tadpoles, with Special Reference to the Nutrition of the Early larvæ of *Rana temporaria temporaria* Linn, *Bufo bufo bufo* Linn, and *Bombina variegata variegata* Linn. Proc. Zool. Soc. Ser. A, 249-260.
- (7) Savage, R. M. (1938). The Ecology of Young Tadpoles, with Special Reference to Carbohydrate Changes in Development, and to the Function of the Envelope. Proc. Zool. Soc. Ser. A, 465-480.

Duration of life in *Rana temporaria* Linn.

By

M. A. WILSON, M.Sc., Ph.D.

It has recently (Smith, 1949) been emphasised how little is known of the growth and duration of life of the Common Frog. The only record I have found of its having been reared from the egg to near maturity is that of Flower (1936). He also mentioned some specimens which a correspondent had succeeded in keeping longer. Photographs of these have been published (Wilson, 1937) and a fuller description follows.

The frogs were reared by Miss R. E. Purdey, formerly on the staff of the Public Central Girls' School, Plymouth, and sometime Secretary of the Plymouth and District Field Club, to whom I am indebted for the particulars on which this account is based.

Spawn was obtained in March, 1930, from the Plymouth area and metamorphosis took place in June. Four of the small frogs were retained, and kept at first in a glass bowl, later in a wooden packing case containing a dish of water and leaves (generally ferns) but no earth. After metamorphosis they were fed on green-fly (*Aphis*), the nymphs of cuckoo-spit (*Philaenus*) and earthworms, and in later years on slugs, caterpillars and larger earthworms. The frogs were kept almost entirely indoors and did not hibernate, although they ate little in winter. Probably the room temperatures were too high for hibernation, which according to Barthélémy (1926) only takes place below 8-10° C.

In 1931 it was possible to identify their sexes, three being female and one male. The latter, which grew faster than the females, began to croak in August, 1931, and had developed nuptial pads by January, 1932. In March, 1933, all the females spawned, but the eggs proved infertile. The following March only two spawned and again the eggs were infertile. During all this period no mating was observed although the male was capable of the nuptial embrace; the females appeared to avoid him by keeping still

when he moved in their direction, but on one occasion he seized a female by the ventral surface*; she was artificially released from amplexus.

The two specimens which spawned in 1934 died shortly afterwards, one in April, the other in May. Although Flower (personal communication) assured Miss Purdey that in nature female frogs do not usually die after spawning, she was impressed by their weakness and relatively great loss of weight (see Table).

The remaining female died in August, 1938, when nearly 8½ years old. She had only spawned once; again temperature conditions may explain this since Barthélémy (1926) found a certain degree of winter cold necessary for the maturation of the female of this species (*Rana fusca* = *R. temporaria* L.).

The male continued in normal health until the end of 1941, when he appeared to have difficulty in seeing moving prey and less power to grasp it. He died in April, 1942, at an age of 12 years 1 month, the longest life recorded for *R. temporaria*.

Some data of the growth and life history of these frogs are given in the following table.

Spawn obtained 1930, Metamorphosis June, 1930	Jan.	Feb.	Feb. 1933	March 1933	Feb. 1934	1935-1942		
	Length	Length	Length	Wt.	Length	Length	Wt.	
MALE (croaking Aug., 1931; nuptial pads Jan., 1932)	65	68	75	42	—	79	80	varied from 29 to 49 (died April, 1942.)
FEMALE 1	63	67	75	43	28.5	80	80	varied from 42.5 to 71 (died Aug., 1938).
FEMALE 2	62	67	73	43	28.5	80 (spawned March 1934; died April, 1934)	—	—
FEMALE 3	40	47	71	42.5	28	76 (spawned March 1934; died May, 1934)	—	—

Length from nostril pad to end of body in mms.

Approximate wt. in gms. (converted from oz. on a letter-balance).

*According to Savage (1934) a ripe female held thus does not struggle, but feigns death until the embrace is released. In one instance this was not till 2 hours later.

Specimens described by Flower (1936) as reaching an age of 4 years were smaller in size and had slower growth rates. The same applies to a male frog which a Plymouth schoolboy (Paul Jeffery, personal communication) has reared from the egg: when nearly 2 years old it was 56 mm. long, a year later 60 mm.; now (October 1949) it is 70 mm. and 7½ years old.

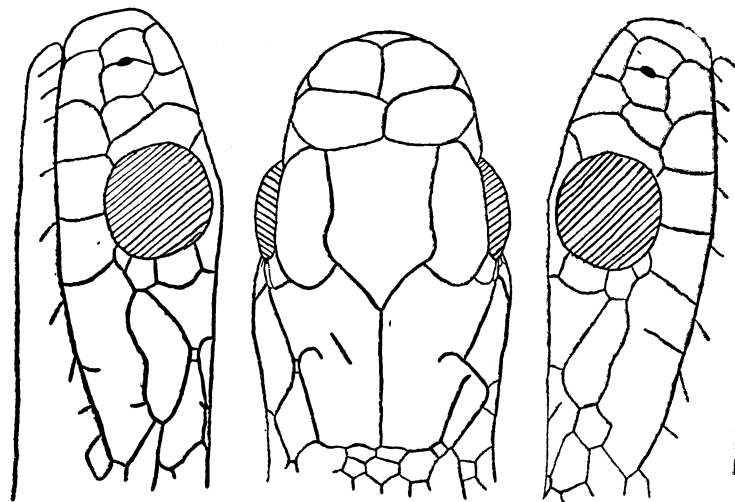
REFERENCES

- Barthélémy, H. (1926). Recherches biométriques et expérimentales sur l'hibernation, la maturation et la surmaturation de la Grenouille rousse ♀ (*Rana fusca*). Compt. Rend. Acad. Sci. 182 ; 1653-1654.
- Flower, S. S. (1936). Further Notes on the Duration of Life in Animals. II. Amphibians. Proc. Zool. Soc. Lond.; 369-394.
- Savage, R. M. (1934). The Breeding Behaviour of the Common Frog, *Rana temporaria temporaria* Linn., and of the Common Toad, *Bufo bufo bufo* Linn. Proc. Zool. Soc. Lond.; 55-70.
- Smith, M. (1949). British Reptiles and Amphibia. Penguin Books. Harmondsworth, Middlesex.
- Wilson, M. A. (1937). "Water-Life" 3; 169.

NOTES

ABNORMAL HEAD SQUAMATION IN *NATRIX NATRIX*

Through the kindness of Dr. Angus Bellairs I received the head of a new hatched grass snake fixed in Kolmer's fluid for histological study of the retina. The head showed a number of abnormal features of the squamation, which are here figured. There is disorganisation of the sutures of the last three supralabials, the temporals and the parietals. A feature which I have not seen before is an incomplete suture in isolation, as is present on the left hand parietal. There is a fair measure of symmetry to the abnormalities which suggests that they may have a genetical basis. Since the embryo normally lies on its left side a derangement due to some extraneous influence during development would I imagine be likely to produce a more markedly asymmetrical abnormality. Klauber (1945) found statistically significant bilateral asymmetry in the head squamation in collections of several different species of snakes. This could perhaps be attributed to the fact that the conditions within the egg are not exactly the same for the two sides of the head. The underside of the head showed four infralabials meeting the anterior genial, a common enough variation. (For a figure of the normal head squamation see Boulenger (1913) or Angel (1946). GARTH UNDERWOOD, Dept. of Zoology, University College of the West Indies, Mona, Jamaica, B.W.I.



- Boulenger, G. A. (1913). The Snakes of Europe. London.
- Angel, F. (1946). Faune de France. Reptiles et Amphibiens. Paris.
- Klauber, L. M. (1945). Herpetological Correlations I. Correlations in Homogeneous Populations. Bull. Zool. Soc. San Diego No. 21.

ANIMAL AND PLANT INTRODUCTIONS IN THE THORNE
DISTRICT, YORKSHIRE

Under the above heading the following note appeared in the October-December issue of "The Naturalist" for 1949 and is of interest to members of this Society.

I wish to notify that I have introduced the following into various localities.

Rana esculenta (Edible Frog). Eight pairs taken from around Ham, near Teddington, introduced into suitable waters near Thorne.

Rana ridibunda (Marsh Frog). Eight pairs taken from around Appledore and Romney, Kent. Introduced into unfished waters at Thorne.

Bufo calamita (Natterjack). Four pairs purchased from a dealer; introduced into disused sand-pits in the vicinity of Finningley.

Lacerta agilis (Sand Lizard). Taken from round Christchurch, Dorset. Seventeen lizards, including nine heavy with eggs; released on sandy wastes round Dunscroft, near Doncaster.

W. BUNTING

Other introductions are *Helix pomatia* (Roman Snail), *Hydrophilus piceus* (Giant Water Beetle), and *Drosera longifolia* (Long-leaved Sun-dew).

SCALE VARIATION IN THE SMOOTH SNAKE,
CORONELLA AUSTRICA LAURENTI.

A male smooth snake from Willis Down, Bournemouth, was presented to the British Museum of Natural History in 1949 by Lt.-Colonel F. C. Fraser. This specimen, normal in other respects, was found to have a number of single subcaudal scales instead of the usual pairs. As far as is known this is the first record of such variation in these snakes. Examination of 90 specimens in the Museum's collection showed this variation to be present in 4 specimens.

Counting the subcaudal scales from the vent towards the tail tip the variations are :—

Male. Austria. 3rd subcaudal scale single.

Very young. Austria. 18th-20th subcaudal scale single.

Male. Germany. 10th, 13th, 15th-22nd, 24th-25th subcaudals single.

Male. Willis Down, Bournemouth. 10th-12th, 14th-20th, 22nd-23rd subcaudals single.

The geographical composition of the series of specimens (numbers in brackets) in the British Museum is :—England (13), France (11), Belgium (5), Germany (8), Italy (5), Austria (23), Roumania (10), Bulgaria (2), Spain (6), Yugo-Slavia (2), Russia (2), Turkey (2), Greece (1).

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