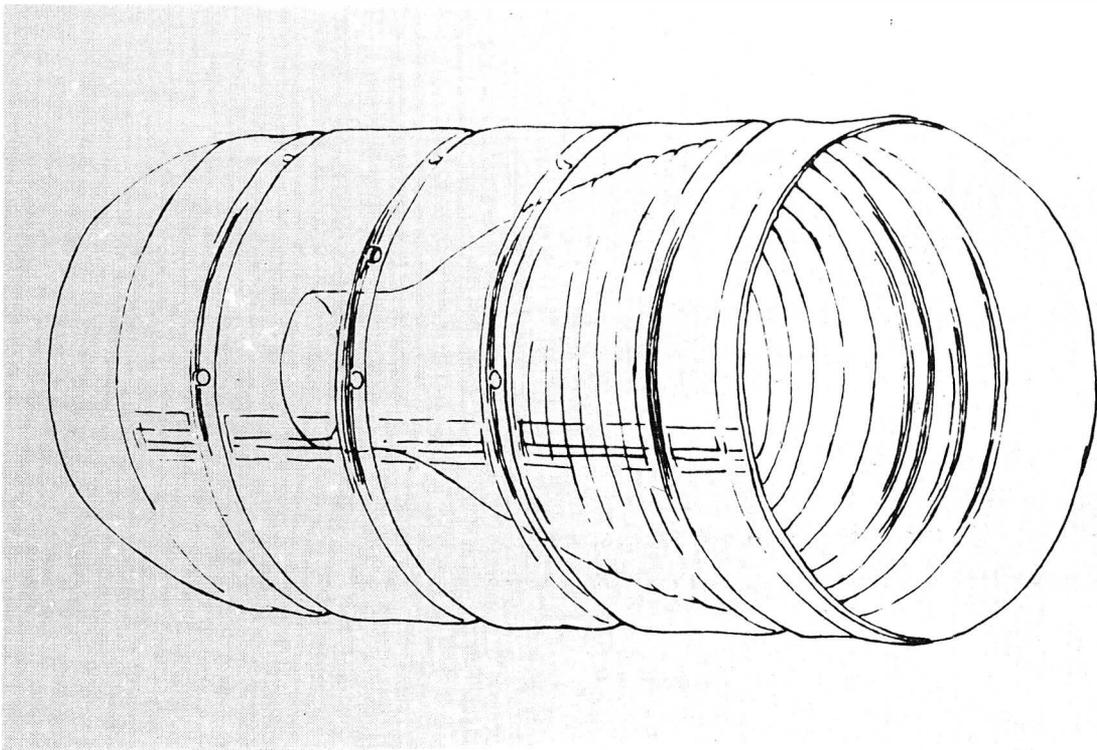


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## A SIMPLE FUNNEL TRAP FOR STUDYING NEWT POPULATIONS AND AN EVALUATION OF TRAP BEHAVIOUR IN SMOOTH AND PALMATE NEWTS, *TRITURUS VULGARIS* AND *T. HELVETICUS*

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### ABSTRACT

A simple funnel trap constructed from a plastic squash bottle is described. The efficiency of trapping compared to netting and torch-surveying was investigated in *Triturus vulgaris* and *T. helveticus*. In terms of newts detected per man-hour, trapping and torch-surveying were about twice as effective as netting, but produced male biases in both species. Male smooth newts were more trap-prone than male palmates. Traps containing a newt were no more or less attractive to other newts than empty traps. Newts with previous experience of a trap were no more or less trappable than those without trap experience.

### INTRODUCTION

Methods for studying populations of aquatic newts (*Triturus* spp) have, in the main, employed netting, torch-survey or trapping techniques. Dip-netting from the pond bank is probably the most widely used method and can be standardized if carried out for a set period of time or using a set number of sweeps (e.g. Cooke and Frazer, 1976; Cooke, Scorgie and Brown, 1980). It suffers from the disadvantage, however, of causing disturbance to both animals and vegetation and is of little use in attempting to assess distribution patterns within the water column. Searching pond edges after dark by torch-light is often a reliable method for revealing the presence or absence of newts (e.g. Frazer, 1978; Beebee, 1979; Griffiths, 1984), and may be semi-quantitative if search effort per stretch of pond bank is standardized. However, identification in poor light of newt species and sex, often at a distance of a metre or so, generally requires some expertise on the part of the observer. Moreover, this method is of little use in ponds which are steep-sided, turbid or with luxuriant stands of marginal vegetation.

Funnel traps have been used by a number of authors in previous studies of newt ecology (e.g. van Gelder, 1973; Bell, 1977; Dolmen, 1983). A number of different designs have been employed, including bownets (van Gelder, 1973) and fry traps (Dolmen, 1983). Inasmuch as the method requires newts to enter traps of their own accord, trapping is more dependent upon newt behaviour than either netting or torch-survey methods. Animals may become trap-shy or trap-prone, and differences in behaviour at both sex and species levels may therefore result in catch biases which can complicate studies of population ecology.

This paper describes a cheap, simple funnel trap which has been used extensively in ecological studies of newts (*T. vulgaris* and *T. helveticus*) in mid-Wales. Natural trappability in smooth and palmate newts and the effects of previous trap experience on trap behaviour were investigated experimentally under field and laboratory conditions.

### THE TRAP

Each trap was constructed from a 1 litre plastic squash bottle. The bottle was cut into two halves by a circular incision at the point where it begins to taper towards the neck. The screw-top was then cut off and the top (funnel) half inverted into the bottom half to form the trap (Fig. 1). Paper clips may be used to hold the funnel in place. A series of holes were punched into the trap to allow expulsion of air when sinking it into water. When placed in the pond, each trap was tied to a stick to prevent drifting and to mark its position.

### FIELD EXPERIMENTS

#### COMPARISON OF TRAPPING, NETTING AND TORCH-SURVEY TECHNIQUES

*Methods.* A comparison of the efficiency of these three methods in detecting newts was conducted in Llysdyman pond, Powys, in April and May 1984. A description of this site is provided by Harrison, Gittins and Slater (1983).

Commencing on the 4th April 1984, 48 funnel traps were placed in the pond at 2100 hr and emptied at 0900 hr the following morning. The traps were positioned so that all areas and depths of the pond were sampled. Around the pond margin traps were positioned so that the funnel entrance faced towards the pond centre. Areas of 0.5 m depth or over were monitored by using two or three traps suspended on a string. These were arranged so that the top trap lay just below the pond surface with the bottom trap, which was weighted, resting on the pond floor. Each 12 hr trapping programme was conducted at weekly intervals until 30th May. Due to parts of the pond drying out, the number of traps used was reduced to 36 from 16th-30th May. The total time spent placing traps out, and emptying and collecting traps, was about 45 min per week.

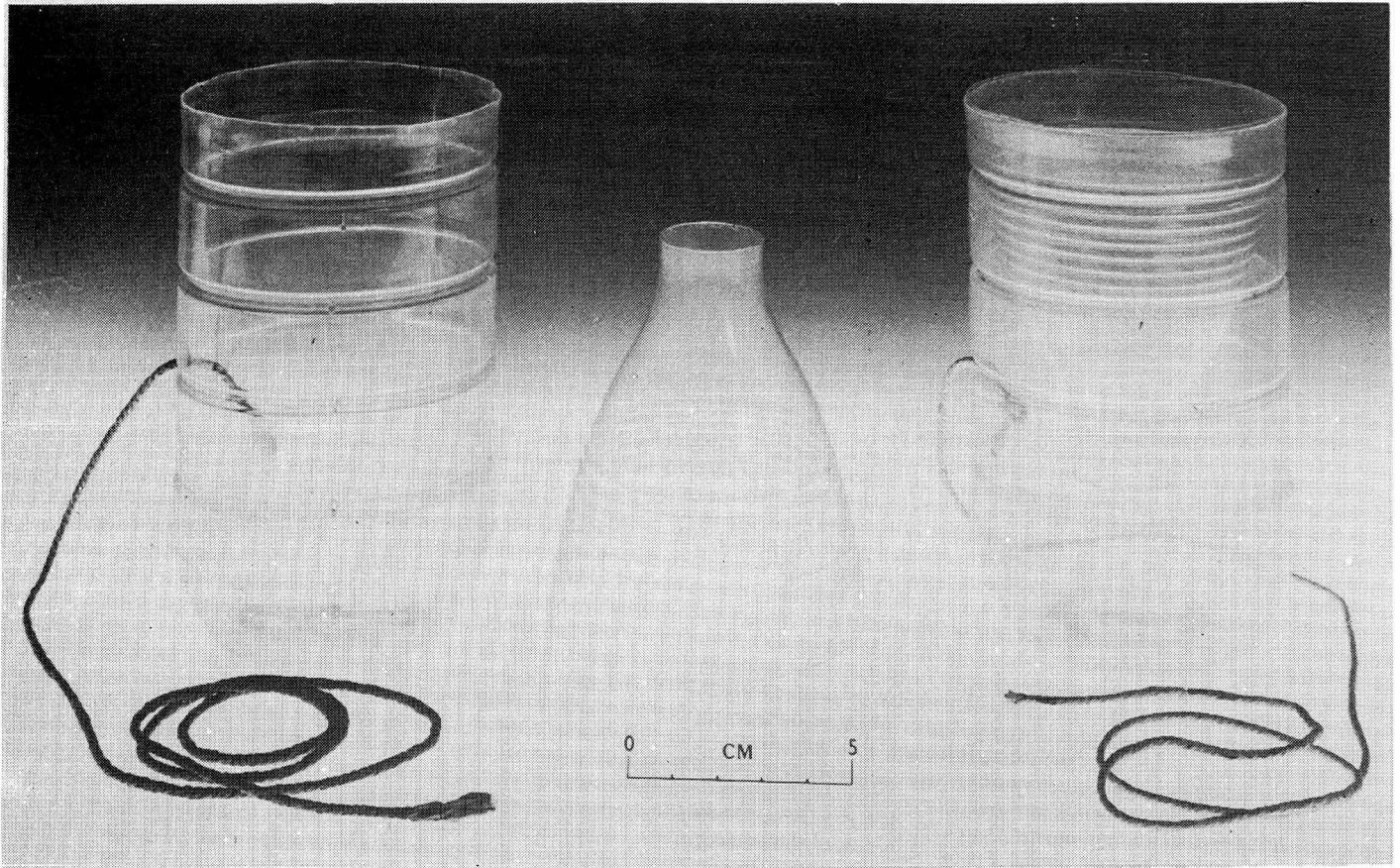


Fig. 1 The squash bottle funnel trap. Trap with funnel removed (left), and trap with funnel in place (right).

Daytime netting sessions were also carried out at weekly intervals during the two-month study period. These were usually conducted 1-2 days after trapping. Each area of the pond where traps had previously been placed was surveyed with three sweeps of a dip-net (approx. 1 mm mesh). Total netting time was about 15 min.

As a result of seasonal changes in turbidity and vegetation cover, it was not possible to carry out a reliable torch-survey on a regular basis. Data for only one evening, 24th April, is therefore included. On this date the water was clear and 30 per cent of the available shoreline was relatively free of emergent vegetation. With the aid of a powerful torch, the newts observed along this shoreline between 2030 and 2100 hr were counted and identified without removing them from water.

*Results.* With 36-48 traps, overnight trapping in April and May produced a total newt catch which was over four times as high as that obtained by netting during the same period (Table 1). A total of 2.25 hr of netting, however, produced only twice as many newts as a single 30 min torch-survey. The proportions of each species and sex captured also varied according to the method used. Thus female *T. helveticus* constituted almost 50 per cent of the newt sample captured by netting, but only about 13 per cent by trapping or torch-surveying. Likewise male *T. vulgaris* made up 30-40 per cent of the newts counted by trapping and torch-surveying, but only about 12 per cent by netting. Both trapping and torch-surveying produced more males than females in both species.

	Male <i>T. vulgaris</i>	Female <i>T. vulgaris</i>	Male <i>T. helveticus</i>	Female <i>T. helveticus</i>	Total	Newts/ Man-Hr
Trapping	184 (40.4%)	38 (8.4%)	173 (38.0%)	60 (13.2%)	455	67.4
Netting	10 (11.5%)	7 (8.0%)	28 (33.2%)	42 (48.3%)	87	38.7
Torch-Survey	12 (32.5%)	3 (8.1%)	17 (45.9%)	5 (13.5%)	37	74.0

TABLE 1. Comparison of numbers of *T. vulgaris* and *T. helveticus* detected in Llysdinam pond using three different techniques. The numbers represent total newts detected by overnight trapping (36-48 traps, 45 min to place and empty traps) and daytime netting (15 min) over nine weeks commencing first week in April 1984, and during a single 30 min torch-survey on 24th April. Figures in parentheses represent percentage of total catch using that method.

EFFECT OF TRAPPED NEWTS ON TRAP RESPONSE

*Methods.* These experiments set out to test the hypothesis that a newt already captured attracts other newts towards that trap. Two traps, one empty and one baited with 'a newt, were placed side-by-side in the pond at 2100 hr and emptied at 0900 hr the following morning. The experiment was repeated with the positions of baited and unbaited traps reversed to avoid complications arising from natural directional preferences. Four pairs of traps were used in each experiment. Four sets of experiments were conducted in two ponds, during April and May 1984, as follows: *Llysdynam Pond* (Contains both *T. vulgaris* and *T. helveticus*):

mid-Wales. In the laboratory newts were subject to natural light-dark cycles via a large window. All newts were in breeding condition and kept at a water temperature of  $14 \pm 2^\circ\text{C}$ . Experiments were conducted between April and June 1984.

EFFECT OF PREVIOUS TRAP EXPERIENCE ON TRAP RESPONSE

*Methods.* Newts were placed singly in plastic aquarium tanks (30 cm long, 22 cm wide, 20 cm deep) two-thirds filled with water. A funnel trap was then placed in each tank and the newts left for 12 hr from 0900 to 2100 hr. Those animals which entered traps during this period of time (i.e. trap-conditioned newts) were released and

	Traps baited with male	<i>T.h.</i>	Traps unbaited	Traps baited with female	<i>T.h.</i>	Traps unbaited
No. <i>T. helveticus</i> captured	10 (5:5)		24 (16:8)	29 (21:8)		20 (16:4)
$\chi^2$		5.76		1.65		
<i>P</i>		<0.025		>0.1		

TABLE 2. The influence of trapped newts on trap attractivity in Bufton's pond (*T. helveticus* only). Figures in parentheses represent *no. males: no. females*. Total no. newts in baited traps: total no. newts in unbaited traps was tested for deviation from a 1:1 result using  $\chi^2$  assuming 1 d.f. The original newt used as bait was not included in the totals.

	Traps baited with male	<i>T.v.</i>	Traps unbaited	Traps baited with female	<i>T.v.</i>	Traps unbaited
No. <i>T. vulgaris</i> captured	8 (7:1)		9 (8:1)	11 (8:3)		7 (4:3)
$\chi^2$		0.06		0.89		
<i>P</i>		>0.5		>0.1		
No. <i>T. helveticus</i> captured	22 (19:3)		18 (14:4)	10 (6:4)		6 (4:2)
$\chi^2$		0.4		1.0		
<i>P</i>		>0.5		>0.1		
Total <i>T. vulgaris</i> + <i>T. helveticus</i>	30 (26:4)		27 (22:5)	21 (14:7)		13 (8:5)
$\chi^2$		0.16		1.89		
<i>P</i>		>0.5		>0.1		

TABLE 3. The influence of trapped newts on trap attractivity in Llysdynam pond (*T. vulgaris*+*T. helveticus*). Legend as Table 2.

- (1) Trap baited with one male *T. vulgaris*.
  - (2) Trap baited with one female *T. vulgaris*.
- Bufton's Pond* (Contains *T. helveticus* only):
- (3) Trap baited with one male *T. helveticus*.
  - (4) Trap baited with one female *T. helveticus*.

*Results.* There was no evidence that a trap already containing a newt was any more attractive to other newts than an empty trap (Tables 2-3). This was the case in both smooth and palmate newts and with traps baited with males or females. In fact, in one experiment at Bufton's pond the empty trap appeared to be more attractive to palmate newts than the trap baited with a male palmate.

LABORATORY EXPERIMENTS

All smooth and palmate newts used in the following laboratory experiments were obtained from sites in

retested for a second 12 hr period from 2100 to 0900 hr. Control experiments were conducted by placing a second group of newts in tanks without traps for 12 hr (trap-unconditioned newts), and then testing their response to traps during a second 12 hr period in the same way as trap-conditioned animals. To avoid complications arising from diel changes in trap behaviour, the experiment was repeated with the conditioning period from 2100-0900 hr, and the testing period from 0900-2100 hr. A total of 32 newts were used in each experimental and control group. This number was made up of 16 *T. vulgaris* and 16 *T. helveticus*, with equal numbers of each sex.

*Results.* Newts with previous trap experience did not differ from newts lacking previous trap experience in their subsequent behaviour towards traps. In neither smooth nor palmate newts was there any significant

association between previous experience and subsequent trap behaviour (Table 4). Moreover, re-organising the data by sex rather than species also failed to reveal any such association, as did pooling data from both species and both sexes.

#### SPECIES AND SEX DIFFERENCES IN TRAP RESPONSE

*Methods.* This experiment set out to investigate differences in trap response using controlled numbers of animals in a laboratory "pond". This consisted of an opaque plastic tank (70 cm long, 50 cm wide, 23 cm deep) filled with water to a depth of 10 cm. Newts were introduced to the tank at least 12 hr before experiments commenced. Three experiments were conducted using the following combinations of animals:

- (1) 10 male + 10 female *T. vulgaris* (experiment conducted three times).
- (2) 10 male + 10 female *T. helveticus* (experiment

conducted three times).

(3) 5 male + 5 female *T. vulgaris* + 5 male + 5 female *T. helveticus* (experiment conducted 6 times).

At 1800 hr 4 traps were placed in the tank, one in each corner, all facing towards the centre. Two hours later the contents of the traps were checked. The dusk test period of 1800-2000 hr was used because both species appear to display a crepuscular activity pattern (Griffiths, unpublished).

*Results.* In both single species and mixed species experiments there were no significant differences in trappability between the sexes in either smooth or palmate newts (Table 5). Moreover, there were also no significant differences in trappability between males of the two species, or between females of the two species. The presence of the other species did not affect the trap response of either smooth or palmate newts (smooth:  $\chi^2 = 0.002$ ,  $P > 0.5$ ; palmate:  $\chi^2 = 0.94$ ,  $P > 0.1$ ).

	SMOOTH		PALMATE		MALE		FEMALE	
	prev. trapped	prev. not trapped						
No. newts in trap	11	8	11	11	9	10	13	9
No. newts out trap	5	8	5	5	7	6	3	7
$\chi^2$	1.17		0.0		0.13		2.33	
<i>P</i>	>0.1		>0.9		>0.5		>0.1	

TABLE 4. Effect of previous trap experience on trap response.  $\chi^2$  values refer to each 2x2 contingency table. Equal numbers of each sex were used in the "smooth" and "palmate" tables, and equal numbers of each species in the "male" and "female" tables. Pooling the data from both species and both sexes also failed to reveal any significant association between previous experience and subsequent behaviour ( $\chi^2 = 0.61$ ,  $P > 0.1$ ).

	<i>T. vulgaris</i>		<i>T. helveticus</i>		<i>T. vulgaris</i> + <i>T. helveticus</i>			
	male	female	male	female	male <i>T.v.</i>	female <i>T.v.</i>	male <i>T.h.</i>	female <i>T.h.</i>
Total No. newts used	30	30	30	30	30	30	30	30
Total No. newts in traps	20	18	13	12	17	15	10	16
$\chi^2$	0.11		0.04		0.12		1.38	
<i>P</i>	>0.5		>0.5		>0.5		>0.1	

TABLE 5. Species and sex differences in trap behaviour in the laboratory "pond". Scores were tested for deviation from a 1:1 result using  $\chi^2$  assuming 1 d.f. Comparing trappability of the two species: males,  $\chi^2 = 1.8$ ,  $P > 0.1$ ; females,  $\chi^2 = 0.03$ ,  $P > 0.5$  (mixed species experiment).

## DISCUSSION

In terms of newts detected per man-hour, both trapping and torch-surveying were about twice as efficient as netting in Llysdynam pond. In both *T. vulgaris* and *T. helveticus*, however, a male bias was observed using trap and torch-survey methods. Female newts may prefer well-weeded areas of the pond (Frazer, 1978; Cooke *et al.*, 1980) and consequently be under-recorded by torch-surveying. Moreover, in searching for mates, male newts may be more active than females during the breeding period and consequently enter traps more frequently. In the laboratory "pond", however, no such male bias was observed. This discrepancy may be explained by the fact that in the laboratory "pond" (which lacked vegetation and contained equal numbers of each sex) male newts did not have to search so actively to find females, and consequently a lower proportion entered traps than under natural conditions.

Bell (1977) also observed that trapping produces a male biased sex ratio in *T. vulgaris*. Assuming that netting produces an unbiased sex ratio, he proposed that trap ratios (i.e. males/total) be multiplied by 0.63 to obtain the true sex ratio. Applying this correction factor to the present trap data obtained for both *T. vulgaris* and *T. helveticus* resulted in sex ratios very close to those obtained by netting (Table 6). When only trapping is carried out, applying this correction factor to trap ratios therefore seems a reliable method of estimating the true sex ratio when the latter is unknown.

	<i>T. vulgaris</i>	<i>T. helveticus</i>
Trap Ratio	0.83	0.74
Trap Ratio x 0.63	0.52	0.47
Netting Ratio	0.59	0.40

TABLE 6. Sex ratio of newts in Llysdynam pond. Sex ratio is expressed as males/total. Adjusting trap ratios using Bell's (1977) conversion factor of 0.63 yields sex ratios close to those obtained by netting.

Palmate newts captured in pit-fall traps during the inward migration to Llysdynam pond outnumber smooths by about 2:1 (Harrison *et al.*, 1983). Likewise, netting produces a larger number of palmates than smooths in the pond. The disproportionately large number of male smooth newts captured in the pond by trapping therefore suggests that these animals are more trap-prone than others. As female smooth newts appear to be less abundant than other newts in Llysdynam pond, male smooths may search more actively for mates than male palmates and consequently be captured more frequently.

Within a pond there may be large differences between closely adjacent traps in the numbers of newts captured. However, this does not appear to be a result of captured newts attracting others. Newts are rarely evenly distributed within a pond and large catches in a

single trap may be a result of this "clumped" distribution, with newts in a group following one another into the trap.

As the traps prevent ascents to the surface for air, newts could become conditioned into avoiding them on subsequent occasions. Alternatively, a trap may provide a relatively safe microhabitat which newts find attractive. Neither of these hypotheses was borne out in the laboratory. Although there may be species and sex differences in trap response, laboratory experiments suggested that trappability is not accentuated or diminished by previous experience of a trap. However, the present data do not permit predictions as to how repeated trapping of a newt may affect its subsequently behaviour.

The funnel trap described here has also proved to be an effective method of capturing newt larvae; tadpoles of the common frog *Rana temporaria* and common toad *Bufo bufo*, and adult crested newts *Triurus cristatus* (under Nature Conservancy Council Licence). However, some precautions should be observed when conducting a trapping programme. As trapped newts cannot make breathing ascents, the 12 hr trapping period described here should be regarded as the *maximum* length of time that traps are left in position. Leaving traps out for longer periods will almost certainly result in fatalities. Moreover, newts captured in traps placed in sunny positions or during hot weather may expire in under 12 hr so the trapping period on such occasions should be reduced accordingly. For similar reasons, it is essential that every trap can be easily relocated by the observer and secure attachment to some form of marker is therefore strongly recommended. The bownets described by van Gelder (1973) overcome the problem of prevention of breathing by having an extension to the water surface.

Clearly, the efficiency of any method of studying newt populations will be dependent on both intrinsic factors associated with newt behaviour (e.g. diel and seasonal activity patterns, courtship, feeding and egg-laying behaviour), and extrinsic factors associated with site characteristics (e.g. pond accessibility, size, depth, vegetation cover the turbidity). There is therefore no one method which is universally "best". The potential field worker should therefore carefully consider the aims of his survey, in addition to intrinsic and extrinsic factors, before deciding upon a methodology.

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## DIEL PATTERN OF MOVEMENT AND AGGREGATION IN TADPOLES OF THE COMMON FROG, *RANA TEMPORARIA*

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### ABSTRACT

In a garden pond in London, tadpoles of the common frog, *Rana temporaria*, displayed a clear diel pattern of movement and aggregation. During the morning, tadpoles moved from the deeper area in the middle of the pond to the pond edges. The number of tadpoles around the edges peaked in the afternoon. At night tadpoles tended to disperse and move back to the deeper area. This cycle was closely related to the diel cycles of illumination and temperature. Tadpoles were not evenly distributed around the pond edges, and a stationary feeding aggregation was formed each day on the west to south-west edge. As there was no thermal gradients along the pond edges, the formation of this aggregation was probably due to factors other than temperature.

### INTRODUCTION

Anuran tadpoles are rarely evenly distributed in a pond and frequently form dense aggregations consisting of several hundred individuals. The structure and function of such aggregations has been studied by a number of authors, but the mechanisms which bring tadpoles together are complex (e.g. Bragg, 1954; Brattstrom, 1962; Wassersug and Hessler, 1971; Beiswenger, 1975). One classification system distinguishes between social aggregates which are formed by "biosocial mutual attraction" and simple (or asocial) aggregates formed by tactic responses to environmental stimuli such as light, temperature or food (Bragg, 1954; Wassersug, 1973). Under natural conditions, however, both social and asocial factors are probably operant in tadpole aggregations.

In comparison with studies of aggregation, diel activity in amphibian larvae has been little studied. Several species, however, have been shown to display diel movement patterns related to microhabitat selection (e.g. Mullally, 1953; Beiswenger, 1977; Heath, 1975; Dolmen, 1983; Holomuzki and Collins, 1983). In common with the vast majority of vertebrates, it is likely that such activity patterns are regulated primarily by daily fluctuations in illumination and temperature, possibly in conjunction with an endogenous time-keeping system.

Clearly then, illumination and temperature are involved in the modulation of both aggregative behaviour and diel movement patterns in larval amphibians. The present study set out to investigate diel movements and aggregations in relation to these environmental factors in tadpoles of the common frog