

Observations on the breeding of toads in a restricted habitat

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Regular observations were made for 11 consecutive years on the toad population frequenting and breeding in a small cement pond in a private garden in suburban Johannesburg, South Africa. The population consisted of two kinds of toads: *Bufo gutturalis* Power and a hybrid population believed to be derived from crosses between *Bufo gutturalis* Power and *Bufo rangeri* Hewitt. Individual animals can be distinguished by differences in the shape of dark spots on their backs. A record was made of every pair found spawning, and several complete counts were made of all the animals found in the pond on an evening. Some individuals were observed repeatedly for the duration of the breeding season, from August to January. In consecutive years the toad population showed a great turnover, only a few individuals appearing in two or three consecutive years. It is concluded that the toads disperse after the end of the breeding season, and, as a rule, do not come back to the same body of water. During the breeding season females may spawn twice, with an interval of nearly two months or more. Male toads may mate frequently. The sudden disappearance of the toad population is noted.

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Gereelde waarnemings is oor 'n tydperk van 11 opeenvolgende jare gedoen op 'n groep Amphibië wat in 'n klein sementdammetjie in 'n private tuin in 'n voorstad van Johannesburg geteel het. Die bevolking het bestaan uit twee soorte paddas, *Bufo gutturalis* Power en 'n waarskynlike kruising tussen *Bufo gutturalis* Power en *Bufo rangeri* Hewitt. Individuele diere kon deur verskille in die donker kolle op hulle rûe uitgeken word. Opnames is gemaak van elke telende paar, en gedurende 'n hele paar aande is al die paddas wat die dammetjie besoek het, getel en ondersoek. Sekere individue is gereeld opgemerk gedurende die teelseisoen vanaf Augustus tot Januarie. In opeenvolgende jare het die hele paddabevolking groot omwentelinge getoon, met slegs 'n paar individue wat in twee of drie opeenvolgende jare voorgekom het. Die gevolgtrekking is gemaak dat aan die einde van die broeiseisoen die paddas versprei en gewoonlik nie weer terugkom na dieselfde plek toe nie. Gedurende die broeiseisoen kan die wyfies twee keer teel met 'n tussenpose van feitlik twee maande of meer. Die mannetjies kan meer dikwels paar. Die skielike verdwyning van die hele paddabevolking is ook opgemerk.

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This communication is based on observations of toads in an artificial pond in a garden in Johannesburg, South Africa. Because this was a restricted habitat, it was possible to keep track of *all* individuals present. The immediate aim of the investigation was to ascertain the changes in the composition of the population of the toads in the pond throughout the breeding season and through several consecutive years, and the participation of individual animals in breeding that was taking place. In particular it was hoped to establish whether the females spawned only once, or repeatedly in the breeding season.

Material and Methods

The pond on which the observations were made is a quadrangular cemented construction 232 × 184 cm and 62 cm deep at its deepest part. It is situated in a 0,1-ha garden in a northern suburb of Johannesburg, surrounded by a brick wall, which is completely unscalable for the toads. Toads entering or leaving the garden could only do so through two gates in the wall, opening onto a paved street. The garden, apart from the main dwelling and outbuildings, contains lawns, a few fruit trees, and ornamental trees and shrubs, some indigenous, others exotic. Some waterlilies and sedges grow in the pond. The pond had been in existence for 12 years before the start of systematic observations, and was always frequented by toads, who called and spawned in the pond. Simultaneously with the amphibians the pond continuously held a population of goldfish.

Two bodies of water comparable in dimensions existed in neighbouring gardens: a fishpond and a swimming pool, both frequented by calling toads. The nearest larger bodies of water are several dams along a small river in a park about 0,75 km away from the pond.

The most common toad in the area is *Bufo gutturalis* Power (Passmore & Carruthers 1979), previously known as *Bufo regularis* Reuss (Poynton 1964; Balinsky 1969), or *Bufo regularis gutturalis* Power (Wager 1965; Pienaar, Passmore & Carruthers 1975). A second form encountered is presumably a hybrid population generated by the interbreeding of *Bufo gutturalis* (in the present sense) and *Bufo rangeri* Hewitt. The supposed hybrid differs from *Bufo gutturalis* in the duration and pulse rate of its call, as analysed with the aid of sonograms by Passmore (1972), as well as in morphological details. Without the use of sonograms the call of the 'hybrid' is at once distinguishable by its shorter duration. The 'hybrid' has paler and less distinct dark markings, but these vary greatly. The most useful distinction for practical purposes is the presence of red coloration on the thighs of both sexes of *Bufo*

gutturalis during the breeding season; this is absent in the 'hybrids'.

Throughout this investigation the data on the two forms of toads have been kept separately, but no differences in their behaviour could be detected.

The 'hybrids' are predominant in certain localities (Passmore 1972), but were less numerous than *Bufo gutturalis* in the study area. The two forms interbreed freely (unpublished information), and mixed pairs were often found in the pond. It is rather remarkable that in spite of this the hybrid population and the population of *Bufo gutturalis* have not merged in a continuous series, but can still be distinguished except for only rare doubtful individuals.

In addition to the toads and the goldfish, *Rana angolensis* occasionally occurred in the pond for limited periods.

The main feature allowing the recognition of individual toads is a series of dark spots arranged roughly symmetrically on their dorsal surface. These start with a pair of spots over the orbits (always separate, both in *B. gutturalis* and in the hybrids), followed by several small dots or spots, and then by two pairs of large spots. These large spots vary greatly in size and shape, the spots on the right and left side usually are not exactly alike. The smaller dots further in front, and frequently small spots around the big ones provide additional characters of distinction (Figure 1). The recognition and identification of individual animals is further facilitated by the occurrence in some individuals of irregularly distributed yellow spots. Finally large 'warts', very irregularly distributed, provide a further distinguishing character in cases where the dark spots are not very clear, as in some hybrid individuals. The spots do not change, individuals observed during one breeding season could be recognized clearly the next season. In the course of the present study there were only one or two individuals where recognition was in doubt.

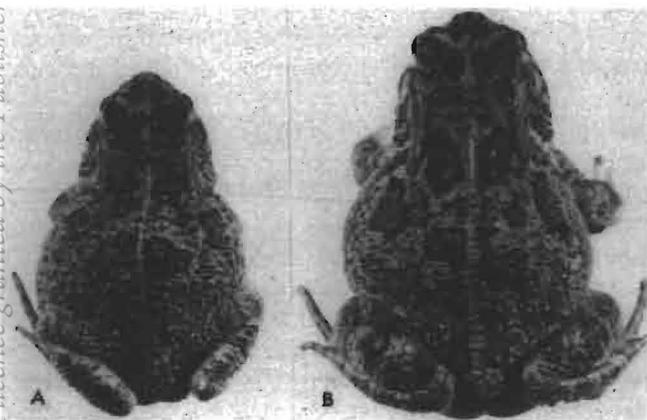


Figure 1 *Bufo gutturalis* Power, male (A) and female (B), showing the pattern of dark spots on their backs, which permits recognition of individual animals.

Drawings of the spots on the back were made of each individual examined, and the drawings were compared with each recapture. For reference, numbers have been given to each animal (in order of encounter).

All toads found in the pond in amplexus were allowed to spawn, and then examined, their spot patterns recorded, and if necessary compared with previous records. The animals were then released into the pond. From time to time a complete census was made of all toads present, whether mating or not. For this purpose all animals in the pond were captured,

examined, drawn, compared with previous records, and released. The animals involved in the census were almost exclusively males, as females entered the water only for breeding, with very few exceptions. The maximum number of toads at one time was 15 (all males).

The majority of spawning pairs were observed and recorded, though a few spawnings were missed (eggs found later).

Results

The records of the animals observed, and of the spawnings are shown in Table 1. The data for *Bufo gutturalis* and for *Bufo* hybrids as well as for males and females are shown separately. The females are readily distinguishable from the males by the absence of the dark pigmentation on the throat. The observations cover a period from the beginning of 1971 to the end of 1981. The recordings are grouped not by calendar year, but by breeding seasons, which in the presently observed conditions continue from August into January of the next year.

The earliest observed spawning of the toads in the pond was on 3 August, and the latest on 21 January. The distribution of the spawnings over the months was as follows: August — 1; September — 24; October — 12; November — 9; December — 18; January — 9.

Table 1 shows that a substantial proportion of the male toads was recorded repeatedly in the same season (second line for each group) thus indicating their continuous presence in the area. An examination of the dates when individual males were observed, shows that at least some of them remained in the area from the beginning to the end of the breeding season (Table 2).

The number of males remaining in the garden throughout the breeding season must have been much greater than indicated in Tables 1 and 2, because if a male did not mate repeatedly, and there was no census performed, his presence would not have been noted.

On the other hand, Table 1 shows that the population changes drastically from year to year. Of all the *Bufo gutturalis* males only nine were found in the pond in two consecutive years, and only one was found in three consecutive years. The remaining 78 males were recorded only in one season, though some of them were recorded more than once in the same season. The figures for hybrids are similar: three were present in two consecutive seasons, and the remaining 43 were seen in one season only, though some were recorded more than once in the same season. There is thus a big turnover in the population from year to year.

The behaviour of the female toads has to be considered separately inasmuch as the females usually come to the pond only for spawning. They enter in amplexus during the night, spawn in the morning, and as soon as the pair separates, the females leave the pond. This peculiarity of behaviour incidentally results in the records for the females being more nearly complete than those for the males: only a few females were missed, either as the result of their leaving the pond before they could be examined, or owing to the mating not being observed (as mentioned previously).

As with the males, the population of the females shows rapid turnover from one breeding season to the next. Of the 52 recorded *Bufo gutturalis* females, 47 were observed only in one season. Three were present in two consecutive seasons. One female turned up in three consecutive seasons. Another female, after spawning in one season was not recorded in the next, but was spawning again in the third season. The case

Table 1 Record of toads occurring and breeding in the garden pond

		1970/ 71	1971/ 72	1972/ 73	1973/ 74	1974/ 75	1975/ 76	1976/ 77	1977/ 78	1978/ 79	1979/ 80	1980/ 81	1981/ 82
<i>B. gutturalis</i> ♂♂	Total recorded	4	6	9	9	13	15	6	12	10	14	0	1
	Recorded more than once same season	0	2	2	0	2	4	0	4	2	3	0	1
	Recorded previous season	0	2	2	1	3	2	1	0	0	0	0	0
	Recorded two years before	0	0	1	0	0	0	0	0	0	0	0	0
	Matings	0	0	0	0	5	7	6	16	7	12	0	1
Hybrid ♂♂	Total recorded			2	0	13	4	3	3	7	16	0	0
	Recorded more than once same season			0	0	3	2	0	1	2	2	0	0
	Recorded previous season			0	0	0	2	0	0	0	0	0	0
	Recorded two years before			0	0	0	0	0	0	0	0	0	0
	Matings			0	0	3	2	3	4	5	9	0	0
<i>B. gutturalis</i> ♀♀	Total recorded					5	6	7	14	6	19	0	1
	Recorded more than once same season					0	0	0	2	0	3	0	0
	Recorded previous season					0	0	1	3	0	1	0	0
	Recorded two years before					0	0	0	1	1	0	0	0
	Matings					4	6	7	16	6	20	0	1
Hybrid ♀♀	Total recorded					1	0	1	3	3	1		
	Recorded more than once same season					0	0	1	1	2	0		
	Recorded previous season					0	0	0	0	2	0		
	Recorded two years before					0	0	0	0	0	0		
	Matings					1	0	2	4	5	1		

Notes: Where the number of matings exceeds the number of individuals observed this is due to some individuals mating repeatedly. Discrepancies between matings of males and females are due to some females escaping without being examined and recorded.

Table 2 Male toads recorded more than twice during same season

Species and individual	Dates observed				
<i>Bufo gutturalis</i> No. 24	14/9	21/9	7/12		
<i>Bufo gutturalis</i> No. 25	14/9	5/10	22/11	18/1	
<i>Bufo gutturalis</i> No. 76	14/9	18/9	26/9	30/11	12/1
<i>Bufo gutturalis</i> No. 88	25/9	14/10	14/12		
Hybrid No. 15	31/8	18/10	29/12		

is of further interest because in the first season the female was not fully grown (though sexually mature), and became full grown in the third season.

Of the seven hybrid females, five were seen only during one breeding season, and two were found in the pond on two consecutive seasons.

Repeated recording of a female in the same season in all cases except one is due to repeated spawning.

One of the main aims of this investigation has been to establish whether female toads spawn only once in the breeding season, or whether they may spawn repeatedly, and if so — how often. Several females have in fact been observed to spawn twice (Table 3). Interclutch intervals range from 55 to 116 days. Although repeated spawning is definitely proven, the majority of the females were observed spawning only once in a breeding season. It is quite impossible that a second spawning was missed so many times (with 53 females observed as spawning only once), but the possibility cannot be excluded that the animals had moved out of the garden and into another body of water before spawning a second time — or

Table 3 Female toads spawning twice the same season

Species and individual	Dates observed		
<i>Bufo gutturalis</i> No. 9	14/9	12/12	
<i>Bufo gutturalis</i> No.18	9/9	11/11	
<i>Bufo gutturalis</i> No.36	20/9	21/1	
<i>Bufo gutturalis</i> No.42	21/11	21/1	
Hybrid No. 3	17/9	17/12	
Hybrid No. 4	27/10	27/12	
Hybrid No.4 (next year)	22/9	16/1	

had come into the garden pond after spawning elsewhere.

The distribution of spawning dates within one breeding season is bimodal, with peaks in September and December. The two peaks cannot be explained by climatic factors, as it was previously shown that spawning in *Bufo gutturalis* toads is largely independent of temperature and rainfall (Balinsky 1969). It could be accounted for if the second peak were the result of influx of new females, which had spawned for the first time elsewhere. It cannot be explained by repeated spawning of females already in the garden from the start of the season.

The males are apparently able to mate repeatedly at any time when there are receptive females available. One *Bufo gutturalis* mated three times in the same season: on 26 September, 30 November, and 12 January. Another mated on two consecutive days: 14 and 15 September. The intervals between matings for *Bufo gutturalis* were: 1, 5, 6, 12, 24, 44, 65, 77, and 78 days, and for *Bufo* hybrids 9 and 11 days.

After frequenting the garden pond for 21 years the toads disappeared. None were seen or called in the garden in 1980. In 1981 one male called in the pond from September to middle of January. In September a female arrived and the pair spawned. Since then to the time of writing (1984) there were no toads in the pond or in the garden.

It is remarkable that the toads disappeared not only from the garden under observation, but also from the bodies of water in the neighbouring gardens, which were mentioned previously, and in which toads were always calling during the same periods as in the pond under observation. Thus the disappearance of the toads affected not only one pond but the whole area.

Discussion

Because in many cases toads have been observed repeatedly at the pond in the same breeding season, it is evident that throughout one season the toad population remains relatively static. The toads which assemble at the pond in the evening scatter in the garden and hide during the daytime, and return again, sometimes to the same position at the edge of the pond.

From season to season, however, there is a great turnover, only a few specimens reappear in two or three consecutive seasons. Some returning males could have been missed if they did not mate or were not taken during a census. This applies less to females, as their presence (during mating) was more completely recorded. The turnover from season to season raises two questions: (i) What happens to the animals that fail to reappear, and (ii) Where do the animals that had not been at the pond before come from?

In view of the known longevity of toads it is quite out of the question that the disappearance of the toads is due to natural old age mortality. Death owing to predation in the garden is unlikely: there were definitely no snakes there, the garden is not frequented by predatory birds or mammals. The conclusion is that a large proportion of toads leave the garden during their inter-seasonal migration and never return. The toads which are found in the garden more than one season are presumably those which do not leave the garden between breeding seasons, rather than individuals who returned to the same body of water to breed. If the latter were true, the return would be equally likely not only in a subsequent season, but after an interval of one, two, or more years. There is no evidence of such accidental return.

If missing animals are indeed those that leave the garden, what happens to them later? Why do they not return? Outside the garden the toads would be exposed to mortality by predation and by other causes, such as being crushed by motorcars on the roads. If the resulting mortality were the only cause of toads not returning to breed in the garden, the annual mortality of adult toads must be on the average 91%, the same for males and females (this is the proportion of animals not returning). That the figure is exactly the same for the two sexes may be important, as there is reason to believe that the recording of the females was more accurate than that of the males. An annual mortality of 91% would appear to be too high an estimate. If the actual mortality does not reach that level, the conclusion is inevitable that some toads either stop breeding, or go for breeding to some other body of water, rather than to the same pond in the garden.

The other question is as to the origin of the animals that annually replenish the population in the garden. The alternate possibilities are either that they originate locally, thus making the garden population self reproducing, or that they migrate

from outside. It has been my practice to remove most of the eggs produced by the animals mating in the pond, so as to prevent the overpopulation of the pond by tadpoles. Nevertheless fairly large quantities of tadpoles did develop, and metamorphosis of some of them into toadlets was observed every year. The garden seems to have been an unfavourable biotope for the further development of the toadlets, however, as juvenile toads were hardly ever observed in the garden. Furthermore, with two exceptions, all toads found in the pond were full grown. In one of the two exceptions a female toad found spawning was noted as being small, and two years later the same female was caught, also mating, and this time it was recorded as being large (full grown). Where the animal was in the intervening year is unknown, but the observation proves that young female toads may mate and spawn while not fully grown. If the population in the garden was self reproducing, mating individuals which were not fully grown would be observed more frequently, which was not the case. The second not fully grown individual observed at the pond was a male. The evidence thus indicates that the population of toads in the garden was annually replenished from outside — presumably from the big dams in the neighbouring park.

The disappearance of the toads from the area of the garden after they had been using the garden pond and adjacent bodies of water for a number of years, poses a question as to the cause of this change.

Did the toads disappear because of an epidemic? It has been usual to find a few (two–three) desiccated toad corpses in the garden at the end of winter. There is no record of increased numbers of corpses found in 1980, when the toads disappeared (no records of finding corpses were kept). After the disappearance of the toads in the area of observation, the toads continued calling each year from the dams in the park. Whether the population there had been diminished or remained the same, cannot be estimated. If the population in the garden pond was replenished each year from outside, the disappearance of toads there must have been the result of cessation of migration of the toads to the area (the garden pond and the neighbouring small bodies of water). No new obstacles for migration had appeared to account for the cessation: the area was fully built up and the streets paved before the start of the present investigation.

While the immediate cause of the disappearance of the toads is not clear, it must be an aspect of the influence of urbanization on animal life, and thus of general and not only local importance.

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