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NOTES ON THE PSYCHOLOGY OF FROGS AND TOADS*

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The behavior, particularly during breeding of the anuran amphibians, has received considerable attention from herpetologists. It has long been known that many of the habits of these animals are adaptive to special environmental situations and to the major biological necessities (food and feeding, protection, and reproduction). But the tendency to generalize and to oversimplify on the basis of the recognized taxonomic divisions has only recently been generally recognized, so that we now know that interspecific differences in habits are as important as anatomical differences in the whole story of the life of toads or frogs of any one species. Such statements as *the frog* does this or *the toad* does that are meaningless unless one knows what species is involved in any case.

During the past seven years, I have been engaged in an extensive field study of the habits of the frogs and toads of Oklahoma, the results of which are now being published in appropriate biological journals. During this study, which was undertaken primarily from an ecological viewpoint, I have here and there come upon phenomena difficult to explain either on purely ecological or on physiological grounds. I look upon these as psychological phenomena; and since I can find little or nothing published upon the psychology of any of this group of animals, I present my observations for what they are worth. Many of these need checking by experimental means and I will consider this report as serving its best purpose if by it experimental psychologists become interested in analyzing further the behavior of frogs and toads.

It is difficult to write about animal behavior without using at least some expressions which may imply teleology or an anthropomorphic viewpoint. I purposely avoid such controversial terms as "instinct" and "intuition" but may have used others unacceptable to some. Nothing which is said is to be taken as teleological, anthropomorphic, or homocentric.

I write from very many notes taken at various times during the past seven years and, to save space, make many general statements. In every

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case, it is to be understood that the behavior reported in this manner is based upon many observations, at all times consistent with each other.

Twenty-five species or subspecies of anuran amphibians are known to occur in Oklahoma. Of these I have observed all except three in their native haunts at least 20 times; many of them I have seen and watched closely hundreds of times, particularly during their feeding and breeding activities. The species observed represent five families and seven genera. These are as follows: (*a*) *Bufonidae,* genus Bufo (the garden toads); (*b*) *Scaphiopodidae,* genus Scaphiopus (the spadefoot toads); (*c*) *Hylidae,* genera Acris, Pseudacris, and Hyla (the tree-toads); (*d*) *Microhylidae,* genus Microhyla (the narrow-mouth toads); and (*e*) *Ranidae,* genus Rana (the frogs). Species names appear at appropriate places in the text.

Observations

The behavior of animals usually centers about three general types of activities, each clearly correlated with a major biological necessity. These are (*a*) food getting, (*b*) protection (both from enemies and the inanimate environment), and (*c*) reproduction. The first two of these are sometimes grouped together as "self-centered" activities whereas the last is contrasted by calling it "altruistic." The self-centered activities of frogs and toads are always non-social in character; in contrast, the reproductive behavior is essentially and necessarily social and altruistic. These things will become more apparent as we proceed.

1. *Food Getting*

All the frogs and toads observed are essentially alike in their manner of food capture. However, there is an interesting difference, amounting to a selective activity, exhibited in Bufo and Scaphiopus on the one hand, and Rana, on the other. Individuals of all species of North American Rana, so far as known, eat any object which is small and which moves or is moved near them. It is a common observation that larger frogs will eat smaller ones even of the same species and it is commonly supposed that toads behave likewise. I find this not to be true. Neither adult toads (Bufo) nor adult spadefoots (Scaphiopus) have ever been seen to eat vertebrates in Oklahoma although some tropical toads may do so. I have had large unfed adults of *Bufo cognatus* Say, *B. compactilis* Wiegmann, *B. woodhousii fowleri* (Hinckley), and *B. w. woodhousii* Girard and small adults of *B. a. americanus* with young toads of all sizes in many mixtures of the species and

have never known one toad to eat another. I have also kept individuals of *Scaphiopus hurterii* Strecker with the young of their own or related species and with both adults and young of the above mentioned Bufos, as well as with young frogs in all possible combinations of sizes and sexes, always with consistent results. Furthermore, in dissecting several hundred specimens of Bufo of each of four species in a recent study of food habits (Smith and Bragg, 1941) no evidence was found of vertebrate remains except a single feather probably picked up incidental to the taking of insects from the ground. My observations show that Bufo and Scaphiopus are like Rana, however, in seldom attacking a non-moving object. Many times I have seen an insect save its life, as it were, by remaining motionless before a toad or spadefoot. The difference, therefore, lies in the fact that a typical frog strikes at any small moving object, whereas toads and spadefoots do not. Thus the toad or spadefoot manifests a selective acumen unknown among the frogs. I have not tested members of other genera in this manner.

2. *Protection from the Inanimate Environment*

The anuran amphibians of Oklahoma divide naturally into three groups on the basis of behavior tending to protect them from inanimate environment: (*a*) those of fossorial habits, (*b*) those of semiaquatic habits, and (*c*) those of arboreal habits. The fossorial species include the garden toads, spadefoots, narrow-mouth toads, and some species of the tree-toad group. Those of semiaquatic habits include all of the frogs, and one of the hylids (*Acris crepitans* Baird). Those of arboreal habits include all Oklahoma species of the genus Hyla (family Hylidae).

The fossorial species are all essentially alike except for intensities of their reactions. Thus, the spadefoots and garden toads are all essentially nocturnal but a few of the latter may be diurnal in moist weather. However, there is a seasonal factor involved in the activities of some of the garden toads. For example, adults of *Bufo cognatus* emerge in large numbers at dusk in spring time to spend the whole of each night in feeding (or breeding). This behavior continues till about mid June or early July, after which fewer and fewer emerge each night until, after August 15, few if any can be found. Since this gradual disappearance of the toads is correlated with the progressively hotter and drier weather of the ordinary summer of their habitat, one might suppose this to be an ecological phenomenon. But recent observations show that it is more than this. Rain in late August does not stimulate the emergence of these animals, nor does a sudden

drop in temperature, at least at Norman, Oklahoma. There is something in the psychological organizations of these adult toads which makes them tend to remain below ground after midsummer, regardless of environmental conditions. *Bufo compactilis* Wiegmann and *B. w. woodhousii* Girard also behave in this manner but not to so marked a degree as *B. cognatus*. However, *B. a. americanus* (Holbrook) and *B. w. fowleri* (Hinckley) show much less of such behavior than any of the others mentioned.

It should be emphasized that the above applies specifically to adults. Typically, *young* toads are active throughout their first summer whenever ecological conditions permit, but they behave as adults toward the middle of their second year and henceforth. There is also a sexual difference in these matters. Old females are often out after all adult males and all second season juveniles have disappeared.

These differences in behavior are obviously adaptive, having developed in the evolution of the animals in correlation with the major biological necessities in the normal environment. It is of some significance that juveniles and old females should feed more frequently than young females and males of all ages after the first year; for the juveniles must (or at least *do*) grow at a very rapid rate (Bragg and Weese, 1943) and the females need a great deal more food than males in order to produce something like 20,000 heavily yolk-laden eggs yearly.

The fossorial habits of typical toads and spadefoots also differ from those of fossorial species in other genera. For example, a typical toad or spadefoot bores straight down by use of special "spades" normally present on the hind feet. Narrow mouth toads (*Microhyla olivacea*) and some other species hide beneath stones and other objects rather than dig into loose soil. But there is one garden toad (*Bufo punctatus* Baird and Girard) in Oklahoma which behaves more like the narrow-mouth toads than like most other garden toads. In captivity, I have never seen them burrow and in nature they are limited (in Oklahoma) to areas of canyons and rocks under the latter of which they seek protection during the day (Bragg and Smith, 1943).

I have observed no such differences as those cited above in the semiaquatic or arboreal species. However, these differ interspecifically in details of behavior upon sensing danger as explained below.

3. *Protection from Possible Predators*

All anuran amphibians in my experience show fear but they differ ma-

terially in their reactions upon sensing danger. The semiaquatic forms typically do one of two things: (*a*) they remain motionless but alert; or (*b*) they plunge frantically into the water and hide on the bottom among aquatic plants or the bottom sediments.

There are, however, some minor interspecific variations. *Acris crepitans* behaves as though more frightened of getting into deep water than of danger approaching from the bank. It enters the water only if escape otherwise is cut off, and then immediately swims to the bank at another point. Only if greatly frightened does it dive to the bottom to hide, the characteristic behavior of the leopard frogs and the bullfrog under similar circumstances. The green frog, *Rana clamitans* Latreille, differs from the other common frogs in ways consistent with theories of protective coloration. When approached, it sits perfectly motionless till one is very close or till a sudden movement is made. Then it dives quickly beneath the surface like other frogs as though to hide on the bottom. However, it seldom goes to the bottom except when greatly frightened, as when nearly caught. Instead it swims sharply to one side and immediately emerges a few feet away where it remains, motionless, almost perfectly protected by its color which blends with the dark green of the algae and pond weeds of its native habitat. By taking advantage of this psychological phenomenon, I have often succeeded in catching these active animals by hand. I have seen young bullfrogs (*R. catesbeiana* Shaw) and adults of two grass frogs [*R. sphenocephala* (Cope) and *R. pipiens pipiens* (Schreber)] behave in this way occasionally but it is only the green frog which appears consistently to do so.

There is also another characteristic of American frogs of the genus Rana which must be mentioned. No matter how active they may be in attempts to escape capture, once caught they tend to remain motionless and limp in one's hand. They may lie thus for a minute or even as long as 10 minutes, then suddenly, by very quick movement, attempt to escape. Often this is successful due to the tendency of unconsciously relaxing the grip on a still object in the hand and to the smoothness and slipperiness of the typical frog's skin. Whether this behavior is used when the frog is caught by a predator and if so whether it is adaptive to their escape from natural enemies such as snakes and herons is, however, questionable. Indeed, it would seem rather to facilitate their being swallowed.

The fossorial species differ from the semiaquatic species in ways consistent with the differences in habitat. Broadly, within their habitat group, however, they follow a single general pattern of behavior on the approach of

danger; but, like the semiaquatic types they differ interspecifically and often intersexually. This is well illustrated by the garden toads, the general pattern among which follows.

Three reactions characterize a frightened toad (Bufo): (*a*) it crouches motionless with the body flattened against the ground and the head lowered; (*b*) if touched or greatly frightened, it hops frantically to concealment among vegetation to hide; (*c*) if caught, it fills its lungs so full of air that the body is rounded and rigid. Species differ in the use of these "devices" of escape. *Bufo compactilis* crouches momentarily and then starts for the weeds. *B. w. woodhousii* crouches longer. *B. cognatus* and *B. a americanus* often fail to move till touched. There is also difference within size groups. Small toads (usually but not always juveniles) tend when caught to "puff up" tighter and more consistently than larger individuals. I have seen small juveniles of several species with the skin so tightly stretched that internal organs could easily be seen when a beam of light from a three-cell flashlight was shone through their bodies. There is also an intersexual difference among adults (not shown by juveniles) independent of size. Adult males tend to puff up much less consistently than females. Instead, they make sounds, called by herpetologists the protesting note, till released. Females remain silent. The protesting notes of the species are characteristically different and are given whenever a male toad is held or touched by other toads as well as by human beings. I have observed this reaction hundreds of times but only once have I seen the protesting continue on release of the animal. The exception was a small specimen of *Bufo compactilis* which I was attempting to photograph. He protested violently while being handled and when released on a table beneath the camera continued for five minutes to "fuss" with the body shaking so that it was impossible to take the photo although he was not held in any way.

The spadefoot toads also tend to puff up when handled, especially when young; but in these both sexes protest as adults although the males are much more vociferous. They also tend to remain quieter when approached. *Scaphiopus couchii* Baird and *S. hurterii* Strecker can usually be picked up easily, but *S. bombifrons* often hides like the garden toads.

Pseudacris triseriata (Wied), *Pseudacris clarkii* Baird, and *Pseudacris streckeri* Wright and Wright tend to utilize their protective coloration by remaining quiet although all three will dive like frogs if near water. These seem to be about the only defensive mechanisms of these animals except their generally small size and great agility. *Microhyla olivacea*

(Hallowell), which often occupies the same general habitat as the species of Pseudacris just mentioned, behaves very differently. It seldom crouches and almost never remains still. It will make frantically for concealment at the least disturbance, even with a light playing into its eyes.

From the above observations, we can conclude, therefore, that (*a*) taxonomically closely related species of anuran amphibians tend to manifest similar responses to similar stimulation evoking the psychological state of fear but (*b*) even very closely related species differ in the details of these responses, and (*c*) sexual and size differences in Bufo (but not in other genera) influence the behavior in the face of danger. It is also evident that most of these reactions are due to psychological differences in the various species under consideration and that their manifestations are closely correlated with the necessities of the animals in their normal environments. This is only another way of saying that psychological characteristics have evolved with the morphological characters and correlated physiological reactions in adjustment to the ecological situation in which the animals now live. In so far as this evidence is sound, therefore, it substantiates the general theory of the evolutionary development of mind correlated with that of body but it goes further than this, even, in its indication that both the evolution of mind and that of body developed phylogenetically in correlation with biological necessities in the environment characteristically occupied by each species. We will see this even more strongly indicated in the discussion of reproductive habits.

4. *Breeding Behavior*

The breeding behavior of frogs and toads follows a generalized pattern which works as though designed (*a*) to get the sexes into union, (*b*) to insure large numbers of eggs being deposited, and (*c*) to do this at the right time and place favorable for development of young. Parental care is not shown by any North American species, the eggs of most forms being deposited and fertilized in the water where they are left to whatever fate may await them. Some phases of this behavior are under ecological control (temperature, rainfall, etc., serving as stimulating factors). Other phases are essentially physiological (see Rugh, 1935, and Bragg, 1941, for effects of the pituitary gland, for example), but some are essentially psychological in nature. The total behavior, therefore, results from the interplay of several types of complex forces all of which must be understood to obtain a complete picture.

One of the prerequisites for sexual union is that a male shall find a female.

This is usually in the dark. How is it accomplished? As is well known, the male of each species has a distinctive sexual call (or "song" as it is often called) which is very attractive, under certain conditions, to females of the same species but not to females of other species. In response to hormonal stimulation, males enter breeding pools and begin their calling. Females, attracted by the call of the male, approach the males which then clasp the females, eggs are laid and fertilized, and the pair separates. Now, within this general pattern of behavior, there are some interesting variations. In several species occupying a prairie habitat (*B. cognatus, B. compactilis, Microhyla olivacea, Ps. streckeri, Ps. clarkii, Rana sphenocephala, S. bombifrons, S. couchii, S. hammondii*) and in a few living only in woodland (e.g., S. *hurterii*) the males are also profoundly stimulated by the calls of others of their own species and therefore tend to call loudest as well as to congregate in a huge and ever growing congress about certain pools. However, in species not particularly adapted to the rigors of amphibian life in the grasslands (*B. w. woodhousii, B. w. fowleri, B. a. americanus, R. pipiens pipiens* Schreber, *R. catesbeiana* Shaw, etc.) there is much less stimulation of the males by other males' calls. Accordingly, there is less tendency for males to gather in large congresses and for all males to call together.

These psychological differences are clearly adaptive to ecological conditions of the habitat and must have arisen in evolution in response to differing biological necessities. In xeric regions (grasslands and deserts) standing water is rare. Accordingly, only those species which have learned (in an evolutionary sense) to take advantage of temporary pools have much chance of surviving. On the other hand, in mesic environments (e.g., the eastern woodlands) standing water is more common—lakes, river margins, and pools of various sorts are present—and the amphibian fauna need not have developed mental traits tending to allow breeding in a temporarily favorable place.

Intersexual differences in behavior are also to be noted in certain species. For *Bufo cognatus,* these have been detailed elsewhere (Bragg, 1940). Briefly, it was found that in this species the females will not voluntarily accept the attentions of calling males in small shallow pools, but that the same individuals will readily accept similar attentions of males in adjoining pools of greater extent. Subsequently, similar phenomena have been observed to occur in *Bufo compactilis,* but no evidence of it has been seen in watching hundreds of matings of *B. w. woodhousii,* and *B. a. americanus* in the field. Again, this difference in behavior (whether of truly psychological or essen-

tially physiological nature) is adaptive; for, in the normal prairie habitat of *B. cognatus* and *B. compactilis* small temporary pools usually disappear before tadpoles could have time to mature sufficiently for metamorphosis, whereas in the moister habitat of *B. a. americanus* this is not so likely on the average to be true.

I wish now to record an observation for which I have no explanation, either in theory or fact, but which may sometime prove to have value in comparative psychology.

I had caught a small adult calling male of *B. a. americanus* at a breeding congress and, wishing to retain the animal alive, placed it into a large, flat, shallow, glass culture dish, covered by another like it. A small amount of water was added and the toad remained there one and one-half weeks in apparently good condition. During the first few hours, this toad made vigorous efforts to escape through the glass but eventually became quiet and seldom would move unless disturbed. At the end of this time, I caught another calling male toad of the same species and of comparable size, but of markedly different coloration, at the same pool from which the first had come. Wishing also to retain this one temporarily, I placed it into the container with the first one at about 10:30 P.M. on the night that it was collected. The two toads were easily distinguished by their respective colorations, the first being consistently quite reddish, the second almost black. In fact, it was this difference in color which stimulated me to retain these two specimens because they were respectively near the extremes of normal color variation for their species.

The behavior of the second toad was like that of the first when originally introduced to the container, i.e., it attempted to escape through the glass, and this activity was still going on at eight the next morning, presumably having been continued through the night. All through the forenoon this toad fought to escape and was still active and vigorous at two in the afternoon. In the meantime, the first toad had again become active and both were trying to escape when observed at two P.M.

Two hours later, the first (red) toad was sitting quietly in the dish, apparently normal: the second one (black) was dead. Subsequently, the red toad lived in this same container for several days more and when eventually removed for study was as active and vigorous as when caught, approximately two weeks before.

Why did one toad die in this container in less than 24 hours when another of the same species and sex and of comparable size had lived there

apparently normally for several days and continued to do so afterwards? As I said, I have no answer, but I do raise some questions. Is it possible that the nervous organization of toads is of a higher order than is usually recognized (cf. Noble, 1931). Is it possible that individuals differ in this organization, as do human beings? Is it possible to ascribe correctly to toads such "human" terms as *discouragement, hope,* etc? Did the first toad show "stoic" characteristics, the second one "lose hope" of escape, become "discouraged" and "give up?" Or was he mortibund anyway through some obscure abnormality not immediately apparent? I emphasize again that I have no opinion: but I do think that such questions need experimental answers from the one most competent to do the work, an experimental psychologist.

Summary and Conclusions

Seven years of observations of Oklahoma frogs and toads has convinced the author that these animals have a psychology centered around the three major biological necessities, (*a*) food and feeding, (*b*) protection, (*c*) reproduction. Differential behavior patterns based upon interspecific and, in some cases, intersexual differences are apparent and each of these is clearly adaptive in nature.

To understand the life of a frog or toad, one must take into account ecological, physiological, and psychological factors and, especially the *interaction* among these. So far, ecological and physiological factors have received far more study than psychological factors. It is the purpose of this paper to point this out and to make a start toward an understanding of the psychology of toads and frogs.

References

1. Bragg, A. N. Observations on the ecology and natural history of Anura: I. Habits, habitat, and breeding of *Bufo cognatus* Say. *Amer. Nat.,* 1940, **74**, 322-349, 424-438.
2. ————. Observations, etc.: VIII. Some factors in the initiation of breeding behavior. *Turtox News,* 1941, **19**, 10-12.
3. ————. Further field notes on the initiation of breeding behavior of Anura. *Turtox News,* 1942, **20**, 12-13.
4. Bragg, A. N., & Smith, C. C. Observations on the ecology and natural history of Anura: IV. The ecological distribution of toads in Oklahoma. *Ecology,* 1943, **24**, 285-309.
5. Bragg, A. N., & Weese, A. O. 1943. Observations, etc.: XIV. Growth rates and development of young *Bufo cognatus* in Oklahoma (mss.).

6. NOBLE, G. K. The Biology of the Amphibia: VIII+557 pp., 174 figs. New York: McGraw-Hill, 1931.
7. RUGH, R. Pituitary-induced sexual reactions in the Anura. *Biol. Bull.*, 1935, 68, 74-81.
8. ———. Experimental studies on the reproductive physiology of the male spring peeper, *Hyla crucifer*. *Proc. Amer. Phila. Soc.*, 1941, **84**, 617-633.
9. SMITH, C. C., & BRAGG, A. N. Food of toads in Oklahoma. *Anat. Rec.*, 1941, **81** (Suppl.), 111.

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