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SOIL WATER ABSORPTION CAPABILITIES IN SELECTED SPECIES OF ANURANS

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ABSTRACT: The relative ability of several species of anurans (*Bufo americanus*, *B. cognatus*, *Hyla cinerea*, *Rana pipiens*, *Scaphiopus couchi*, and *S. hammondi*) to absorb water from the soil was examined. Fossorial species from xeric habitats, *S. couchi*, *S. hammondi* and *B. cognatus* had absorption thresholds between 2.5 and 3 atm. In decreasing order of ability to absorb moisture from the soil were *B. americanus*, *H. cinerea* and *R. pipiens*. The ability of anurans to absorb moisture from the soil is probably a factor determining their distribution.

MANY species of amphibians spend considerable time in areas where surface water is absent, and some desert frogs spend most of their life in areas devoid of surface water. Since amphibians have a permeable skin and lose body water rapidly, reabsorption of water to replace such losses is essential. Most studies on water reabsorption in anurans have been concerned with the absorption of free water (Claussen, 1969; McClanahan, 1967; Warburg, 1965; Bentley

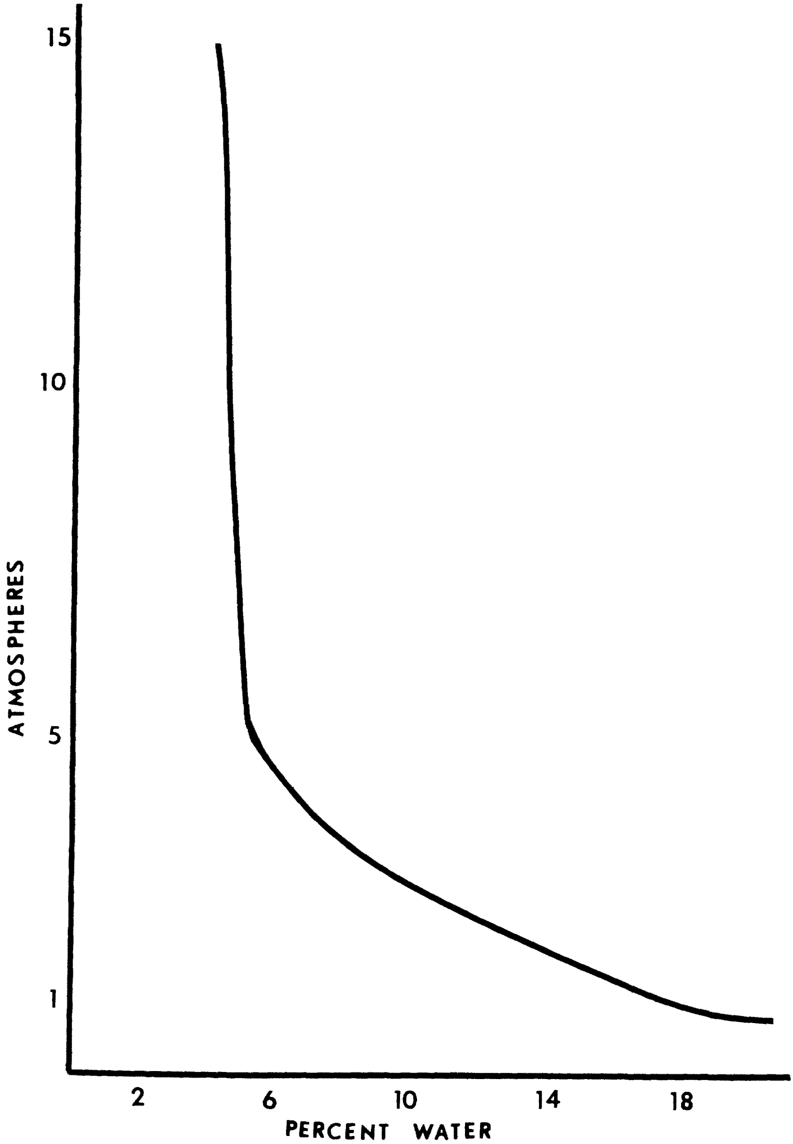

FIG. 1.—Moisture tension curve for the test soil giving the relationship of soil water concentration in per cent dry weight and atmospheres moisture tension.

et al., 1958). Several species have been found to be capable of absorbing water from the soil (McClanahan and Baldwin, 1969; Lee, 1968; Dole, 1967; Packer, 1963; Stille, 1952). Water uptake from soil has also been demonstrated in salamanders (Heatwole and Lim, 1961; Spight, 1967b).

Since there are limited data on the ability of anurans to absorb water from soils at different soil moisture tensions, we conducted the present study to evaluate the relative ability of several species of anurans to absorb water from soil.

Methods

The test soil was a sandy loam of the following composition: 9.6% clay, 4.8% silt and 85.6% sand. A moisture tension curve for this soil was constructed using a porous plate apparatus (Richards, 1941). Readings were taken at 1, 2, 3, 5 and 15 atm with each point on the curve representing the mean of four values (Fig. 1). Soil samples of different moisture tensions were prepared by incorporating a given per cent of water (by weight) to a desired amount of preweighed oven-dried soil.

Three animals of each species were tested at the selected moisture tensions. All frogs were kept in an aquarium at room temperature (22–25 C) and were not fed for one week prior to measurements.

Each frog's bladder was emptied. The animals were weighed and placed in a laboratory desiccator containing anhydrous calcium sulfate. Desiccation for 12 hr resulted in about a 10% loss of the initial body weight (dehydration deficit as defined by Spight, 1967a). Following dehydration, each frog was placed in a plastic dish containing soil of the desired moisture tension. We buried the frogs in the soil in order to insure complete body contact with soil. The dishes were covered and sealed for 12 hr. Any animal that migrated to the walls of the container during rehydration was not included in the sample.

Immediately upon removal from the soil, the frogs were brushed clean and weighed. Animals were returned to the soil and reweighed until they reached a constant weight.

Other frogs were placed in a container of water and held for 12 hr to compare rates of rehydration from free water and saturated soil. Rehydration rates were calculated on the basis of body surface area using the equation $\log SA = 1.131 + 0.597 \log W$ (Hutchison et al., 1968).

Results

There was a positive correlation between the ability of frogs to absorb water from the soil and the habitat and behavior of a species. *Bufo cognatus*, *Scaphiopus couchi* and *Scaphiopus hammondi* were able to absorb water at a soil moisture tension of 2.5 atm (Figs. 2 and 3). These fossorial species inhabit semiarid and arid regions of the southwestern United States. *Bufo americanus*,

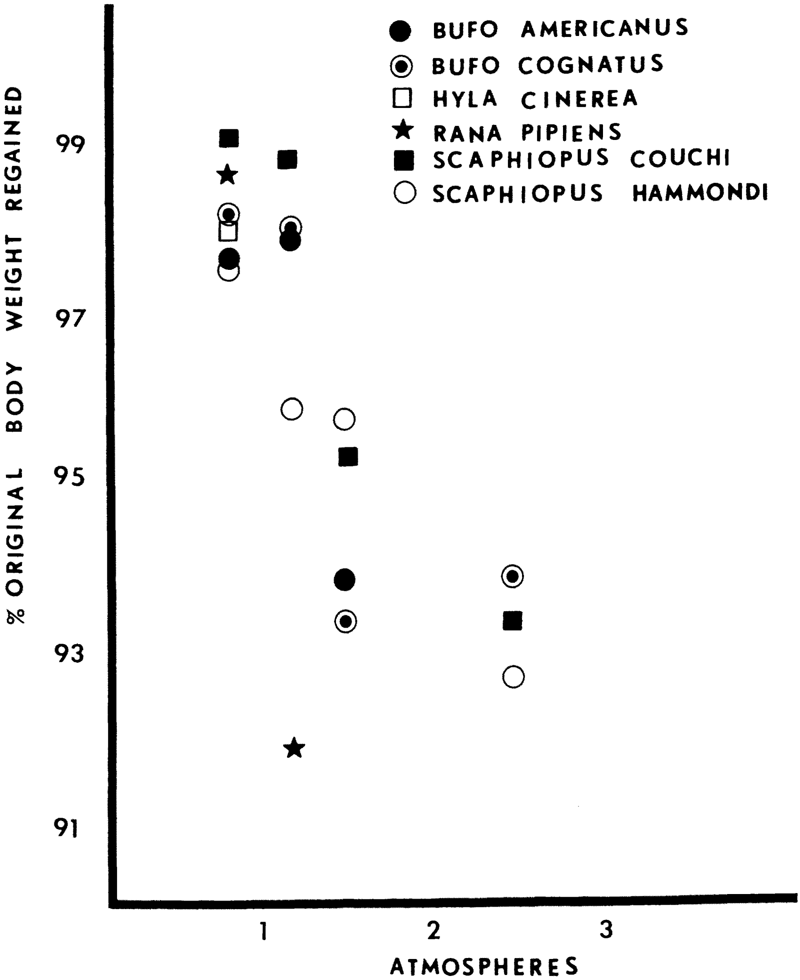

FIG. 2.—The rehydration per cent of several anuran species in soils of different moisture tensions.

a fossorial toad from the eastern states, was able to absorb water at a soil moisture tension of 1.5 atm. *Hyla cinerea* had a soil water absorption threshold at 1.2 atm, and *Rana pipiens*, which inhabits moist terrestrial areas, was able to absorb moisture from soil only at 0.8 atm.

S. couchi, *B. cognatus*, and *B. americanus* were able to fully rehydrate using soil moisture at a tension of 1.2 atm (Fig. 1). If 70% of dehydration deficit regained is the criterion for full rehydration, *S. hammondi* was also able to do this (Fig. 3).

All species were able to rehydrate more rapidly in free water

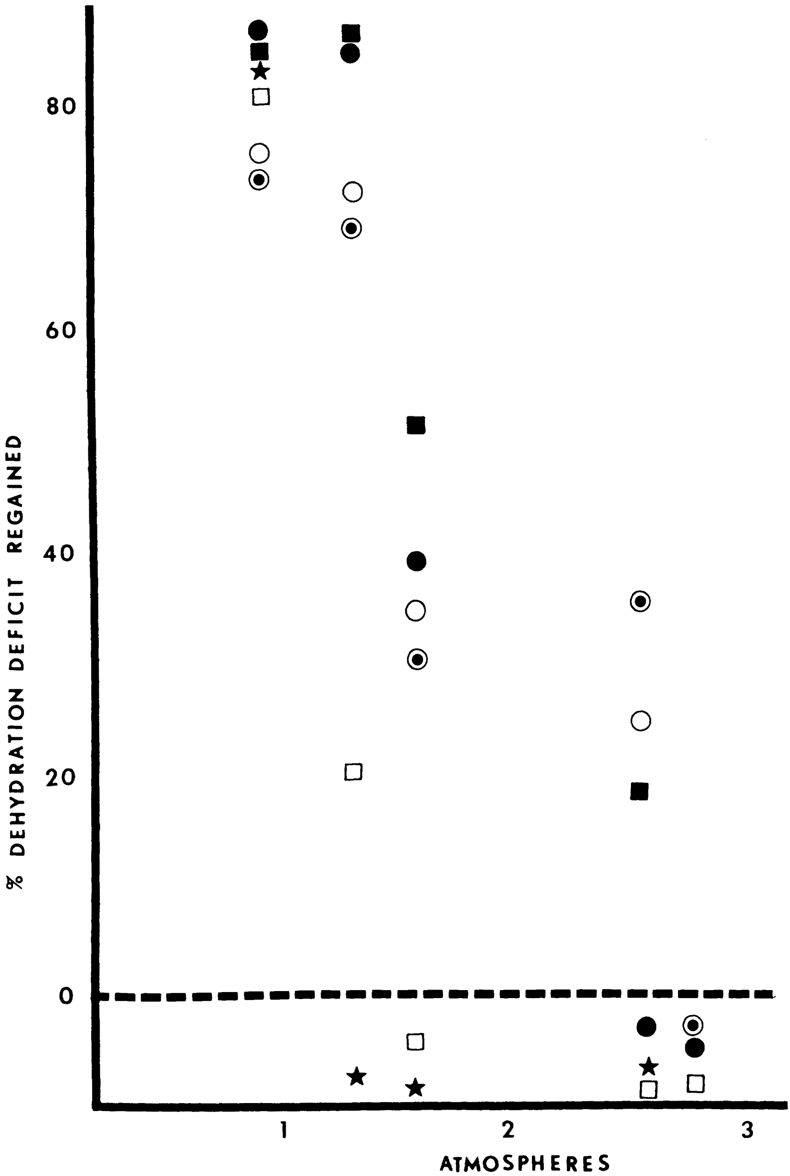

FIG. 3.—Rehydration in several anuran species expressed a per cent of dehydration deficit regained in 12 hr in soils of different moisture tensions. See Fig. 2 for legend.

than in soil saturated with water at 0.8 atm. Mean rehydration time in free water was 8.5 hr in comparison to 12 hr in saturated soil.

Rehydration rate was related to soil moisture tension at soil

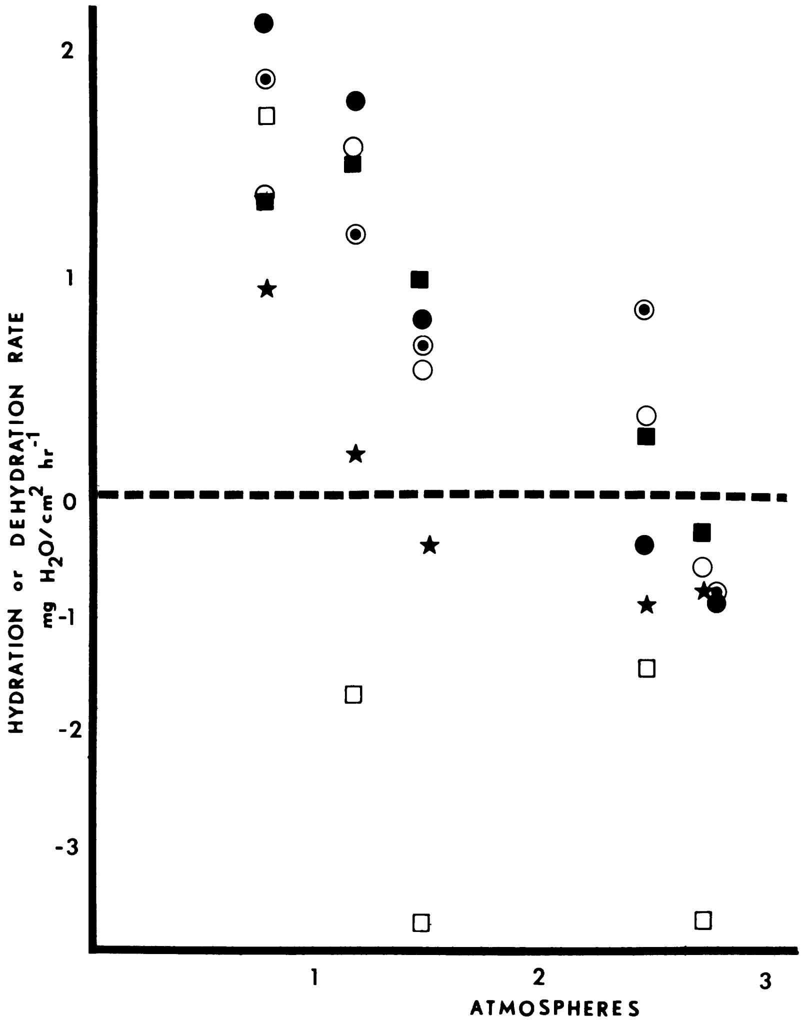

FIG. 4.—Rehydration or dehydration rate in several anuran species in soils of different moisture tensions. See Fig. 2 for legend.

moistures where species could not rehydrate (Fig. 4). There was no significant difference in rates of water loss to the soil in species unable to rehydrate at a given moisture tension except in *Rana pipiens* at soil moisture tensions of 2.75 and 1.5 atm.

DISCUSSION

Ruibal et al. (1969) reported that the "absorption threshold" for *Scaphiopus hammondi*, based on field and laboratory data, appeared to be above 10 atm. In this study *S. hammondi*, *S. couchi* and *B. cognatus* lost water to the soil at a soil moisture tension of only 2.75 atm and had an absorption threshold between 2.5 and 2.7 atm. Ruibal et al. (1969) did not allow the frogs to fully hydrate before measurements were made, and the frogs probably had a higher osmotic concentration of body fluids, which will affect the ability of frogs to absorb water from the soil. Ruibal et al. (1969) state "their gain and loss of weight (water) was the result of the immediate relation between the osmotic concentration of the toad and the soil moisture tension." Our study tested the relative ability of anurans from different habitats and with different behavior patterns to absorb moisture from soil. Consequently all frogs were allowed access to free water for one week prior to initial dehydration and were therefore subjected to essentially the same dehydration deficit, i.e., 10% fully hydrated weight.

Comparison of rehydration rates from soil and water obtained in this study with those reported in the literature are difficult because of variance in the time on which the rate was based on dehydration deficit. Spight (1967a) demonstrated in salamanders that hydration rate is a function of the dehydration deficit. The rates of water absorption from soil by anuran species was essentially the same as free water reabsorption rates of salamanders at 10% dehydration deficit (Spight, 1967a). Rehydration rates reported in other studies are based on higher dehydration deficits. Packer (1963) reported that *Heleioporus eyrei* absorbed water at essentially the same rate from wet sand (13.4% water) and free water. There was a difference in the rehydration rate from soil at 0.8 atm and free water in this study, but soil at 0.8 atm is not saturated and wet sand at 13.4% may be. We assume that there would be no difference in rehydration rates in a saturated soil and in free water.

Of the species examined, only *R. pipiens* and *H. cinerea* had absorption thresholds as low as the salamanders studied by Spight (1967b). Spight (1967b) concluded that his study of four genera of salamanders exemplified the generalization that among closely related animals, species from quite different habitats have only minor differences in physiology. This generalization does not hold for the anurans we studied. Fossorial forms had higher absorption thresholds than nonfossorial forms, and fossorial species from xeric habitats had higher absorption thresholds than fossorial species from mesic habitats. We suggest that increased effectiveness in absorption of soil moisture may be a general adaptation of fossorial species, although other unrelated fossorial species should be examined.

Thorson (1955) and Claussen (1969) suggested that there is no obvious correlation between habitat selection and the rate of rehydration in anurans. Claussen (1969) concluded that distributions of anurans are probably determined by factors such as differences in ability to tolerate desiccation, storage and utilization of bladder water, and relative ability to reabsorb water from the soil. Our study supports the conclusion that ability to absorb water from the soil is a factor which in part determines the distribution of anurans.

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