

tiff that service which he paid for. (Auito v. American Casualty Co., 89 N.E.2d, 313, Ohio C.P. 1949.)

Either the injured or the insurance company may bring an action to obtain a determination of their rights under the policy. In the above case the insured initiated the action against the insurance company.

Declaratory judgment suits may be used to determine the title or right to possession of property, whether real or personal. In such actions the court may determine the construction or validity of deeds, leases, wills, and trust agreements, or it may determine rights where no instrument is involved, as rights acquired by adverse possession. Easements and restrictive covenants are frequently litigated in declaratory actions. In addition, courts may determine personal rights and status in such actions. For example, in one case the court determined a wife's marital status after her husband had procured a Mexican divorce. This was desirable since the wife had a right to know if the divorce was valid or if she was still married. Also, courts may determine legitimacy, paternity, and the right to custody of children in declaratory judgment suits.

A person may have the validity of a state statute or a municipal ordinance determined in a declaratory action. This is an especially useful remedy if the legislation is criminal since the person is not compelled to violate the statute or become a respondent in a criminal action in order to obtain a determination of its validity or construction. As stated by one court, "Plaintiffs seeking a declaratory judgment are not required in advance to violate a penal statute as a condition of having it construed or its validity determined." (Dill v. Hamilton, 291 N.W.62, Neb. 1940.) This statement should indicate the significance of declaratory judgments as a method of preventing persons from acting at their peril.

Declaratory judgment statutes are remedial in that they provide an additional remedy for litigants; they have not changed either the substantive rights of the parties or the method of trial. Both the Federal Rules and the Uniform Declaratory Judgments Act specifically preserve the right to a trial by jury in declaratory judgment suits. The right to a jury trial exists where such a right would exist in a coercive action based on the same facts. Judge Murrain of Oklahoma once stated in an opinion, "The procedural remedy afforded by the declaratory judgment act is neither legal nor equitable, however, its utilization does not alter or invade the right of trial by jury as

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# SPADEFOOT TOADS

By DR. ARTHUR N. BRAGG  
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**A**MONG THE MOST INTERESTING of North American native animals are the spadefoot toads (genus *Scaphiopus*), so-called because of the spadelike structure on each hind foot by which the animal burrows into the soil. Despite the fact that the first one of these toads was discovered over a century ago, we still have much to learn about their habits. Many generally well-qualified zoologists of the United States who live where these animals occur in abundance have never even seen one, and only within the past fifteen years have the tadpoles of all undoubted species of the spadefoots become recognized, even by specialists particularly interested in them.

The spadefoots inhabit suitable local niches in most regions of central and southern North America from southern Canada (in the West only) to beyond Mexico City to the south. Eight forms have been named, although some of these are not yet securely established as distinct from some others. The six generally recognized species are (1) the eastern or solitary spadefoot (technically, *Scaphiopus holbrooki* Harlan), (2) the southern spadefoot (*S. couchi* Baird), (3) the western spadefoot (*S. hammondi* Baird), (4) the plains spadefoot (*S. bombifrons* Cope), (5) the Mexican spadefoot (*S. multiplicatus* Cope), and (6) the savannah spadefoot (*S. hurteri* Strecker). Some believe that the forms *hammondi*, *bombifrons*, and *intermontanus* constitute subspecies or regional races of one basic species. Others think that there should be two genera recognized, *Spea* and *Scaphiopus* (in a restricted sense). Others hold them to represent subgenera, with four forms in each. All of this uncertainty in the names applied reflects our inadequate understanding of the evolution of the group. For our purpose here it suffices to use the common name without prejudice as to the final technical distinctions which will later be made as knowledge advances.

My own experience with spadefoots has been largely with the four forms which occur in Oklahoma, namely the savannah

spadefoot, the plains spadefoot, the southern spadefoot, and the western spadefoot. The last mentioned has never been found breeding in Oklahoma; I have studied this one in New Mexico.

Spadefoot toads are small, short-legged animals of secretive nocturnal habits. They range in length, as adults, from two to four inches, although some females may be slightly larger. Their color varies so much as to baffle general description; but some shades of brown, grey, or dark green are common on the back, the belly being characteristically immaculate white. In at least three forms, white or whitish areas also occur on the back. A few are warty; others are smooth. The skin is delicate and thin, more like that of a frog than of a toad. It secretes a thin watery mucus much like that of a frog. All adult females (and, to a much smaller extent, males) secrete a musty-smelling material which when handled is irritating to human mucous membranes and has a very unpleasant, extremely peppery taste. I tried it once and once was enough! This is thought to protect the animals from predators, the females needing protection more than the males because they are by nature the "custodians" of the eggs, all-important for the survival of the race.

Spadefoots are as nearly entirely nocturnal as any North American animal. Almost never has one been found active except at night, and then only during breeding. They often are very secretive, as well. For example, I have several times observed thousands, sometimes literally hundreds of thousands, of young savannah spadefoots emerging from a pool at their metamorphosis and have hoped each time to collect samples of them in the region of the pool to study their growth rates. Always, within two weeks, usually much less, they have almost completely disappeared. Only twice have I found one or a few individuals of known age and on both occasions the animals were of a size which showed rapid growth. From this it must follow that the animals were active and feeding either in

areas unsearched or at a time of day not utilized by me, such as the very early morning.

SOME RECENT OBSERVATIONS indicate that adults tend to emerge later and later at night to feed as a given season progresses. Other observers on other species of spadefoots report similar tendencies. Some years ago Ball, in connection with his studies of the eastern spadefoot, pointed out that only a few times in 125 years have these spadefoots been seen in New England although reported at least once as far north as Cambridge, Massachusetts. Ball found them abundant in Connecticut in regions where they had not been reported for many years. It is very unlikely that their sudden appearance after so long a time could be due to migration or other forms of reintroduction; hence it is practically certain that they had resided unnoticed in Connecticut through the years. But some other species are not so secretive. In Oklahoma and Texas, the plains and southern spadefoots are often abundant on prairie roads at night, especially in late spring and in moist weather in summer.

In former years, before the habits of other species were known, the scarcity of records of the eastern spadefoot gave rise to an error which persists in some circles even now. The idea was that this animal spends a large percentage of its time below ground, usually emerging only briefly each year or two during heavy rains to breed and then returning to the soil. No one seemed to wonder how such an animal could feed, although its structure obviously suggests feeding habits like other frogs and toads, none of which can or do secure food below the earth's surface. The spadefoots do remain buried in the soil for long periods when necessity demands it, but only at times of extreme drought.

The thin, shiny skin of spadefoot toads suggests frog-like habits and habitats. From skin structure alone one would infer that they live in moist climates and in or about streams and ponds. Nothing could be farther from the truth! The habitat of these animals is characteristically dry land and, as a group, they are the inhabitants of prairies, semi-desert, and desert communities. Only two of the eight forms are present in the moister eastern part of the United States—the remainder tend to live in regions of very dry climates. In Arizona, for example, where the largest garden toad present (*Bufo alvarius*), as well as some other toads, tends to stay about irrigation

ditches, pools, and streams, spadefoots of at least three species range widely among the cacti of the dry terrain. They also occur in large numbers throughout the vast dry plains of western Texas and in their extension into Mexico, particularly in the West; and they are found in the deserts of southern California, not rarely and in specially moist situations as one would predict from their skin structure, but widespread in some of the driest regions in the country. The drier the climate in any part of the United States or Mexico, the more likely will spadefoots of some sort be present in abundance. Sometimes only one species will be represented, but more often at least two, and sometimes three forms occur together.

Such observations give rise to the theory formulated by Dr. V. M. Tanner that the present home of the majority of spadefoots is in or near their point of origin. They apparently arose somewhere in the southwestern deserts of the United States or Mexico and, spreading out from there, differentiated into several species or forms during the thousands of years since the first was produced.

How can such an amphibian, belonging to a great vertebrate class still partially tied as a whole to an aquatic environment, manage to exist in what superficially seems to be so adverse a habitat? One could, perhaps, conceive of a sparsely distributed, single form doing so in special localized areas to which it is adjusted, just as, for instance, several fishes exist in the desert water holes; but here is a group definitely belonging to the desert fauna in a more fundamental sense than such fishes, a group represented by several species, usually extremely abundant as individuals and often living for long periods far removed from natural waters. Obviously, the spadefoot toads have peculiarities not usually associated with amphibians that adjust them nicely to their lives in dry places. What are some of these characteristics?

ONE SUCH CHARACTERISTIC is their habit of burrowing which protects them from desiccation. Another is the associated habit of shunning the light and thus emerging only at night, which, relative to the day during the hotter months, is cool, even in desert regions; perhaps one should say especially in desert regions. But their most interesting characteristics are associated with their breeding pattern and habits.

Like most frogs and toads, the spadefoots lay their eggs in water; these hatch to tadpoles which feed on materials available in pools, grow somewhat, and eventually metamorphose to the adult form. Like those of

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Since Dr. Arthur N. Bragg, Professor of Zoology, Herpetologist of the Oklahoma Biological Survey, and Curator of Amphibians in the J. Willis Stovall Museum, joined the University Faculty in 1934, he has been one of the most active researchers in the faculty. He has written well over a hundred articles for publication in scientific journals. The Quarterly gladly prints this article on what has been Professor Bragg's lifelong interest.

other types of frogs and toads, too, the eggs are protected by heavy gelatinous coats through which the larvae must emerge at hatching. Fertilization of the eggs is external to the body of the female and occurs immediately as the eggs are laid.

Spadefoots breed normally only during or immediately after rains and usually in the pools recently formed. This might indicate merely that this is the only water available to them, something often true; but with plenty of water present, no spadefoot utilizes it until rain comes! Rainfall is an absolute necessity for the initiation of their breeding behavior. Not only this, but also some spadefoot species react more to the amount of rainfall, others more to its rate of fall. In general, those species which typically inhabit the drier regions breed more actively after violent rains (the western, plains, and southern spadefoots, for example), whereas those of moister regions (eastern and savannah spadefoots) react more to amount than to rate of rainfall.

Temperature also influences the breeding behavior of these toads. They begin breeding only at air temperatures no lower than about 9 or 10° C. (49-50° F.). At or near these critical limits a very few individuals may breed after rain, but breeding in large numbers does not take place when air temperatures are below 10° C., usually not below 12° C. Several observations, indeed, have been made which indicate that in the plains spadefoot stimulation from a violent storm is in conflict with inhibition by cold.

Accumulated soil moisture also may be a factor in the initiation of breeding behavior of spadefoots. Some years ago Albert and Minnie Trowbridge, then students at the University, pointed out that the plains spadefoot about Norman did not always breed after the first spring rains, as commonly thought at that time. Rainfall data, some secured at temperatures high enough not to complicate matters, were presented

tending to show that this species has a breeding season modified by the effect of ground moisture. When sufficient soil moisture had accumulated, then and *only* then, could rainfall initiate breeding activity.

Because practically nothing has been observed specifically on the physiology of spadefoot toads, we must fall back upon the probabilities deduced from the study of other amphibians. Vertebrates in general are known to have a reproductive cycle, often annual. The physiological basis for control of this sexual cycle has been found to be basically hormonal in character in all vertebrates so far studied, including several species of frogs; secretions of the pituitary glands as well as other hormones seem always to be involved.

In many frogs and toads, the gonadal cycles and hormonal cycles are synchronized to form a seasonal reproductive cycle, culminating in a breeding period of rather short duration sometime during each year. Typically, this period falls in the spring-time, and seems to be reasonably definite for each species except that it may be modified in time, within limits, by variations in temperature and rainfall. But whatever the details may be and however much modified by locally prevailing temperature or rainfall, whenever this phase of the cycle has passed, no further breeding normally occurs.

In the spadefoot toads, however, a seasonal reproductive cycle is not at all the case. Two or more years may pass with no breeding whatever by any members of a large population, whereas in another even possibly adjoining population, one or more breeding periods may occur. Or the reverse may be true: that is, a few or a large number of a given population may breed each year for several years. The basic reason for this is, of course, that the animals breed only after rain, which, in deserts, may not occur locally for long periods.

FROM THE ABOVE it is evident that the spadefoot toads do not have a breeding *season*. Their breeding *periods* come sporadically during any of the warmer months whenever sufficient rainfall occurs to stimulate this activity. Interpretation, therefore, solely on the basis of gonadal and hormonal cycles common in many species in other genera, is difficult. Either such cycles do not occur in spadefoots, or they are modified to include the sudden culmination of the cycle in properly stimulated individuals during and immediately after each rain of sufficient severity or amount.

These details in the breeding pattern of

the plains spadefoot are duplicated in many important respects by other species—but there are also differences. The plains spadefoot, the western spadefoot, and the eastern spadefoot all typically use deeper pools or deeper parts of single pools when these are available (water one to three feet in depth). In contrast, the savannah spadefoot and the southern spadefoot use water of a few inches to one foot in depth even when deeper water is also available. However, all spadefoots in my experience will use any temporary water, deep or shallow, rather than not attempt to breed at all. What such apparent preference is based upon, I have no way of knowing, but it is evident that it is one fairly effective barrier to the crossing of species. In southwestern Oklahoma, for example, three species breed in the same region following violent rains. Two of these are “deep-water” species, the other a “shallow-water” form. I have found evidence of the crossing of the “deep-water” populations in this region but never of the “shallow-water” one with either of the others. Any such method as this of sexual isolation is involved in the mechanism of evolution and is important to students of speciation.

One of the most intriguingly interesting things about the spadefoot toads is the evolutionary adjustment made by their tadpoles to desert and prairie pools of temporary water. Biologically these animals face two interrelated problems: (1) They must develop fast enough so that on the average at least some will succeed in metamorphosing before evaporation of the water from their natal pool is complete, and (2) to do this they must secure food in enormous quantities from a place which by nature is likely to have little of it. “Deep-water breeding” forms do not face these problems so acutely as do the others, of course: accordingly their growth rate is not so fast.

In the savannah spadefoot and the closely related solitary spadefoot, the problem of food is partially met by social action; that is, by co-operation rather than competition as one might expect among the crowded individuals in a pool. As the water level falls and conditions worsen, half grown tadpoles swarm together in schools, stirring up the bottom of the pool and wafting particles through the mass of swimming animals, which catch them as they come by them in a steady stream. A marked current often flows out behind such a solid mass of swimming tadpoles, carrying with it mud and plant debris from the pool's bottom. Nothing organic in the pool escapes them: plant stems are thoroughly scraped, planckton organisms are eaten, dead animals even of their own kind are taken avidly by these

animals: even bottom mud with its small accumulation of organic matter is eaten when other sources of food fail. Under some conditions not clearly understood these tadpoles become avid cannibals, attacking each other viciously. Biologically this is sound practice for them because it is much better that *some* should survive to reproduce than that *all* should starve or fail through lack of food to metamorphose in time to escape desiccation as the water level falls to zero.

In many pools the race with evaporation is lost and all are killed, despite their fast rate of development (faster than any other known amphibian). But even then they unconsciously serve their species, for their dead bodies become a portion of the organic matter of the former pool's bottom, and are food for oncoming generations later developing here with further rains.

As the water evaporates when these tadpoles are near metamorphosis, they often co-operate in another manner. They form what I have called metamorphic aggregations. At such times the animals gather on the bottom and mill slowly about without feeding. They may behave thus for hours or they may separate and re-form into other aggregations later. Eventually all in such great masses have all four legs and are ready to leave the water. What happens then appears to depend on the time of day (probably actually an obscure effect of light). In any event, if the majority become ready to leave the pool during daylight, nothing especially happens. If, however, this occurs at night, the whole mass moves *en masse* to the shore and crawls out. Only then does the tail begin to shrivel. Within a half hour only a stub remains and before morning each tadpole is a complete little spadefoot.

Such metamorphic aggregations have been reported in only one species (the savannah spadefoot) but it has also been seen in the eastern form. It probably does not occur or, if so, is very rare in other species.

No one knows exactly what such peculiar behavior means to the lives of the animals. It has been suggested that the lashing tails of hundreds of thousands of tadpoles may waft mud from the area beneath them, thus digging a depression. Such action might in this way conserve the all important water for a few hours longer. Indeed I have known this to be the case in at least three instances: but sometimes such aggregations form where there is plenty of water and at other times fail to form when there is not.

Thus we see that there is still very much to learn about the lives of the spadefoot toads. Enormous strides have been made in the past fifteen years but each season of

observation offers still more problems. But after all, this is what keeps us intellectual workers happy. If we knew it all now, about the spadefoots or anything else, life would be boring indeed.

## Books

*The Agricultural Regions of the United States.* By Ladd Haystead and Gilbert C. Fite. University of Oklahoma Press, 1955. Reviewed by Thomas Harry McKinney.

This book is a concise analysis of the economic and geographic factors that make American agriculture what it is today. It is designed to be severely functional and is intended as a tool for students, county agricultural agents, teachers of vocational agriculture, businessmen, and all others interested in understanding why our nation's farm output is the largest and one of the most varied in the world today. At the same time, the authors express the hope that some of the drama, the beauty, and the quiet emotional liaison between the husbandman and his environment show through the utilitarian goals.

Almost everybody has his own idea of

what he considers to be the typical American farm. The picture he has in mind is usually based on limited observation or childhood experience. The authors contend that the "typical" American farm is nonexistent. Furthermore, they feel that this fallacy of reasoning from the specific to the general causes many people to make errors in judging modern American agriculture. "Farm patterns not only have changed incredibly in the last generation, but are in a continuous process of change right now." For this reason, "nobody can make a fair judgment on anything concerned with American agriculture unless he has a clear picture in mind of the scope, variegation, and transitions of this highly mutable industry."

Eleven chapters are devoted to fact-filled discussions of agriculture in the various geographic regions of the United States, ranging from "New England: Land of Abandonment" to "The Western Slope: Land of Tomorrow." Useful, up-to-date information on soil groups; crop and livestock production; and number, size, and class of farms is presented, by states, for each region.

Ladd Haystead and Gilbert Fite have done a competent job in presenting a brief but thoroughgoing analysis of agriculture

in the United States. They have succeeded where other writers often fail. They include the enormous quantity of statistical data needed in a book of this type, yet they do it in such a way that the reader is not burdened or bored by its presence. As well as being informative, the book is easy to read and interesting.

## Declaratory Judgment Suits . . .

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at common law." (*Hargrove v. American Central Ins. Co.*, 125 F2d, 226, 10 Cir. 1942.)

Forty-six of the forty-eight states have passed declaratory judgment acts; Oklahoma and Mississippi are the two exceptions. However, the federal courts in Oklahoma may grant declaratory judgments. As a result, this remedy is available in Oklahoma where citizens or corporations of other states are involved, but the action must be brought in a federal court. An Oklahoma citizen cannot bring such an action in the courts of his own state. Since this remedy has such enormous and far-reaching possibilities in preventive relief—prevention of uncertainty and misunderstanding as to rights—Oklahoma courts should be authorized to grant declaratory judgments.

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