The edge of the Sonoran Desert in Coachella Valley, California, with Mount San Jacinto (elevation 10,805 ft.) to the west. (Photo by R.B. Cowles).

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Recorded in the Chiricahua Mountain Region during the Dry and Wet Seasons; in the Tucson Region during the Wet Season; and Miscellaneous Sounds: by Charles M. Bogert, Dept. of Amphibians and Reptiles, Museum of Natural History, N.Y.

Doves, Mockingbirds, Robins, Rattlesnakes, Grosbeaks, Kingbirds, Woodpeckers, Whippoorwill, Hummingbird, Owls, Crickets. Thunderstorm, Flash Flood, Toads, Frogs, Bobcats, Beetles, Javalinas, Mountain lion-Puma.

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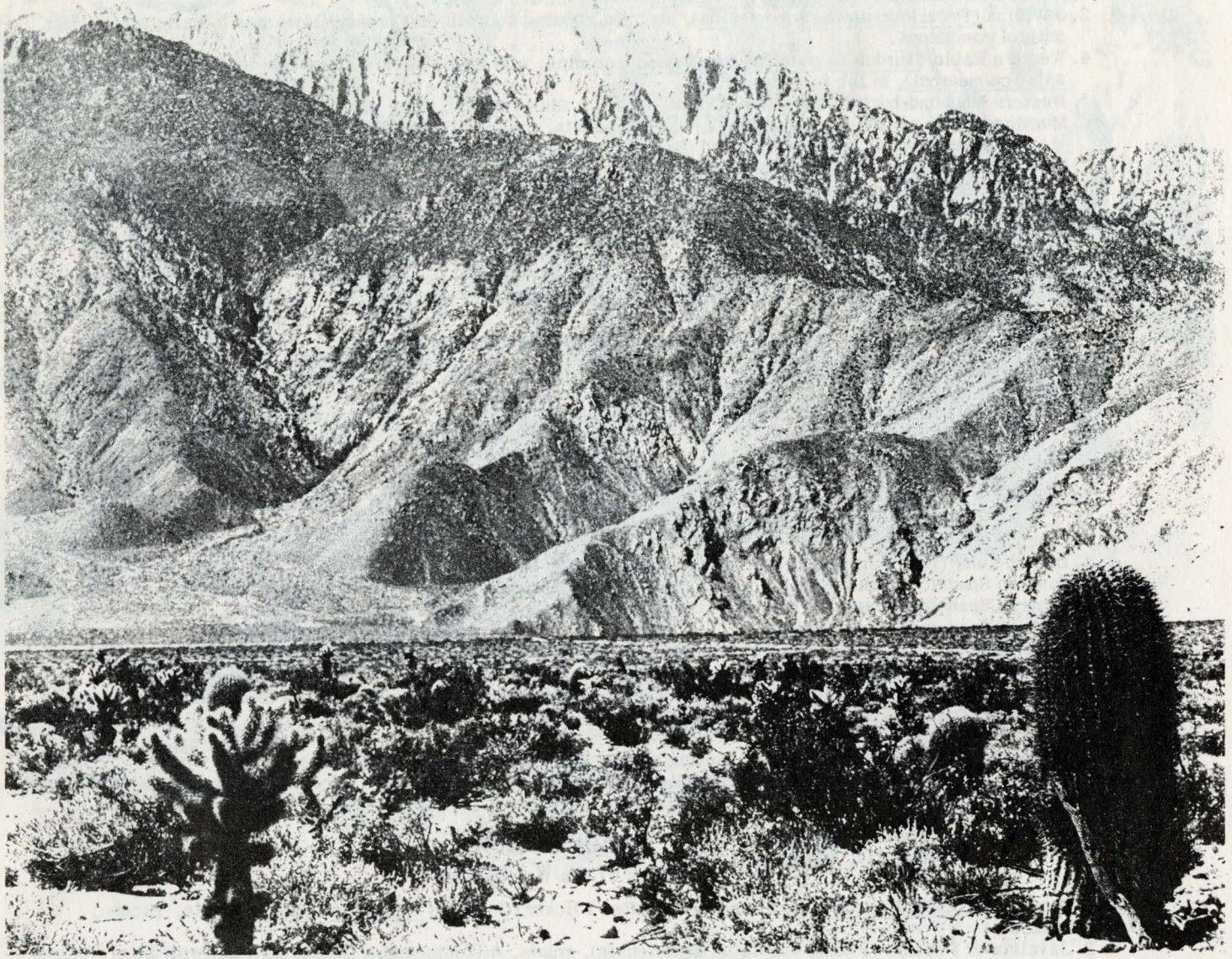

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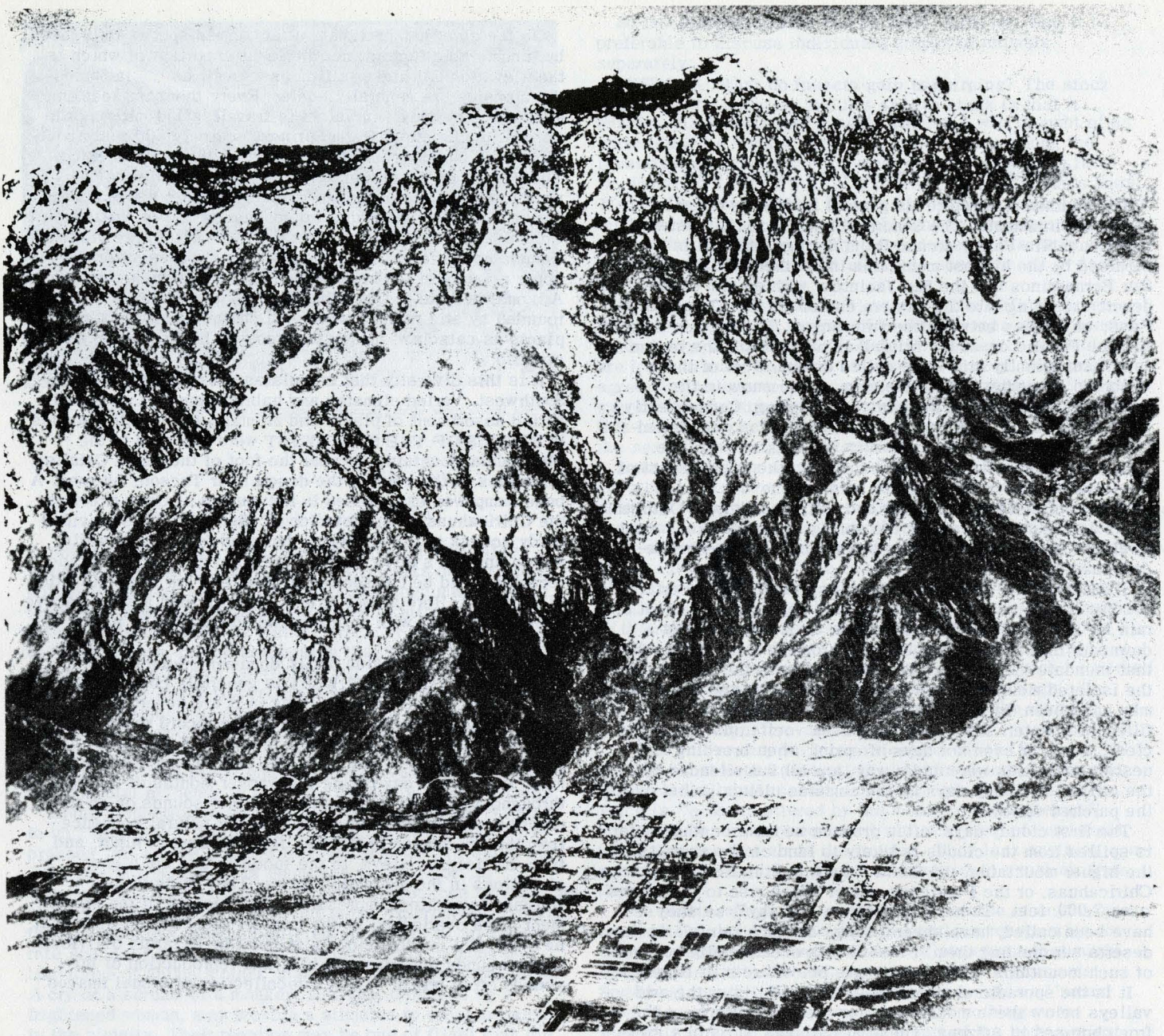


The town of Palm Springs in Coachella Valley, California, at the edge of the Sonoran Desert, with Mount San Jacinto rising to an elevation of 10,805 feet in the background, from the air. (Photo by Frank Bogert).

SOUNDS OF THE SOUTHWEST

by Charles M. Bogert

Department of Amphibians and Reptiles
The American Museum of Natural History

Natural sounds, whether the songs of birds, the flutter of wings, the calls of amphibians, the chirping of insects, or such noises as thunder, are an integral part of most environments. Aside from their biological significance, many animal calls are intrinsically interesting. Prior to the advent of the portable tape recorder, naturalists struggled with descriptions of sounds — a thoroughly unsatisfactory procedure as most investigators realized. One frog is described as having a call "like the loud purr of a cat, with the metallic sound of grinding gears." Other authors described the same calls as "a low-toned tirr-r-r-r," as "a loud crah-crah-crah," "a resonant yeow," or "a snore-like cry." It is manifest that these descriptions convey almost no meaning. Even without the psychological overtones that enter into the use of phonetic symbols, language is inadequate to describe sounds, particularly those produced by animals.

Fortunately it is no longer necessary to try to put into words what can more readily be put onto tape. SOUNDS OF THE SOUTHWEST is the result of one summer's work with a Magnemite tape recorder. The sounds recorded are those that anyone traveling in the arid portions of southern California, Arizona and New Mexico might hear during a single summer. The record is not exhaustive, but it includes songs, calls, or noises heard during the end of the dry season in Arizona, as well as those heard during and following the rainy season. Most of the recordings were made in the field, with the following exceptions. The sounds produced by amphibians as well as the beetle held in the hand are, of course, from captive specimens. The bobcat, a juvenile, had been captured in Round Valley a few hours before its growls were recorded in Cave Creek, Arizona. The purring of the mountain lion and the noises emitted by a young javalina (or collared peccary) were recorded in the zoo maintained by the Arizona-Sonora Desert Museum near Tucson; these were obtained through the courtesy and the able assistance of the Director, Mr. William H. Carr, and the Assistant Director, Mr. William H. Woodin, 3rd.

Where the Sounds were Recorded

The Southwest, despite its general aridity, is a region of varied environments. The Sonoran Desert extends westward into Coachella Valley around Palm Springs where it is bordered by the highest mountains in southern California, the San Bernardinos and the San Jacintos, with an arm of the desert extending into the eastern end of the San Gorgonio Pass, which lies between the two ranges. Toward Los Angeles and the Pacific coast the rainfall is heavier and the region is not sufficiently arid to be called desert. West of the Colorado River the bulk of the rain, or the snow in the mountains, falls during the winter and spring. Consequently much of the activity among animals, particularly the breeding of the frogs and toads, reaches its peak at this time.

In direct contrast, winter and spring in the regions east of the Colorado River are likely to be dry. The wet season is largely confined to the summer and fall, from July to October. Birds and mammals breed in the spring, but amphibians must await the onset of heavy rains before pools or streams become available.

Throughout the deserts rainfall is sporadic and uncertain — some localities may not receive any appreciable amount of rain for several years in succession. Or it may come as a downpour that fills the streams with roaring flash floods that that inundate the valleys. Thunder echoes in the canyons of the isolated mountains surrounded by deserts, and lakes that may have been dry for months or even years are suddenly filled with water. Birds that have been vociferous during the clear, warm, or even hot days of spring when breeding and nesting activities were under way, are all but silenced by the arrival of cloudy days as the cumulus clouds gather over the parched valleys.

The first cloudy days often produce no rain. or what water is spilled from the clouds is likely to land on the summits of the higher mountains, the Santa Catalinas, the Huachucas, the Chiricahuas, or the Pinalenos, all of which rise to elevations over 7,000 feet. These "islands in the sky" as they have been called, have several times as much rainfall as the deserts surrounding them. Flash floods occasionally pour out of such mountains while the deserts below are still bone dry.

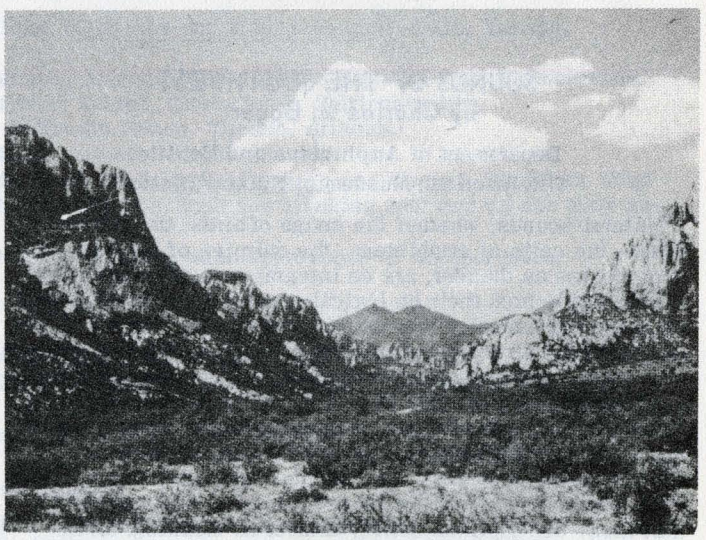
It is the sporadic cloudbursts in the foothills or the arid valleys below these mountains, however, that bring out the frog choruses in Arizona. These amphibians, the frogs, treefrogs, toads and spadefoots, have been buried in the ground throughout the long dry season. They are rarely in evidence during the day, but as soon as darkness approaches, sometimes with earth still caked on their backs, they emerge by the thousands, probably by the millions if the whole desert is taken into consideration. At close range the choruses set up, particularly by the Great Plains Toad (Bufo cognatus), are almost deafening.

There is, then, something of a sequence of sounds, some of them seasonal and some more or less dependent upon weather conditions, or upon the daily rhythm of light and darkness. However, no two regions are identical ; frog choruses in California, except in the higher mountains, have subsided by the time amphibians start to call in Arizona. Both temperature and rainfall govern the activities of the cold-blooded reptiles and amphibians, whereas the breeding and courtship of the internally heated mammals and birds are much less influenced by temperature than they are by the seasonal differences in the length of the day. Photoperiodicities, to use the technical term, exert a profound influence on the breeding seasons of many mammals and birds. Most of them breed during the spring in California just as they do in Arizona.

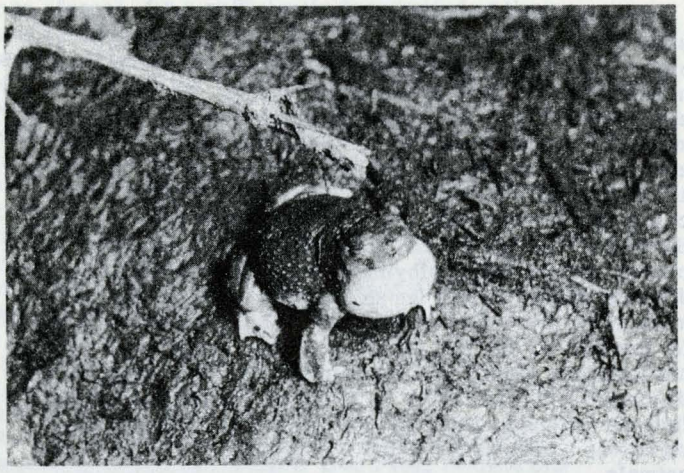
On the other hand, climate at any given spot is influenced by innumerable factors, not the least important of which is the elevation. At higher altitudes as well as latitudes the climates are generally cooler. Every thousand feet one ascends is roughly equivalent to traveling 150 miles northward. The climate at Palm Springs, scarcely 500 feet above sea level, closely resembles that of northwestern Mexico. The summit of Mount San Jacinto, only five miles to the west in airline distance, but over 10,000 feet above Palm Springs, has a climate that approximates that of British Columbia. Pines, fir, and spruce forests not unlike those in Canada or the foothills of the Rockies are present on the upper reaches of the higher mountains in southeastern Arizona, despite the fact that some of these ranges are surrounded by arid regions with such characteristic desert plants as catsclaw, mesquite, creosote bush, cactus, and ocotillo.

It is this diversity that stimulates the naturalist in the Southwest. Varied climates and habitats support an equally varied assortment of plants and animals. Many of the sounds in SOUNDS OF THE SOUTHWEST were recorded in the Chiricahua Mountains, or near the foot of the Santa Catalina Mountains at the edge of the desert near Tucson, Arizona. A base camp was established in the canyon of Cave Creek in the Chiricahuas at an elevation of 4500 feet. This provided ready access to the deserts a thousand feet below, while within an hour's drive on the Forest Service road, the tape recorder could be transported to Rustler Park at an elevation of 8000 feet. Here a cool stream emerges from a spring above a meadow dotted with wild iris and surrounded by pines, firs and quaking aspen.

Thus, while the region partly documented auraly in SOUNDS OF THE SOUTHWEST is generally characterized as arid, not all of the animals living in it are desert animals. Nor are all of the sounds reproduced on the record restricted in their occurrence to one season, to one time of day, or to one region. Rattlesnakes, for example, can be encountered at almost any time of day during the warmer months of the year throughout much of the Southwest. Other sounds on on the record are arranged in an approximately natural sequence from the dry season to the wet, from daytime to night, and from the desert valleys, to the foothills and the higher elevations in the mountains above. They bring to the listener an auditory impression of one aspect of the environment often overlooked by the traveler preoccupied with what he sees. But subconsciously at least he is rarely oblivious of the sounds that surround him, and reproduction of the sounds often brings with it a recollection of visual images.



Mouth of Cave Creek Canyon, from the east, Chiricahua Mts, Arizona.



Western Spadefoot (Scaphiopus hammondi) male with vocal sac inflated while calling.

Why do Animals Call?

Animals call, sing, stridulate (by scraping a file-like structure against another surface, as crickets do), or make noises in various ways. The sounds produced may alarm or intimidate enemies, or calls may serve to attract a mate. Others are interpreted as warning cries, or as manifestations of fright or pain, on the assumption that something resembling these emotions in man is present in the lower animals, at least in those above fishes. However, it is often difficult to ascertain whether the sounds produced by an animal are an expression of emotion, much less whether they have any functional significance. Somewhat doubtful theoretical explanations or interpretations are all that can be offered when experimental evidence is lacking, as it is for most animals.

Sound production in animals has sometimes been referred to as "language," but only in the limited sense that it expresses the animal's prevailing excitement. As early as 1900 the phonograph was employed in an effort to ascertain the significance of the sounds produced by capuchin monkeys. Garner, who carried out these experiments, reports that the monkeys attached different meanings to 30 separate sounds. However, the vocal expressions of monkeys, like those of animals other than man, never represent facts. A cry or a scream of a monkey, like that produced by a frightened woman, may provide a stimulus to other monkeys in the vicinity. Their reaction may be one of flight from the enemy that provoked the scream. As such it has protective value. It serves the same purpose as the expression of the soldier when he sees that he is outnumbered by an approaching enemy: "We'd better get the hell out of here." But the scream of the animal is not motivated by intellectual processes any more than is the scream of a woman who realizes that she is about to fall off a pier. Unlike the soldier, the monkey is not consciously protecting the others in his group. He is merely giving vent to his excitement.

Some animal psychologists are willing to extend the import of animal expressions to include humor" or "emotion." Other investigators would not go so far although most of them agree that "animal language" is almost entirely concerned with feelings. Even such animals as monkeys and the higher apes that have a "vocabulary" of many sounds at their command are quite incapable of carrying on a conversation. The call of one bird evokes that of another, the mating call of a frog entices the gravid female to the breeding site, or the hen emits sounds that bring her chicks to her side. Such actions represent a response to a communication, but they can scarcely be interpreted as even the rudiments of conversation.

So few generalizations can be made, however, that it is preferable to discuss individuals groups of animals separately:

INSECTS. What do insects gain by chirping? The stock answer to the question, and it's still in stock is that it enables the male to find a mate. The male was thought of as serenading the female. But there are skeptics among the investigators. One of the foremost entomologists, the late Dr. Frank E. Lutz (in A Lot of Insects, G. P. Putnam's Sons, 1941) tells how confident he was of "sound-making's value to the insects that do it," and he thought he had some clue as to how they got that way. Four decades after his early experiments he asked, "why must all of the sounds made by insects be 'useful'?"

Students of insects are well aware of the difficulties entailed in determining the possible significance of the second produced by any particular insect. Consequently entomologists are loath to make dogmatic statements. Some of them will agree that sounds serve as means of communication, that they may have some significance in warning, or in recognition, and that they are in some fashion concerned with the attraction of the sexes for mating, at least in a few species.

Lutz, quoted above, points out that the adult life of a male cricket is about a month. He spends most of his time chirping but very little of it mating. The female may wave her antennae in his direction, but otherwise she seems to pay little attention to a chirping male. As a further complication in any interpretation of the cricket's behavior, the female also waves her antennae at males that are not chirping, or what is even more disturbing and certainly less complimentary to the male, she waves them at sticks or stones. Lutz believes, however, that the female hears the male, for like many of her relatives, the female cricket with which he worked does have auditory organs, located on the front legs.

The Greeks are said to be responsible for the rhyme,

"Happy are cicadas' lives
For they all have voiceless wives."

It is true that sound production is confined to male cicadas. But technically all insects are voiceless. By definition a voice is "a sound uttered by the mouth of living beings" (Webster). Insects are equipped with a system of semi-rigid tubes that conduct air to the tissues. They lack anything comparable to the lung that would enable them to expel air from the mouth.

The shortcomings that prohibit insects' use of anything resembling a wind instrument are doubtless responsible for their production of sound by means of structures that might be classified with the strings or percussion instruments. Somewhat inaptly, these are usually discussed as "sound producing organs." They may consist of nothing more elaborate than the tapping of some part of the body against some object, or the vibration of the wings. Or, as in the cicadas which produce a great volume of sound, there may be special membranes set in vibration by muscular action. Some noises made by insects are still classified as being of "uncertain origin." But by far the greater number of sounds we hear, especially among the bugs, beetles, locusts, the crickets and their relatives, are the result of friction of one part of the body rubbed against another. These sounds are produced by special structures called stridulating organs.

Such structures function in much the same fashion as does the violin. Pulling a rosined bow across the strings sets them to vibrating. This produces a sound that is amplified by the sounding board, the wooden part of the violin. The cricket rubs one wing against the other. What produces the sound is a series of teeth like those of a file on the underside of the heavy rib across the front of each fore wing. These are rubbed against a rough, more or less circular area on the upper side of each wing, setting the wings into an exceedingly rapid vibration. A space in the center of each wing is clear, and this serves as a sounding board, amplifying the sound.

Beetles too have evolved a great variety of stridulating organs, and many of the sounds they make result from the rubbing together of contiguous segments, usually with a file-like surface on one of them. Darwin, who was so often right and, incidentally, not inhibited by animal psychologists who entered the scene later, discussed stridulation in beetles. In his book on the Descent of Man (of all places), he observes that beetles stridulate under various emotions, in order to excite or to call the female, in anger or in defiance, even from distress or fear if held so that they cannot escape. Indeed, Darwin went so far as to assume that one beetle "stridulates to encourage the female in her work, and from distress when she is removed."

Animal psychologists would find most of Darwin' s assumptions gratuitous, but few of them could come up with alternate explanations. Like Dr. Lutz, many of them would ask why it must be assumed that all sounds have some purpose. The same men, however, would object if it were assumed that crickets chirped or beetles made their noises just for the hell of it. They would prefer some non-committal explanation—that chirping or stridulation is merely an expression of a state of excitement, or that it is "part of their behavior pattern."

Whatever the explanation for sounds produced by insects, a fair number of them get along without making any, or those produced are quite incidental to flight or to other activities. However, some soldier termites produce a clearly audible sound by striking the floor of their tunnel, or several soldiers may hammer in rhythmic unison. It is certainly to be doubted that the termite knows why he is thumping, but there is some basis for interpreting the results as a warning signal to other members of the colony.

It may be added that Dr. Lutz did much of his work with cricket,(Gryllus domesticus),which does have "ears," tympanic organs, or phonoreceptors. Other insects lack such specialized structures but are still sensitive to sound owing to presence of hair sensilla. It is generally believed that the Tree Cricket or Temperature Cricket(Oecanthus niveus) (Band 10, Dry Season) is deaf, because it has no auditory organs. However, the lack of auditory organs is not conclusive proof of deafness. When the tympanic organs of other crickets are extirpated normal responses to sound are abolished, but some sensitivity to sound is still retained.

By means of refined techniques of "wire tapping," the electrical discharges of nerves leading from tympanic organs to sensory nerves or the central nervous system can be recorded and the sensitivity of insects to sound can be measured. In katydids a response was detected for stimulation by sounds between 800 and 45,000 cycles or vibrations per second. Sounds at the maximum frequency, of course, are well beyond the range of hearing in man, and it is perhaps not without significance that sounds of such high frequency are often produced by the animals capable of hearing them.

Sonoran spadefoots in amplexus (clasping, or in position for deposition and fertilization of the eggs.

AMPHIBIANS. Frogs and toads are more often heard than seen. Ordinarily only the male is provided with a voice. It plays a part in sex recognition, but the call most often overheard is the one used to attract the female. She may be either mute or able to produce much less audible sounds. The male selects the breeding site — a pool, stream, or whatever sort of place is characteristic of his species. Upon his arrival he starts calling. Other males are attracted by the call to the breeding site selected by the first male to arrive. Somewhat later the females seek out the source of the chorus, presumably employing auditory cues to locate individual males. When a female comes in contact with the male, or sometimes even when she is barely close enough for the male to see her, he abruptly stops calling and clamps his forelimbs around her. He clings to her back until she has deposited her eggs, which he fertilizes as they pour forth from her oviducts. From the biological viewpoint the call serves as a substitute for the courtships employed by other animals.

It strains the connotations of the word to refer to frog calls as "song," although several have been described as melodious. No two species produce the same sounds and the female is attracted only by the call of her own species. Even when several kinds of frogs breed simultaneously in the same pond, the female is rarely seized by a male of another species. Voice may be a factor in the female's selection of a partner to fertilize her eggs, although other cues are employed. Males of other species are rejected, however, if they attempt to seize her.

Whatever supplementary means are used, voice plays an important role in reproduction and hence also in the maintenance of the species. Each kind of frog is specialized for some particular mode of existence. In many instances an egg of one species fertilized by the sperm of another results in the formation of an embryo that fails to develop because of genetic incompatability. It would be disadvantageous if hybrids were often produced, for such bastard offspring in all probability would be ill-adapted for survival in any habitat. Biologists recognize what have come to be known as "isolating mechanisms," anatomical, psychological, or other differences between species, however closely related, that prevent or discourage the production of hybrids.

Such differences between populations often come about as the result from temporary geographical separation of stocks having a common origin. The voices recorded in SOUNDS OF THE SOUTHWEST bring to light an example of this sort. One group of tree frogs (Hyla) in the United States is represented in three areas. The Eastern Tree Frog (Hyla versicolor) inhabits most of the eastern half of the country, from New England to central Texas, but it is absent from the latter state west of the Pecos River. Farther west another species, the Canyon Tree Frog, (Hyla arenicolor) is present in southern Colorado and Utah, ranging southward through western Texas, and the mountains of Arizona and New Mixico, onto the Mexican Plateau. However, it is absent from the lower deserts to the west around the Colorado River. Beyond this gap in the range a population similar in appearance and habits lives in the mountains west of the desert, in southern California and nothern Baja California.

In the past it was assumed that these tree frogs on both sides of the desert belonged to the same species. However, the voice of individuals recorded in the Chiricahua Mountain of Arizona proves to be similar to that of the Eastern Tree Frog, but lower in pitch. Both of these frogs have a call (the call of H. arenicolor is reproduced on Bands 5a, 5b, in the Wet Season series on the record), consisting of a trill, a wavering sound, in direct contrast to the simple "quack" of the Canyon Tree Frog in California (heard in the background of the Pacific Tree Frog, (Hyla regilla) chorus recorded in the San Jacinto Mountains of southern California, Band No. 2 included with Miscellaneous Sounds on the record).

The recordings of these voices, therefore, supply evidence that the populations on each side of the desert have been geographically isolated, without any interbreeding or ex-

change ofgenes, for a sufficiently long period of time, possibly thousands of years, for them to have evolved along somewhat different lines. Enough differentiation has occurred, not only in the voice but in morphological characters as well, that it is doubtful whether they would interbreed, were the intervening deserts suddenly to become wet enough to permit them to expand their distributions to the extent that their ranges would overlap. Whether females from Arizona respond to the call of males from California is a problem that can be settled only by experiment. Nevertheless it seems improbable that the call of one would attract the other. Other factors might make it impossible for them to interbreed. In other words, "isolating mechanisms" of one sort or another may have arisen during the long period that the two populations were separated geographically. The populations on opposite sides of the desert could well behave as though they were distinct species.

The similarity of the call of the Canyon Tree Frog in Arizona and that of the Eastern Tree Frog, despite pronounced differences in pitch, suggest that there may be a gradual trend from New England to Arizona in the characteristics of the voices of these tree frogs, with intermediate voices in Texas. Such gradients or "clines" have been demonstrated in frogs for other characters. Now that portable tape records are available, similar phenomena can almost certainly be demonstrated in animal calls.

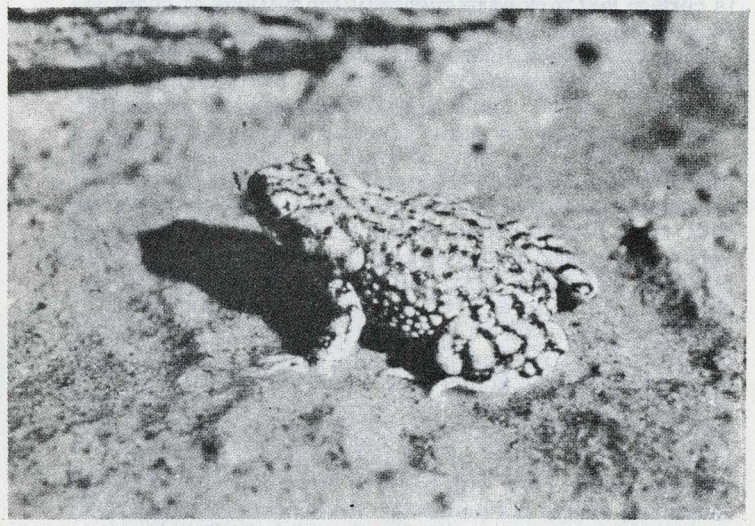
In addition to species recognition, frogs employ their voices for other purposes, notably for sex recognition. One male toad while calling is sometimes approached by another. If the approaching male attempts to seize the other, however, the latter emits a "warning croak" and is promptly released. While the toad and spadefoot chorus (Band No. 3 of the Wet Season) was being recorded in the Rillito northwest of Tucson, several Colorado River Toads were calling (apparently in vain for no females were observed to arrive; they may all have deposited their eggs on previous nights), the males periodically shifted their position in the pool. Occasionally they came in contact with another male, who promptly interrupted his mating call and substituted the "warning croak" (Band No. 7 in Tucson Wet Season), or in this instance a lower-pitched trill.

Frogs may produce still other sounds when held in the hand, or when seized by some enemy such as a skunk or snake, as must often happen. Some of these sounds, possibly expressions of fright, are included on the record. Like the mating calls, each is not only different, but characteristic of the species. Some toads utter a chirping sound only during the breeding season, especially when disturbed. The chirp differs from the mating call, usually in being shorter in duration. In addition there is sometimes a "warning vibration" produced by males. This is barely audible to the human ear, and seems to be quite independent of the vocal cords. The warning vibration, elicited whenever the back is stimulated, results in the prompt release of one male clasped by another.

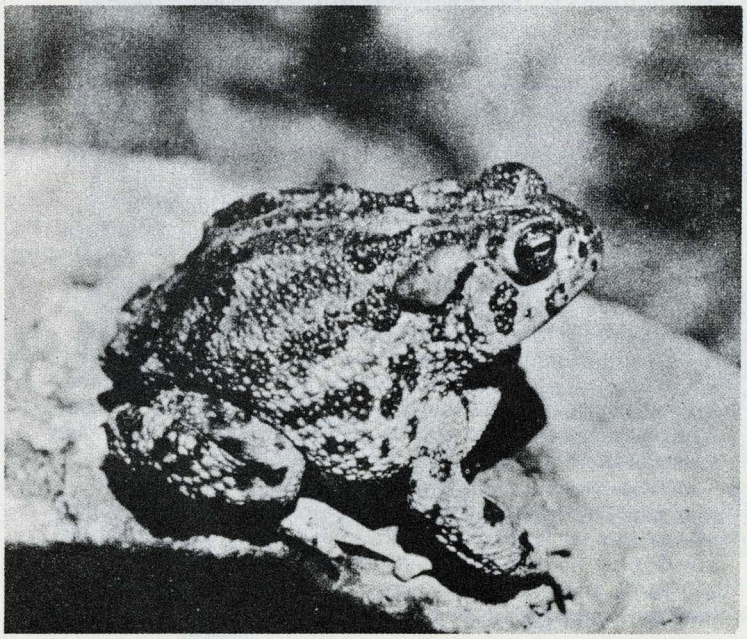
Tailless amphibians commonly call from the edge of the pond in which they breed, or from near-by rocks, bushes, or trees. They can also call while under water since the mouth and nostrils are kept tightly closed. Air is driven back and forth between the lungs and the mouth. Often one or two slits in the floor of the mouth afford the passage of air to a distensible throat. Here the thin skin balloons out into a transluscent sac, or a pair of sacs, or the throat may merely assume a swollen appearance when the frog is calling. These vocal pouches serve as resonators for the sound produced when air, forced from the lungs, passes over the elastic rims of the vocal cords, causing them to vibrate.

Unlike frogs, the vast majority of which have a voice, the limbless tropical caecilians and most tailed amphibians, the salamanders, are mute. Indeed one family of salamanders is devoid of lungs, although some members of this group produce feeble sounds, probably accidentally, when the air is forced from the mouth. Vocal cords are believed to be present in the Pacific Giant Salamander (Dicamptodon ensatus) which is said to emit "a screaming sound" when

Colorado River Toad (Bufo alvarias) from near Tucson, Arizona. This is the largest toad inhabiting the United States.



Little Green Toad (Bufo debilis insidior) from San Simon Valley, New Mexico.

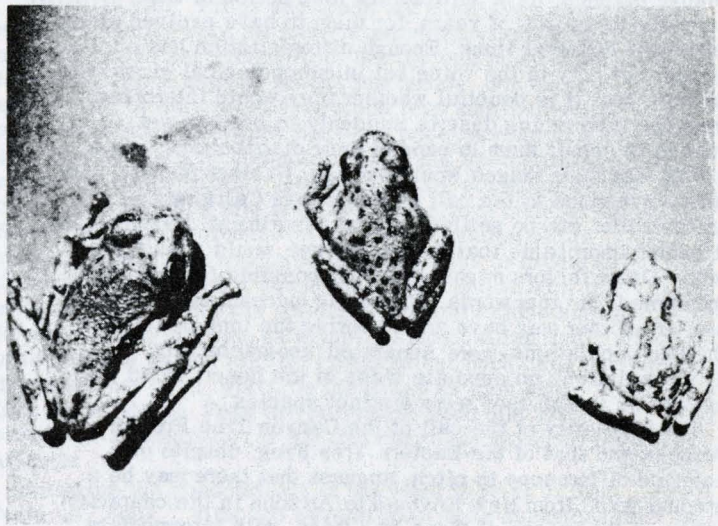


Great Plains Toad (Bufo cognatus) from San Simon Valley, New Mexico.

molested. One investigator describes it as a "bark," while another mentions a "low-pitched rattling sound" that is uttered when the animal is irritated. Eventually we should have a recording of it. It is doubtful whether voice has any significance in the courtship of salamanders, and it is not always certain that it has any special function when present.

Some years ago Julian Huxley wrote, "if the chirping of male grasshopper-like insects was the first deliberate sound produced by life, the croaking of the male frog-like amphibia was almost certainly life's first vocal music." The production of sound by an occasional salamander throws some doubt on this statement. Some fishes, backboned animals lower in the evolutionary scale than the Amphibia, are able to produce sounds. In a few fishes, including the aptly named "grunts," the accomplishment is attributed to the grating together of their teeth; other fishes have special muscles that cause the air bladder to vibrate. It is more or less academic whether the sound is produced by shunting air back and forth over the vocal chords or that muscles act more directly to set up vibrations from the air bladder.

Whatever the manner in which sound is produced, or regardless of questions raised concerning its function, it is reasonable to suppose that there is some selective advantage in the ability that many animals have to produce it. It is certain that they have been at it for millions of years. Indeed, the vocal powers of some reptiles may have antecedents in the amphibians that gave rise to them well over 200 million years ago.



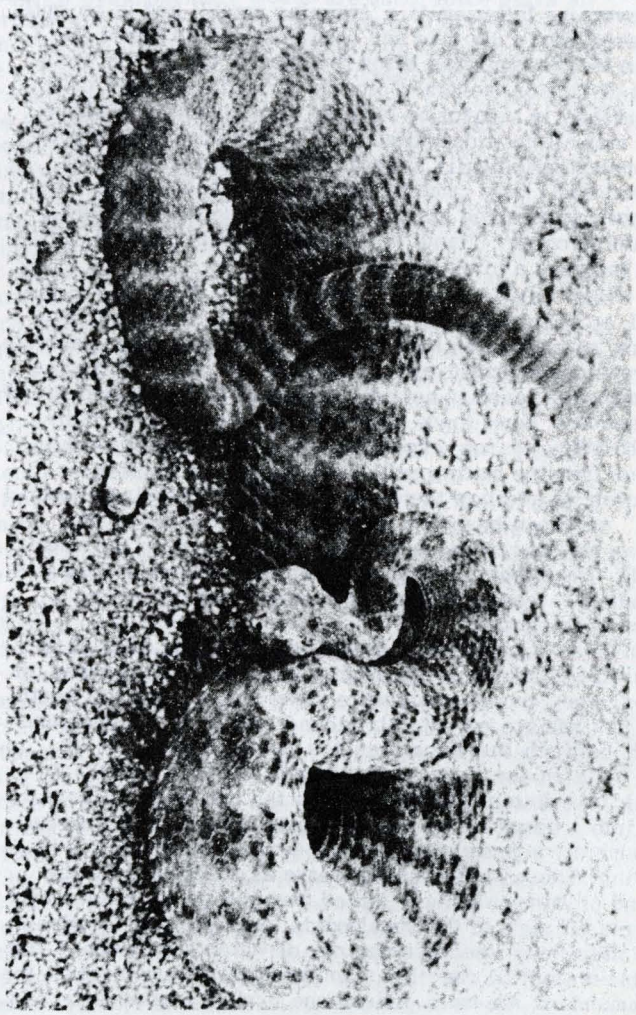
Canyon treefrogs, left to right, from Mexico, Utah, and California. The call of the population east of the deserts is conspicuously different from that in California, to which a name remains to be applied. (Photo by R.C. Stebbins).

REPTILES. Alligators roar, and some of the larger tortoises emit loud sounds strangely reminiscent of the stockyard. Many lizards called geckos produce noises; indeed the very name is onamatopoeic in origin, imitative of the sounds produced by a large gecko that inhabits southeastern Asia. Rattlesnakes rattle as everyone knows, and a good many other lizards as well as snakes hiss. Indeed, the snakes of one group (the Pine Snakes and Bull Snakes, Pituophis) inhabiting the United States have a special membrane so situated on the epiglottis that air expelled from the lungs causes it to vibrate and produce a fluttering sound. Other snakes produce noises by rubbing one part of the body against another part, with file-like structures on the keel of individual scales not unlike the stridulating organs of some insects. These enhance the sound, and the inflated lung produces a taut balloon-like body that acts as a resonator.

Few people outside New Zealand have ever heard the croaking sound made by the Tuatara (Sphaendon punctatus). This reptile is lizard-like in some respects, but it is more closely linked to the primitive reptile stock that gave rise to the earliest lizards as well as to the crocodilians, and dinosaurs. No effort has been made to find out why, on cool, misty nights the Tuatara utters its croak. However, like the majority of reptiles with a voice, it is largely nocturnal in its activities, and one Tuatara may be made aware of the presence of others by the amphibian-like call. When held in the hand, the Tuatara makes a grunting noise. But this is not produced in a manner indicative of any value as a frightening device that might serve to discourage the attack of an enemy.

The same cannot be said of some of the larger geckos, for the large Malayan Tokay or Tuk-kaa (Gekko gecko) lurches toward to an intruder with the jaws widely spread and simultaneously lets out a loud squawk. The combined effect of the sound and the behavior is sufficient to induce most human beings to withdraw the hand, and it may be conjectured that somewhat similar effects are produced on other mammalian enemies, as well as on birds.

Malcolm Smith (1935, The Fauna of British India), with first-hand knowledge of the Tuk-kaa, reports that the normal call of this gecko is "remarkably loud and clear and can be heard if the surrounding conditions are quiet, at least 100 yards away. Each call consists of a preliminary cackle, then the sound 'tuk-kaa' repeated deliberately and distinctly



Tiger Rattlesnake (Crotalus tigris) Rincon Mountains, Arizona.

several times, finally capped by a low gurgle." He adds that the call is not continued throughout the year but commences about the middle of the cold weather and becomes more frequent as the hot weather approaches. The lizard inhabits human dwellings and at the peak of its calling activities it may be heard throughout the night, one lizard after another taking up the cry from house to house.

No one has yet demonstrated about the sounds made by geckos have any significance in their courtship, nor is it known whether sound plays any part in the maintenance of territories. Some geckos call more often during the mating season, but this could be little more than a manifestation of greater excitability. Some of the lizards are solitary in their habits while others are gregarious, perhaps drawn together only by an electric light that serves to attract the moths or other insects on which they feed. In such ports as Acapulco in the Mexican tropics it is not unusual to see as many as five geckos clustered about an electric light on a porch.

There is somewhat better evidence that crocodilians maintain territories. One alligator is known to respond to the bellow of another, with what F. A. Beach terms "an aggressive response." Experimenting in the laboratory, Beach found that a fundamental note approximately equal to B flat two octaves below middle C, or 57 vibrations per second, evoked a roar in a half-grown male American alligator. This reptile was able to localize the source of the stimulation. Beach suspects that "the auditory stimulation and the resultant vocalization were associated with emotional excitement and an increased tendency toward actively aggressive behavior." It has also been suggested that female alligators tend to approach roaring males, but this has not yet been substantiated.

Structures presumed to be vocal cords have been described for alligators, and in addition to their roar or bellow, alligators emit short grunts under some conditions. Or when disturbed they can produce a loud hiss by the forcible expulsion of air. Grunting noises are uttered by the young, to which the female responds. Collectors in the Everglades of Florida imitate the grunting noise in order to attract the female, sometimes successfully.

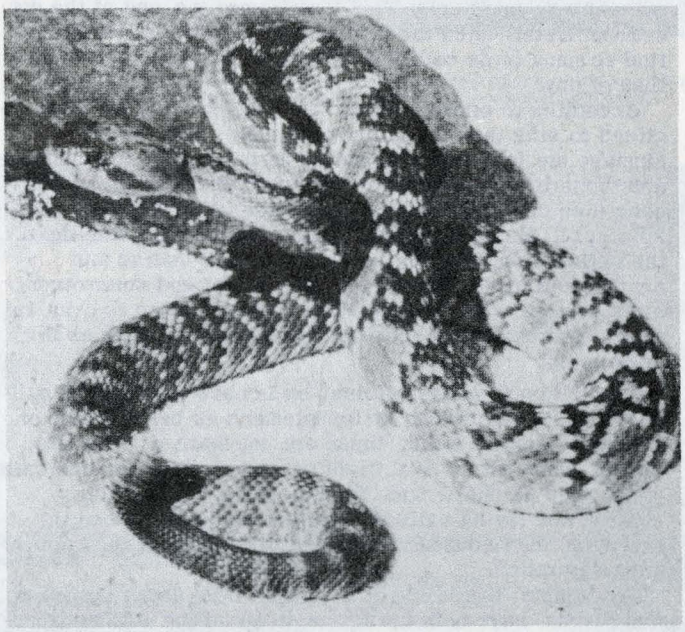
Hissing is not accepted by some authors as "true vocality," despite such specializations as those of the bull snakes. It is however, virtually the only sound made by many snakes. The name "Puff Adder" for the large African Viper (Bitis arietans) is derived from the snake's ability to produce a vigorous hiss "resembling more the noises horses make when forcing air through their lips," with each exhalation of the breath. The hooked-nosed snakes (Ficimia), as well as the Sonoran Coral Snake (Micruroides euryxanthus), apparently are able to expel air from the cloaca at the tail-end of the body, producing what has been described as a "popping noise." Such noises usually accompany other behavior readily interpreted as "warning demonstrations," not "calculated" to instil fear in the enemy. but serving that purpose.

Like the hissing of the Puff Adder, the rubbing together of keeled scales in the African Egg-Eating Snake (Dasypeltis) or the Saw-scaled Viper (Echis carinatus), the sounds made by rattlesnakes (all species of Sistrurus and Crotalus) are not vocal. Hissing may accompany rapid movement of the tail, where loosely interlocking segments impinge on adjacent ones as the tail is vibrated at a rate that varies from 45 to 60 cycles per second. The sounds produced depend on the kind of rattlesnake, the condition of the rattle (which is sometimes lost off the tail), the temperature, the stage of growth (rattlers are born with but a single button on the tip of the tail, and a "pre-button," which is lost when the skin is shed shortly after birth), and other circumstances. A large rattlesnake can be heard at least 100 feet away, but the noise produced by the smaller species is scarcely audible to human ears only a few feet distant.

Why do rattlesnakes rattle? It has nothing to do with courtship or mating, indeed snakes are deaf to air-borne sounds, and there is not the slightest indication that one snake can hear the rattling of another. The rattle is not employed to "warn prey" as some misguided naturalists have assumed. Nor can it be described as a simple automatic nervous reaction, merely an accompaniment of the snake's excitement, as equally misguided psychologists have stated; for the rattler manifestly exercises control over the use of the rattle. The snake may be aware of an approaching enemy, but often the rattle is not brought into play until the enemy heads directly toward the snake. It might be assumed that the sound produced by the tail is the response of a "startled" rattlesnake. This assumption is belied by the fact that a rattler behaves as though it were startled when approached by a king snake. However, even if rattling beforehand, the reaction of a rattler to the ophidian enemy (whose presence is recognized by its scent rather than visual cues) involves a characteristic posture, coupled with the immediate cessation of rattling.

The production of sound by these snakes is best interpreted as the snake's reaction to some particular frightening situation, or to special situations. It serves a purpose similar to the raised body and spread hood of the cobra, namely, to threaten or to alarm the intruder. Despite the snake's ability to distinguish between ophidian and mammalian enemies, it cannot be assumed, however, that the rattlesnake has any knowledge or intent. But the rattle does have adaptive or survival value. A California weasel used in an experiment refused to come near a sidewinder that was rattling, but the weasel did not hesitate to attack the snake when its rattle was removed so that it could produce no sound.

To summarize this brief account of sound production in reptiles, there is no conclusive evidence that sounds produced by reptiles, whether vocal or otherwise, have any significance in their courtship, even though the bellowing of the Galapagos turtle accompanies the mating. Further investigation may however, alter this tentative conclusion. The sounds produced by other reptiles can be interpreted usually as part of a more elaborate defense mechanism that serves to frighten or to intimidate intruders.



Black-tailed Rattlesnake (Crotalus m. molossus) Tinajo Renaldo, Arizona.

BIRDS. Darwin held that male birds sing in order to charm the female. Controversy concerning the significance of bird songs has been raging ever since. Birds produce an almost endless variety of sounds, not all vocal, but those from the mouth, whether musical or otherwise, are considered calls or songs. Beyond settling on some necessarily arbitrary definitions, there is little general agreement among ornithologists concerning the significance of calls.

It is known that the songs of birds more commonly reach their greatest perfection during periods of reproductive activities. However, Darwin's interpretation was modified at an early date when it was suggested that bird song was primarily associated with the maintenance of a breeding territory. According to this view such birds as the nightingale sing in order to advertise their territorial ownership to other males of the species. However, objections were raised to this interpretation by those who maintain that a bird sings merely because it is emotionally aroused; the social effect, namely the implied "threat" of the resident male, is merely a by-product.

Similar interpretations were staunchly supported by Friedrich Hemplemann of the University of Leipzig. To him a bird's song might charm the human ear, but for the bird it was merely an outlet for emotional excitement. Few students of animal behavior have doubted Hemplemann's belief that a bird has no intention when it sings. It bursts forth whenever it is excited or aroused, most often during the pairing season, for this is the time of the bird's greatest stress.

Hemplemann distinguishes calls, warning notes, or similar sounds produced by birds as innate impulses, distinct from the sexually differentiated song of the male, for the latter is a "secondary instinct," not inborn, but subsequently acquired through association with, and in imitation of older birds.

Aside from these theoretical considerations, a few other generalizations can be made, but there are exceptions to virtually every one. Birds are affected by the weather, and on windy or rainy days few songs or calls are heard. On bright, sunny days many more birds are in evidence, particularly early in the morning or late in the evening. Most birds are comparatively quiet during the middle of the day. At dawn in the foothills of the Chiricahua Mountains in Arizona as many as a dozen different birds called simultaneously in one place. This was toward the end of the dry season. Later, when the rains came, it was impossible to find so many birds calling at one time, regardless of the time of day.

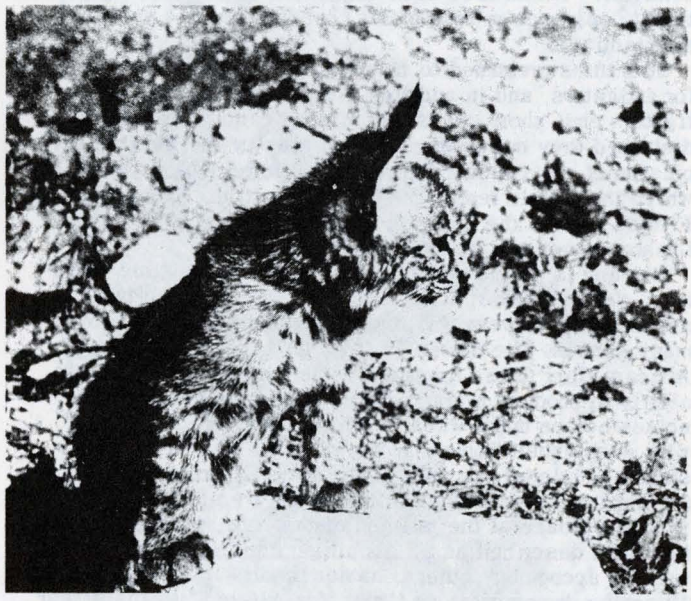
According to ornithologists, the smaller birds are more inclined to sing than the larger ones, birds with bright plumage are less likely to sing than those with dull plumage, and those living in trees are more frequently endowed with song than those that live along shores. Some birds do not sing at all. Moreover, some do not confine their singing to the period when they are going about their mating and nesting activities. The thrush, the oriole, and some other birds begin to sing long after the mating season is over. In direct contrast, other species stop singing as soon as the eggs hatch.

In addition to songs, several birds have a number of call notes, those referred to by Hemplemann as being innate or inherent. In other words, these are not learned. They are simple manifestations of fright or pain, or they include calls interpreted as challenges, feeding calls, wooing notes, nesting and laying calls. Even when birds are raised in isolation, such sounds are uttered from birth, or they appear with maturation.

Some birds, notably parrots, myna birds, crows, magpies, and ravens, have both the inclination and the ability to imitate strange noises. Some parrots can distinguish and reproduce an astounding variety of sounds variable in pitch and timbre. Many of these birds, as is well known, can imitate the human voice. This does not imply that parrots or the other birds that talk actually do so in a purposeful manner. There is never any real speech in the sense that birds attach a meaning to the sounds produced. The parrot talks, sometimes on cue, but only because of the satisfaction gained by his impulse to imitate human or other sounds.

Birds, except some of the larger ones, are equipped with a special modification of the lower end of the trachea. Here three or four bony rings of the wind-pipe, together with parts of the bronchi, have fused to form what is known as the syrinx. But not even the most skillful students of anatomy can examine a syrinx, which contains the vocal cords, and find any explanation of the manner in which the melodious sounds are produced. It is almost a cliche in discussions of the problem to mention that there is no perceptible difference between the syrinx of the crow and that of the nightingale.

Much remains to be explained as far as the sounds produced by birds are concerned, and it is only recently that any evidence has come to light to demonstrate that birds produce ultrasonic sounds, those beyond the range of human hearing. Sound plays a role far more significant in the lives of birds than it does among the amphibians and reptiles. In part, at least, this can be ascribed to the evolution of social behavior among birds. Most reptiles are inclined to be solitary, and the choruses of amphibians are little more than breeding aggregations.



Desert Bobcat (Lynx rufus baileyi) juvenile from southern Arizona.

MAMMALS. Like the birds, mammals descended from reptiles, but from a different stock, and their specializations have been along very different lines. In general, sound is less important in the lives of mammals than it is in birds. Coyotes howl, African lions roar, marmots whistle, and countless other sounds are produced that give vent to emotional feelings of one sort or another in mammals.

Presumably many of the sounds have some adaptive value, but often it is far from obvious. Bobcats, mountain lions, and probably numerous other members of the cat family produce similar sounds readily identifiable with the purr of the domestic cat. Is it merely a manifestation of a feeling of well being or contentment? Or does it produce some feeling of satisfaction, like that presumably gained by a child who sucks his thumb? Perhaps it has some social significance; no one appears to have had sufficient

curiousity to find out whether a cat ever purrs when it is alone. A tape recorder, if anyone were willing to devote time and tape to the problem, would doubtless supply the answer. However, the odds are that cats purr only in the presence of other animals, whether they be cats or people, preferably friendly.

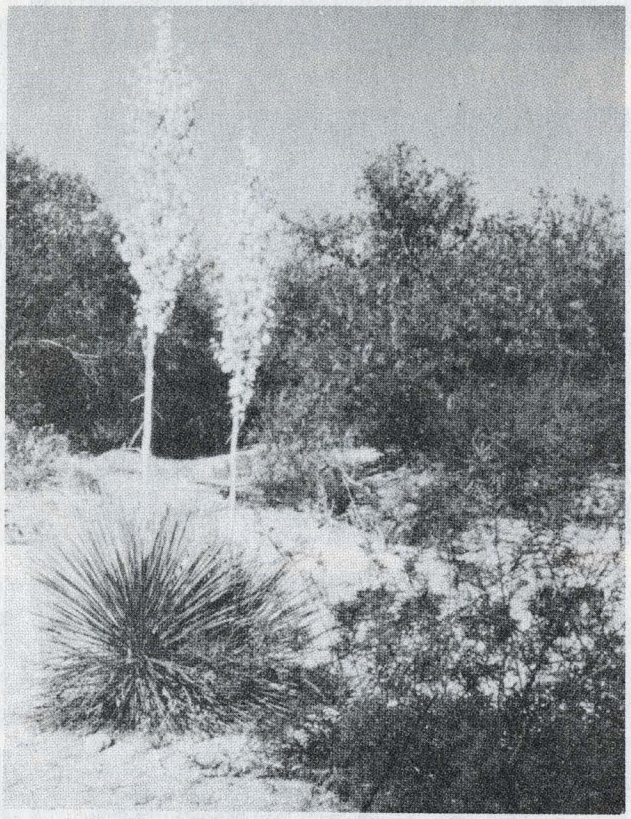
It may be that coyotes howl for much the same reason that a cat purrs. Several people have probably wrestled with the question, but it can scarcely be believed that anyone has come up with an answer that satisfied anybody but himself. Coyotes in captivity have been observed to howl in response to the whistle of a train, but this gives very little clue to the reason for the coyote's vocalizations on the lone prairie, where, if we can believe the ballads, the animal devotes most of its time to such activity.

The growls of a captive bobcat are more readily interpreted, especially if we observe the behavior that accompanies their production. The growl increases in intensity if the animal is approached, or suddenly reaches maximum proportions, as the cat, with its mouth wide open, lunges toward the intruder. This is essentially the same intimidating behavior employed by the large Malayan Gecko. It frightens the intruder, regardless of whether the lizard or the bobcat intend it to do so, or are merely expressing a feeling of fear or anger. We can be even less committal and say that these animals are "reacting to a situation." Investigators tend to interpret mammalian sounds in terms of human feelings and emotions. Indeed, it is a reasonable assumption that these states, at least in mammals that by human standards seem more intelligent than others, more closely approximate our own feelings and emotions than do those of birds. Sex inevitably enters the picture, and many sounds uttered by mammals are believed to be mating calls. There are also cries of warning, cries of appeal, and probably also cries that are in some fashion concerned with recognition. Two desert bobcats reared as pets in Tucson, Arizona, by Mr. William H. Woodin, 3rd, were given the run of the house during the day. At night they left to forage in the desert. Frequently one returned before the other. When they met, or often when one approached the other from the rear after a brief separation in the house, a very distinctive chirping sound was produced (Band 4 in the Tucson Wet Season sequence on the record). Seemingly one cat recognized the other, and the chirping sound was uttered by one as a means of letting the other know of his presence.

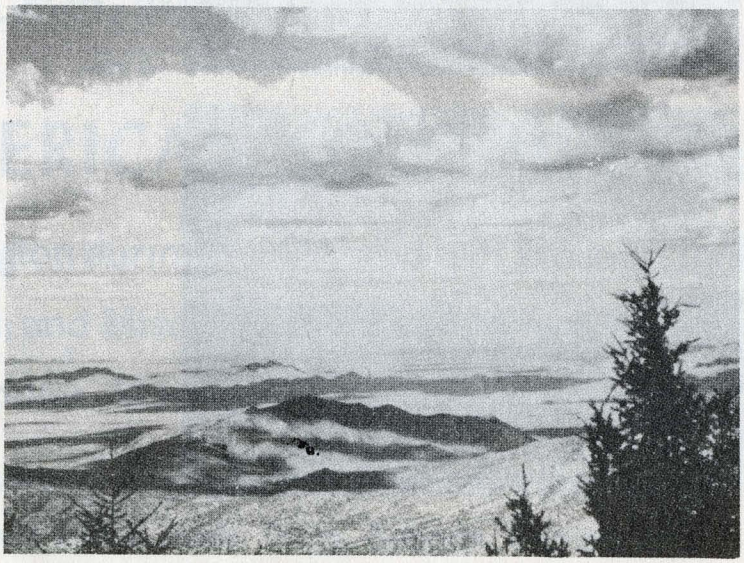
In addition to special sounds reserved for such occasions, the bobcats sometimes growl or purr, depending on circumstances. Probably a detailed study of these animals would reveal a modest "vocabulary" of sounds. It is to be doubted whether such cats have a "language" as well developed as that of the capuchin monkeys studied by Garner, but similar phenomena are involved. Various sounds are used to communicate, or to impart information in a very loose sense of the word. Mammals convey an impression of their feelings to others of their species. However, an enemy or another species may not have to understand the "language" to get the full import of an angry animal's expression. It is not intellectual; it is not uttered with forethought; it is not conversation. But it serves a purpose in the sense that it has adaptive value. It aids in the survival of the species, but not necessarily in the survival of the individual.

Sound has more than the usual adaptive significance in the lives of bats. These specialized mammals produce sounds that serve not only as a means of communication but also of locating objects in the dark. Because bats not only forage at night but inhabit caves where even good vision would be of no avail, they depend largely upon their production of ultrasonic sounds that are reflected from objects. By means of their binaural localization of the source of sounds reflected back from obstacles in their pathway bats are able to fly in total darkness. Thus bats employ what is essentially a high-frequency sound echo-ranging device, otherwise comparable to radar in which high frequency radio waves are employed. Bats also emit audible sounds.

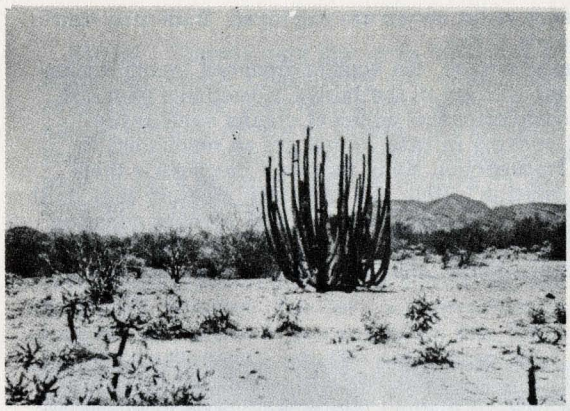
As in human beings, the sounds produced by other mammals have their origin in the larnyx, sometimes with specialized modifications of adjacent organs such as the pharyngeal pockets in bats, which act as resonators for ultrasonic frequencies. Many mammals can modify their sounds in duration, pitch, and intensity. Whether they do it with any intention or purpose in mind is another question. Many students of animal behavior would answer the question with both purpose and intention with an emphatic "no."



Mesquite bottom vegetation, with the bloom of one of the yuccas in the foreground along the San Pedro River in southern Arizona.

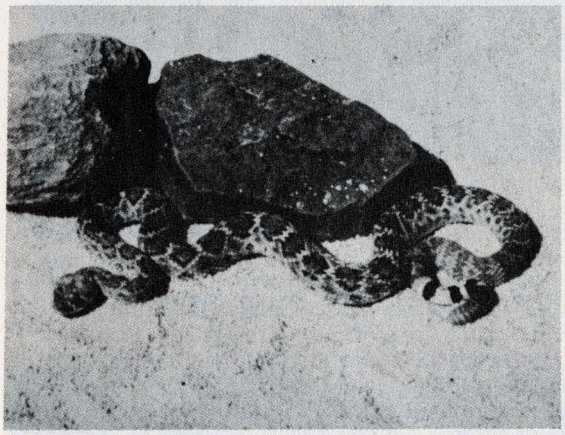


The deserts to the east of the Chiricahua Mountains, viewed from an elevation of 8000 feet, near Rustler Park, Chiricahua Mts., Arizona.

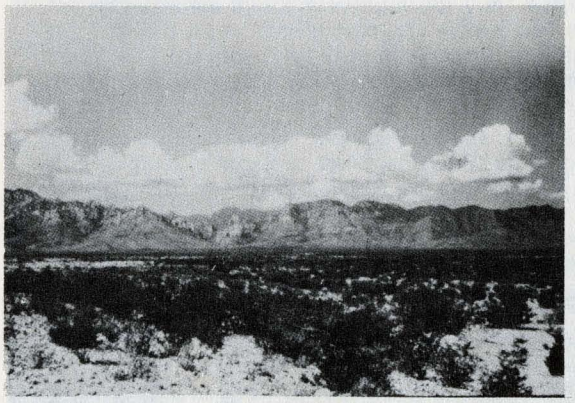


A view of the Sonoran Desert south of Hemosillo in Sonora, Mexico. The large columnar cactus is one with edible fruits known locally as a "pitahaya."

Sonoran Spadefoot (Scaphiopus couchi) female, 2 miles east of Portal, Arizona.



Desert Diamond-back Rattlesnake (Crotalus atrox) Tucson, Arizona.



Chiricahua Mountains, with creosote bush desert in foreground.

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