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RELICT SPECIES OF THE CHIHUAHUAN DESERT

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ABSTRACT. Aridity on the Chihuahuan Desert of the southwestern United States and northern Mexico was relieved at times during the Pleistocene by pluvial periods. These moist periods permitted invasion of the desert by more mesic species from the east, and 14 such species exist on the desert today as relicts. They show little divergence from their main populations to the east. Five areas on the Chihuahuan Desert appear to be particularly suited to the existence of relicts. All of the relicts are in constant danger of extinction by either drought or flash flood.

Those of us who have worked on the Chihuahuan Desert have had an opportunity to study some aspects of desert formation and adaptation not available to workers on other deserts. The opportunity has arisen through the existence of pluvial periods during or immediately following the Pleistocene which apparently caused a gradual withdrawal of the eastern border of the desert and permitted the invasion of more mesic-adapted species from the east. The return of arid conditions in the Recent Era and the eastward advancement of the desert during the recent drought have enabled us to see how mesic species are gradually crowded out by increasing aridity during desert formation, and how some mesic species adopt a precarious form of existence around oases. In recent years, there has been considerable discussion in the literature of relict species which evolved during isolation resulting from Pleistocene splits in the ranges of ancestral species. The "recent isolates" of the Chihuahuan Desert, however, which for the the most part show little morphological divergence from their main populations to the east, have been largely ignored.

THE CHIHUAHUAN DESERT

The Chihuahuan Desert (Fig. 1), or Chihuahuan Biotic Province (of Blair, 1940, 1950; Dice, 1943; Goldman and Moore, 1945; Milstead, In press), lies in the area bounded by the 99th and 108th meridians and the 21st and 33rd parallels. The topography of the desert is rugged with alternating highlands and basins. For practical purposes, it may be thought of as a plateau with elevations from 2000 to 5000 feet that is crossed by several mountain ranges which rise to elevations of from 6000 to over 9000 feet. The climate is arid and of the

type characteristic of subtropical deserts. The average annual rainfall varies from 10 to 18 inches west to east and the major portion of the rainfall occurs between april and October. Spring and fall rains are gentle and the most beneficial, but most of the rain comes in summer storms. The summer rains are usually of the violent cloudburst type which may yield up to an inch or more of rain in half an hour. Such storms coupled with parched land and scant vegetation cause rapid run-off of the water and frequently produce violent flash floods in the watercourses. Rainfall, whenever it occurs, is usually very local, so that some areas may have less than two inches per year and others may have more than 20. Hot summers and cool winters are characteristic of the Chihuahuan Desert. The mean July temperature ranges from 76° to 84° F. and the mean January temperature ranges from 44° to 50° F. The daily temperature range averages about 30° F. Grass and desert shrubs form the principal vegetation with some broadleaf deciduous trees and evergreens in the mountains and along streams.

Formation of the western deserts is presumed to have begun in Miocene times and continued through Pliocene and into early Pleistocene times. Although it was quite arid, at least in places (Zinn, 1953), by the late Tertiary, the Chihuahuan Desert possibly did not reach its present state of aridity until the early Pleistocene with the final uplift of the Cordilleran ranges and the formation of arid conditions on the Great Plains. The present conditions of aridity probably existed throughout most of the Pleistocene, but it is generally agreed (Zinn, 1953; Martin and Harrell, 1957; Blair, 1958; and others) that pluvial periods did exist at times. The extent to which these periods of increased humidity spread over the Chihuahuan Desert and adjacent Edwards Plateau and their effects on the fauna and flora have been the subject of considerable debate in recent years. Martin and Harrell (1957) and others have taken the view that the pluvial periods did not permit the formation of more than a cool savannah or open woodland through central and south Texas at any time during the Pleistocene. On the other hand, Blair (1958) and others have argued that the pluvial periods were extensive enough to have permitted the formation of a cool forest corridor throughout Texas at some time in the Pleistocene. The relicts of the Chihuahuan Desert present no evidence to support either side of the question. Several of the species are typically forest forms and could have reached the Chihuahuan through a forest corridor. The others could have reached the Chihuahuan during pluvial times at an earlier or later date. On the other hand, no forest corridor was necessary even for the forest forms. All of them range

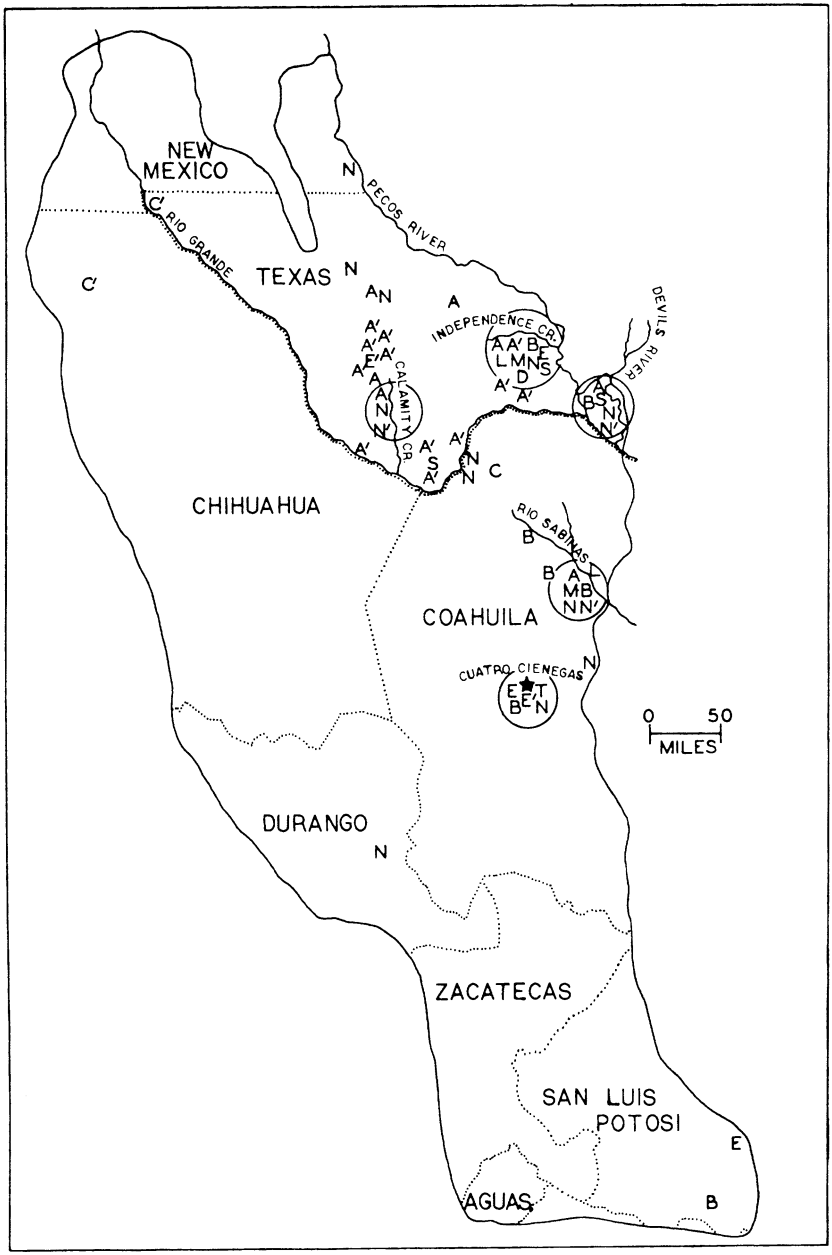

Figure 1. The Chihuahuan Desert and the approximate localities at which relict species have been recorded: A, *Acris crepitans*; A', *Ancistrodon contortrix*; B, *Bufo valliceps*; C, *Coluber constrictor*; C', *Chrysemys picta*; D, *Diadophis punctatus*; E, *Eleutherodactylus latrans*; E', *Eumeces tetragrammus*; L, *Lygosoma laterale*; M, *Micrurus fulvius*; N, *Natrix erythrogaster*; N', *Natrix taxispilota*; S, *Syrrhophus marnocki*; and T, *Terrapene coahuilae*. Circles indicate areas of relict species concentrations.

across the grassy Texan Biotic Province (of Blair, 1950) to reach or cross the Balcones escarpment (see Brown, 1950, for Texas locality records). All but two of the relicts (*Eleutherodactylus latrans* and *Syrrohophus marnocki*) range no farther west than the Balcones Escarpment or the eastern portion of the Edwards Plateau. Thus, some increase in humidity was necessary for their spread to the Chihuahuan Desert, but this could have been accomplished under only a slight increase (6 to 10 inches) in annual rainfall. Martin and Harrell (1957) have argued that other relicts in Texas and Mexico, notably the plethodontid salamanders, reached the areas in which they are now relictual by mid-Cenozoic times. The absence or small amount of morphological divergence exhibited by all but one (*Terrapene coahuilae*) of the Chihuahuan relicts, in comparison with other populations of their respective species, indicates that the invasion of the desert by most of the relicts took place a very short time ago; i.e., during or immediately following the Pleistocene.

In recent years (1949–1957), a severe drought caused a decrease of four to six inches in the annual rainfall of the eastern Chihuahuan Desert, where all but one (*Chrysemys picta*) of the relict species occur, and permitted the desert to extend eastward along the Rio Grande at least as far as the Devils River. It also caused a lowering of the water table in many areas and this contributed to the failure of numerous springs and seeps (notably Leon Spring at Fort Stockton) and reduced flow of all of the permanent streams. Extirpation of the relict species at many localities probably followed.

ACCOUNT OF SPECIES

Altogether 14 species are here recognized as relict species on the Chihuahuan Desert. These consist of four amphibians and ten reptiles. All of the amphibians are salientians. Only one salamander (*Ambystoma trigrinum*) is known from the Chihuahuan Desert and it is not here considered to be a relict species. The reptiles include two turtles, two lizards, and six snakes.

The fourteen species have a number of things in common: (1) all exist on the Chihuahuan Desert as apparently disjunct populations considerably removed from the main portion of the range of their species; (2) all or most of them represent the more mesic or hygric elements of their respective faunae within their normal range outside of desert areas; (3) their distribution on the Chihuahuan Desert is spotty rather than widespread and is typically restricted to the more mesic areas such as damp canyons, springs, or permanent streams; and

(4) away from these mesic areas the country is much more arid than any of that within the major portion of their range.

These are the criteria which have been used in deciding which species to include in the list of relicts. In time, as more becomes known about the distribution and habits of these species, some may be deleted from the list. Seven other species perhaps should be included: *Hyla arenicolor*, *Rana pipiens*, *Chelydra serpentina*, *Sceleporus olivaceus*, *Gerrhonotus liocephalus*, *Opheodrys aestivus*, and *Drymobius margaritiferus*. All seven answer the requirements of one or more of the criteria listed above, but they have not been included because their widespread distribution in North America or in areas contiguous with the Chihuahuan Desert leaves considerable doubt as to whether or not they should really be thought of as disjunct species.

All of the relict species have become adapted to life on the Chihuahuan Desert by restriction of habitat. For most, this has meant restriction to areas of permanent water, and, for some, restriction to other types of suitable habitats. Presumably, curtailment of habitat would also involve the necessity of adapting to a restricted diet and to other changes in habits. Adaptation to a desert climate would also necessitate modifications relative to temperature tolerance. Changes in habits to adapt to a restricted habitat in a desert climate have been more extensive in some relict species (e.g. *Terrapene coahuilae* or *Lygosoma laterale*) than in others (e.g., *Acris crepitans* or *Natrix erythrogaster*.)

The approximate localities at which the relict species have been recorded on the Chihuahuan Desert are shown in Fig. 1. An annotated list of the species follows below.

Eleutherodactylus latrans Cope. The Barking Frog has been recorded from two Chihuahuan Desert localities in Mexico: five miles south of Cuatro Cienegas, Coahuila (Schmidt and Owens, 1944), and ten miles west of Naranjos, San Luis Potosi (Smith and Taylor, 1948). On the basis of circumstantial evidence, Milstead *et al.* (1950) listed it as a probable on the Stockton Plateau of Trans-Pecos Texas.

Syrrhophus marnocki Cope. The Cliff Frog has been recorded from three areas on the Chihuahuan Desert, all in Texas: Big Bend National Park (Schmidt and Smith, 1944); the Devils River (Brown, 1950); and the Stockton Plateau (Milstead *et al.*; 1950). Collections in Big Bend National Park in 1957 and 1958 yielded several additional specimens and indicated that the population is still quite strong. It appers to have disappeared from the Stockton Plateau, however.

Bufo valliceps Wiegmann. Schmidt and Owens (1944) record the Gulf Coast Toad from four localities in Coahuila: La Babia, near Muzquiz,

Cuatro Cienegas, and La Mariposa. Taylor (1952) records it from Capulin, San Luis Potosi. In Texas, it has been recorded from the Devils River (Brown, 1950) and Independence Creek (Milstead *et al.*, 1950). Collections at both of the Texas localities in 1957 failed to yield any additional specimens. Taylor (1952) has reported that the Chihuahuan population in San Luis Potosi has developed certain morphological characteristics which distinguish it from other populations of the species.

Acris crepitans Baird. The Cricket Frog is one of the more widespread relicts of the Chihuahuan Desert, and has been recorded from a number of localities. Coahuila: Sabinas River near Musquiz (Schmidt and Owens, 1944) Texas: Calamity Creek and tanks on Blackburn's Ranch between Paisano Pass and Cathedral Mountain (Strecker, 1909); Leon Springs at Fort Stockton (Netting and Goin, 1946); Phantom Lake near Toyahvale and two to three miles west of Toyahvale (Wright and Wright, 1949); and Independence Creek (Milstead *et al*, 1950). Recent collections at all of the Texas localities except Blackburn's Ranch have failed to yield any specimens of this species. Cricket Frogs are usually abundant wherever they occur and failure to collect them suggests extirpation or reduced numbers as a result of drought or other factors.

Terrapene coahuilae Schmidt and Owens. This species is a Chihuahuan Desert endemic known only from the type locality, Cuatro Cienegas, Coahuila. It does, however, appear to be rather abundant at the type locality and may in time be found at other sites in the same general area. This is perhaps the most interesting species of the Chihuahuan Desert because, in its adaptation to desert life, it has changed from a terrestrial to an aquatic habitat. So far as known, this is the only aquatic member of the genus *Terrapene*. In adopting an aquatic existence, *T. coahuilae* has undergone a loss of pigmentation on both soft and hard parts, and has developed a more streamlined shell and more extensive webbing than other members of the genus. This species is included here as a relict species of the Chihuahuan Desert because I presume that it evolved from remnants of a population of *Terrapene carolina* which inhabited the area at an earlier time. At what time these remnants became isolated and what segment of the *T. carolina* complex they represented is subject to controversy. *Terrapene carolina* does not now occur in either the Balconian biotic province (of Blair, 1950) or the Tamaulipan biotic province (of Dice, 1943; Goldman and Moore, 1945; Blair, 1950) which lie immediately to the east of the Chihuahuan Desert. Representatives of this species did occur in both of these provinces at the close of the Pleistocene (Milstead, 1956;

see also Auffenberg, 1958) and perhaps earlier. Invasion from either of these provinces could have occurred during any of the pluvial periods, and the invasion probably extended across most of the Chihuahuan Desert. Evolution in the genus *Terrapene* has taken place at a very slow rate. This fact and the differences which exist between *coahuilae* and other members of the genus suggest that isolation of the *coahuilae* ancestors may have taken place in pre-Pleistocene times. On the other hand, the *coahuilae* differences are not vastly greater than those which exist between the extinct *T. putnami* and *T. c. triunguis* (See Auffenberg, 1958), and doubtlessly *coahuilae* and its ancestors have been subjected to more rigorous selective pressure than any other members of the genus. The portion of the *Terrapene carolina* complex from which *coahuilae* evolved is obscured by the fact that *coahuilae* exhibits both primitive and advanced characteristics. The postorbital bar is as strong in *coahuilae* as it is in *T.c. major* and other primitive forms, while the plastral ratios agree with those of *T.c. triunguis* which I consider to be the most advanced member of the genus.

Chrysemys picta belli Gray. The Western Painted Turtle has been recorded from only two localities on the Chihuahuan Desert: Rio Santa Maria near Progresso, Chihuahua (Smith and Taylor, 1950), and El Paso county, Texas (Brown, 1950). Brown reports that the El Paso specimens are no longer available.

Lygosoma laterale Say. The Ground Skink has been recorded from two localities in Coahuila by Schmidt and Owens (1944): Nogales and the Sabinas River near Musquiz. In Texas, it has been recorded from Independence Creek (Milstead *et al*, 1950). Collections at the Texas locality in 1957 yielded no additional specimens.

Eumeces tetragrammus Baird. There are only two records of the Four-lined skink on the Chihuahuan Desert. Strecker (1909) records "one example from among rocks, on the road from Paisano to Blackburn's." A second record was recently obtained three miles west of Cuatro Cienegas, Coahuila (Zweifel, 1958).

Natrix erythrogaster transversa Hallowell. The Blotched Water Snake is the most widely distributed relict on the Chihuahuan Desert. Coahuila: Schmidt and Owens (1944) report specimens from the Sabinas River near Musquiz, Hermanas, and Cuatro Cienegas. New Mexico: Pecos River at Carlsbad (Conant, 1955). Texas: Calamity Creek (Strecker, 1909); Rio Grande at Boquillas (Murray, 1939; Schmidt and Smith, 1944; Brown, 1950; Minton, 1958); near Toyahvale, Phantom Lake near Toyahvale, and 25 miles northwest of Toyahvale (Brown, 1950); Independence Creek (Milstead *et al.*, 1950); and Hot Springs, Big Bend National Park (Minton, 1958).

Collections at the Toyahvale locality in 1956, at Calamity Creek in 1956 and 1957, and at the Independence Creek locality in 1957 yielded no additional specimens. Specimens have been collected at Boquillas and Hot Springs in recent years.

This species has also shown a habitat change in adaptation to life on the Chihuahuan Desert, but it is not as major a change as that exhibited by *Terrapene coahuilae*, nor has it brought on morphological changes other than paler coloration. Over most of its geographic range, *Natrix erythrogaster* is predominantly a nocturnal species. At the Independence Creek locality, Milstead *et al.* (1950) recorded it as predominantly diurnal. The same habit is implied by Strecker's (1909) reference to these snakes as "frequently observed in Calamity Creek." The snakes have apparently retained nocturnal habits at Boquillas. The Stockton Plateau and upper Calamity Creek typically have much cooler nights than the Rio Grande Valley, however. Competition with *Ancistrodon contortrix* at Independence Creek may have influenced the adoption of diurnal habits by *Natrix erythrogaster*.

Natrix erythrogaster bogerti Conant. Known only from the type locality: Rio Nazas near La Goma, Durango. (Conant, 1953).

Natrix taxispilota rhombifera Hallowell. The Diamond-backed Water Snake has been recorded from Las Rusias, Coahuila (Schmidt and Owens, 1944); The Devils River (Brown, 1950); and Calamity Creek (Strecker, 1909). Collections at Calamity Creek in 1956 and 1957 and at the Devils River in 1957 yielded no additional specimens.

Diadophis punctatus arnyi Kennicott. The Prairie Ring-neck Snake has been recorded from only one locality on the Chihuahuan Desert: The Stockton Plateau in the Independence Creek area(Milstead *et al.*, 1950)

Coluber constrictor stejnegerianus Cope. Schmidt (1953) records the Rio Grande Racer as extending westward along the Rio Grande to Northern Coahuila. Apparently the only specific locality record is that given by Zweifel (1954); eight miles southwest of Piedra Blanca, Sierra del Carmen, Coahuila.

Micrurus fulvius tenere Baird and Girard. Only two records exist for the Texas Coral Snake on the Chihuahuan Desert. Schmidt and Owens (1944) recorded it from Las Rusias near Musquiz, Coahuila, and Milstead *et al.* (1950) recorded it from Independence Creek.

Ancistrodon contortrix pictigaster Gloyd and Conant. Although it does not have as widespread a distribution on the Chihuahuan Desert as some of the other relict species, there are more locality records and more specimens of the Trans-Pecos copperhead than any other relict. All of the records of this subspecies are in Texas: Paisano Pass

(Stecker, 1928); Mitre Peak and Musquiz Creek between Alpine and Fort Davis (Gloyd and Conant, 1943;) Big Bend National Park (Gloyd and Conant, 1943; Schmidt and Smith, 1944; Minton, 1958); Sanderson and Limpia Canyon near Fort Davis (Flury, 1949); Independence Creek (Milstead *et al.*, 1950); Rosillos Mountains (Minton, 1958); Black Gap Wildlife Management Area (Axtell, 1959); 10 miles east of Sanderson (Sul Ross State College specimen); and Stonehouse Canyon, 3 miles west-northwest of Lajitas (Texas Tech College specimens).

The Independence Creek population of copperheads was one of the greatest aggregations of poisonous snakes ever recorded outside of a den, but it was all but extirpated by a flood in 1954. Collections along Independence Creek in 1957 yielded only a very few specimens.

The copperhead population in Stonehouse Canyon is apparently the remnant of another aggregation. In the past, the canyon contained three springs: two in the upper canyon and one in the lower. Water flow from the upper canyon springs was of sufficient volume to warrant the building of a dam eight feet high to impound the waters. At present, however, all three springs have been reduced to seeps. Seepage from the two above the dam is not sufficient to cause even a puddle on the Canyon floor, but seepage from the lower canyon spring maintains a pool about 30 feet long by 10 feet wide by 3 feet deep. During two weeks in July, 1958, J. W. Gibbons and I collected 11 copperheads from this pool and, in August, Ernest Tanzer collected two additional specimens. Food available to the copperheads around the pool consists of insects, sunfish (*Lepomis sp.*), and frogs (*Rana pipiens*).

Altogether, thirteen specimens from Stonehouse Canyon are in the Texas Tech Zoology collections: ten of those originally collected there and three well-developed embryos from one of the females. When the coloration and subcaudal counts of these specimens are compared with other material, they tend to confirm the evidence that the specimens from Independence Creek are intermediate between *A. C. pictigaster* and *A.c. laticinctus*. The subcaudal counts are:

pictigaster

Stonehouse Canyon
Females: 54 — 56 : 54.5 (4 specimens)
Males: 55 — 60 : 58.0 (9 specimens)
Davis Mts. and Big Bend National Park (Gloyd and Conant, 1943)
Females: 52 — 56 : 54
Males: 57 — 59 : 58

pictigaster x *laticinctus* — Independence Creek (Milstead, et al., 1950)
Females: 43 — 60 : 51.5 (42 specimens)
Males: 50 — 59 : 54.5 (40 specimens)
laticinctus — Edwards Plateau, (Gloyd and Conant, 1943)
Females: 37 — 52 : 45
Males: 44 — 54 : 48

This does indicate, however, that the Independence Creek specimens are somewhat closer to *pictigaster* than to *laticinctus*. The Trans-Pecos Copperhead, *Bufo valliceps* in San Louis Potosi, and *Terrapene coahuilae* are the only relicts that have exhibited morphological divergence during their isolation of the Chihuahuan Desert.

LOCAL CONCENTRATIONS OF RELICTS

Some of the relict species of the Chihuahuan Desert have been recorded only once or a few times, others have been recorded several times and occasionally in aggregations, and others appear to be locally abundant wherever they have been recorded. Most of the relicts are restricted to the eastern portion of the desert, but there is no definite pattern to their distribution. Five localities, however, appear to be unusually suitable for mesic species in that several relict species have been recorded at each, and some of these species have been recorded in abundance. Two localities are in Coahuila: Cuatro Cienegas with five relict species and the Sabinas River in the Musquiz area with six species. The other three localities are in Texas: the Devils River with five species, Calamity Creek with three, and Independence Creek with nine. Twelve of the fourteen relict species are included in those represented at these localities. The species and the five localities are shown in Fig. 1.

Calamity Creek has the least number of relicts recorded at any of the five localities, and all of the records are those of Strecker (1909). The three species recorded by him (*Acris crepitans*, *Natrix erythrogaster*, and *Natrix taxispilota*) are well known in most parts of Texas and are sufficiently distinct to rule out any possibility of error in Strecker's identifications. Several trips in 1956 and 1957 to the same general area where Strecker collected failed to yield any further specimens. Calamity Creek has suffered greatly in the recent drought and the relict fauna may have been extirpated.

The Independence Creek area of the Stockton Plateau has the greatest number of recorded relicts of any area in the Chihuahuan Desert. This is due in part to the area's proximity to the eastern edge of the desert and in part to the mesic habitat provided by constantly flowing

springs and a dense live-oak motte. Seven of the nine relicts of the area are largely restricted to the motte and the creek. A savage flood through the area in 1954 either extirpated or seriously hurt the populations of these seven species. Collections made in the summer of 1957 yielded a few additional specimens of the copperhead, but none of the other relicts recorded by Milstead *et al.* (1950). During our stay in 1949, the forest floor was covered with rich humus and a six to eight inch leaf litter. In 1957, the forest floor was largely bare and drift wood and other flood litter was still lodged up to 20 feet above the ground in trees.

Thus, the relict species restricted to areas of permanent water are in constant danger of extinction from two sources; drought and flash flood. The same species might survive a flood in a more mesic area, but floods in those areas do not have the rapid rise and scouring effect of flash floods. The mesic species which are most likely to survive as relicts on a desert are those which are the most hygric and can adapt to survival around permanent water. It is ironic that they are in ever danger of extinction by too little water or too much.

TABLE 1

Relict species of the Chihuahuan Desert, the faunal elements they represent, and the biotic provinces from which they are presumed to have invaded the Chihuahuan Desert.

Species	Faunal Element	Origin of Desert Invasion	
		Balconian	Tamaulipan
Eleutherodactylus latrans	Balconian	x	..
Syrrhophus marnocki	Balconian	x	..
Bufo valliceps	Gulf Coast	x	x
Acris crepitans	Eastern U.S.	x	?
Terrapene coahuilae[1]	Chihuahuan	x	x
Chrysemys picta	Eastern U.S.	..	..
Lygosoma laterale	Eastern U.S.	x	?
Eumeces tetragrammus	Gulf Coast	..	x
Natrix erythrogaster	Eastern U.S.	x	x
Natrix taxispilota	Eastern U.S.	x	x
Diadophis punctatus	Eastern U.S.	x	..
Coluber constrictor	Eastern U.S.	..	x
Micrurus fulvius	Gulf Coast	x	x
Ancistrodon contortrix	Eastern U.S.	x	..

[1] Presumed to have evolved on the Chihuahuan Desert in Pleistocene or pre-Pleistocene times, but presumed to have evolved from *Terrapene carolina* which was in both the Balconian and Tamaulipan piotic provinces at least during the Pleistocene and possibly earlier.

BIOGEOGRAPHIC RELATIONSHIPS

The fourteen relict species of the Chihuahuan Desert are representative of four faunal elements. Two species are largely limited in distribution to the Balconian Biotic Province of central Texas, and one species is limited to the Chihuahuan Biotic Province. Three species are widely distributed on the Gulf Coastal Plain and eight are widely distributed in the eastern United States. All but one (*Chrysemys picta*) of the relicts are presumed to have invaded the Chihuahuan Desert during pluvial times from either the Balconian Biotic Province (of Blair, 1950), the Tamaulipan Biotic Province (of Dice, 1943; Goldman and Moore, 1945; Blair, 1950), or both. The Balconian province merges with the desert for a considerable distance along the Pecos and Devils rivers in Texas and the Sierra del Carmen of Coahuila. The Tamaulipan province of the Coastal Plain of south Texas and eastern Mexico grades into the Chihuahuan Desert in south central Texas near Del Rio, in eastern Coahuila, and eastern and southern San Luis Potosi. Absence of barriers between the desert and these two provinces has produced broad transition zones in which there is a very gradual shift from one environment to the other. Thus, only a slight increase in humidity would permit invasion of the desert by species from both the Balconian and Tamaulipan provinces. The relict species, the faunal elements they represent, and the biotic provinces from which they are presumed to have invaded the Chihuahuan Desert are listed in Table 1.

SUMMARY

Pluvial periods during or immediately following the Pleistocene apparently caused a gradual withdrawal of the eastern border of the Chihuahuan Desert, and this permitted the invasion of more mesic-adapted species from the east. Most of these invaders presumably died with the return of desert conditions, but some species remained as relicts which cling to a precarious existence around oases. Fourteen such species occur on the Chihuahuan Desert. All are isolated from the major portion of their species range to the east, but most have shown little morphological divergence. *Terrapene coahuilae* is the one exception. It is suggested that it evolved on the Chihuahuan Desert from *Terrapene carolina*. The invasion by *T. carolina* may have taken place in pre-Pleistocene times. *Ancistrodon contortrix* and *Bufo valliceps* have undergone some morphological divergence and *Natrix erythrogaster* appears to have changed its habits from nocturnal to diurnal. A recent collection of copperheads from Presidio county, Texas, is compared with specimens from central Texas and the Stock-

ton Plateau. It is concluded that the specimens from the Stockton Plateau are intermediate between *Ancistrodon contortrix laticinctus* and *Ancistrodon contortrix pictigaster*.

Five localities on the Chihuahuan Desert appear to be particularly suited for relict species in that 12 of the 14 relicts are represented in collections from those areas. Drought and flood in recent years appear to have annihilated or greatly reduced the numbers of relict populations in several areas.

ACKNOWLEDGMENTS

Visitations in 1957 and 1958 to the sites where relict species have been recorded in Texas were carried out as a part of a study of sympatry and interrelationships in the canyon lizards, *Sceloporus merriami* and *Urosaurus ornatus*. The work was made possible under grants G3405 and G5175 from the National Science Foundation. The work on relict species was done as a sideline to the lizard study. C. W. Pittillo served as research assistant on the project in 1957 and J. W. Gibbons in 1958.

LITERATURE CITED

AUFFENBERG, WALTER. 1958. Fossil turtles of the genus *Terrapene* in Florida. Fla. State Mus. Bull., 3 (2): 53–92.

AXTELL, RALPH W. 1959. Amphibians and reptiles of the Black Gap Wildlife Management Area, Brewster County, Texas. Southwest. Nat., 4 (2): 88–109.

BLAIR, W. FRANK. 1940. A contribution to the ecology and faunal relationships of the mammals of the Davis Mountains region, southwestern Texas. Misc. Publ. Univ. Mich. Mus. Zoo., (45): 1–39.

————. 1950. The biotic provinces of Texas. Tex. J. Sci., 2 (1): 93–117.

————. 1958. Distributional patterns of vertebrates in the southern United States in relation to past and present environments. AAAS Zoogeography: 443–468.

BROWN, BRYCE C. 1950. *An Annotated Check List of the Reptiles and Amphibians of Texas*. Baylor Univ. Press, Waco, Tex.: i–xxi, 1–259.

CONANT, ROGER. 1953. Three new water snakes of the genus *Natrix* from Mexico. Chic. Acad. Sci., Nat. Hist. Misc., (126): 1–9.

————. 1955. Notes on *Natrix erythrogaster* from the eastern and western extremes of its range. Chic. Acad. Sci., 147: 1–3.

DICE, LEE R. 1943. *The Biotic Provinces of North America*. Univ. Mich. Press, Ann Arbor: i–viii, 1–78.

FLURY, ALVIN G. 1949. Range extensions for two west Texas snakes. Copeia, (4): 293.

GLOYD, HOWARD K., and ROGER CONANT. 1943. A synopsis of the American forms of *Agkistrodon* (copperheads and moccasins). Bull. Chi. Acad. Sci., 7 (2): 147–170.

GOLDMAN, EDWARD A., and ROBERT T. MOORE. 1945. The biotic provinces of Mexico. J. Mamm., 26 (4): 347–360.

MARTIN, PAUL S., and BYRON E. HARRELL. 1957. The Pleistocene history of temperate biotas in Mexico and Eastern United States. Ecol., 38 (3): 468–480.

MILSTEAD, WILLIAM W. 1956. Fossil turtles of Friesenhahn Cave, Texas, with the description of a new species of *Testudo*. Copeia (3): 162–171 (See also Copeia 1959, (1): 88.

————. In Press. Competitive relations in lizard populations. *In* vertebrate speciation. Univ. Tex. Press.

MILSTEAD, WILLIAM W., JOHN S. MECHAM, and HASKELL McCLINTOCK. 1950. The amphibians and reptiles of the Stockton Plateau in northern Terrell County, Texas. Tex. J. Sci., 2 (4): 543–562.

MINTON, SHERMAN. 1958 (1959). Observations on amphibians and reptiles of the Big Bend region of Texas, Southwest. Nat., 3 (1–4): 28–54.

MURRAY, LEO T. 1939. Annotated list of amphibians and reptiles from the Chisos Mountains. Contrib. Baylor Univ. Mus., (24): 1–16.

NETTING, M. GRAHAM, and COLEMAN J. GOIN. 1946. *Acris* in Mexico and Trans-Pecos Texas, Copeia, (4): 253.

SCHMIDT, KARL P. 1953. *A Check List of North American Amphibians and Reptiles*. Amer. Soc. Ich & Herp: i–viii, 1–280.

SCHMIDT, KARL P. and DAVID W. OWENS. 1944. Amphibians and reptiles of Northern Coahuila, Mexico, Zool. Ser. Field Mus. Nat. Hist. 29 (6): 97–115.

SCHMIDT, KARL P., and TARLETON F. SMITH. 1944. Amphibians and reptiles of the Big Bend region of Texas. Zool. Ser. Field Mus. Nat. Hist., 29 (5): 75–96.

SMITH, HOBART M., and EDWARD H. TAYLOR. 1945. An annotated check list and key to the snakes of Mexico. U.S. Nat'l Mus. Bull., (187): I–IV, 1–239.

————. 1948. An annotated check list and key to the amphibia of Mexico. U.S. Nat'l Mus. Bull., (194): I–IV, 1–118.

————. 1950. An annotated check list and key to the reptiles of Mexico exclusive of the snakes. U.S. Nat'l Mus. Bull., (199): I–IV, 1–253.

STRECKER, JOHN K., JR. 1909. Reptiles and amphibians collected in Brewster County, Texas. Baylor Univ. Bull., 12 (1): 1–20.

TAYLOR, EDWARD H. 1952. Third contribution to the herpetology of the Mexican state of San Luis Potosi. Univ. Kans. Sci. Bull., (34): 793–815.

WRIGHT, ALBERT H., and ANNA A. WRIGHT. 1949. *Handbook of Frogs and Toads*. Comstock Publ. Co., Ithaca: i–xii, 1–640.

ZINN, ROBERT L. 1953. Basin deposits of the Presidio area. West Tex. Geol. Soc., Field Trip to Chinati Mts.: 52–54.

ZWEIFEL, RICHARD G. 1954. Notes on the distribution of some reptiles in western Mexico. Herpetologica, 10: 145–149.

————. 1958. The lizard *Eumeces tetragrammus* in Coahuila, Mexico. Herpetologica, 14: 175.

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