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Reviewed work(s):
Source: *The Southwestern Naturalist*, Vol. 2, No. 2/3 (Apr. - Jul., 1957), pp. 89-104
Published by: Southwestern Association of Naturalists
Stable URL: http://www.jstor.org/stable/3669496
Accessed: 10/01/2012 14:15

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THE SOUTHWESTERN NATURALIST 2 (2–3): 89—104 APRIL-JULY, 1957

DISTRIBUTIONAL PATTERNS OF TEXAS FRESH-WATER FISHES

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ABSTRACT. Distribution patterns of most fresh-water fishes in Texas closely resemble those of terrestrial organisms, though there are 3 exceptional groups: (1) those limited by stream divides, (2) those of marine and freshwater forms meeting in fresh waters near the coast, and (3) certain species of northeastern Texas (Austroriparian) whose ranges include outliers or extensions into other biotic provinces. It is concluded that the basic factors controlling distribution patterns of fishes are climatic and geological, these determining the properties of the water.

In recent treatments on the biogeography of Texas, many distributional patterns have been delimited (Blair, 1950, and Tharp, 1939 and 1952). Although Tharp divided the state into more subdivisions than did Blair, the demarcation lines for his Vegetation Regions conform closely to those for Blair's Biotic Provinces and Districts (Fig. 1). In addition, Tharp emphasized differences associated with the coastal prairie more than Blair, who in turn separated the district known as the lower Rio Grande Valley more distinctly. Their areas approximate those of Johnson (1931) as both authors correlated the biologic distributions with geologic and climatological data. Obviously, the edaphic and climatic factors are critical to the survival of organisms in any region. Both Blair and Tharp base their conclusions chiefly on the distribution of terrestrial organisms. At least one group of aquatic organisms, the fishes, has distributional patterns that closely resemble those derived from terrestrial studies.

Correlation of fresh-water fish distribution with Life Zones in Texas as given by Bailey (1905) is not very close. The life-zone boundaries of Bailey that approximate the boundaries of Blair and Tharp fit the distribution patterns of fresh-water fishes, whereas no correlation is noted where Bailey's boundaries differ.

Additional support for the general validity of these boundaries can be derived from the geographic distribution of historic Indian groups. Kroeber's (1939) maps for Indian tribal areas roughly correspond with Blair's and Tharp's regions. T. N. Campbell (personal communication, 1957) reports that the correlation at about 1500 A.D. is perhaps even better than indicated by Kroeber. He would locate the Caddo and Atakapa Indians in the Austroriparian Biotic Province with occa-

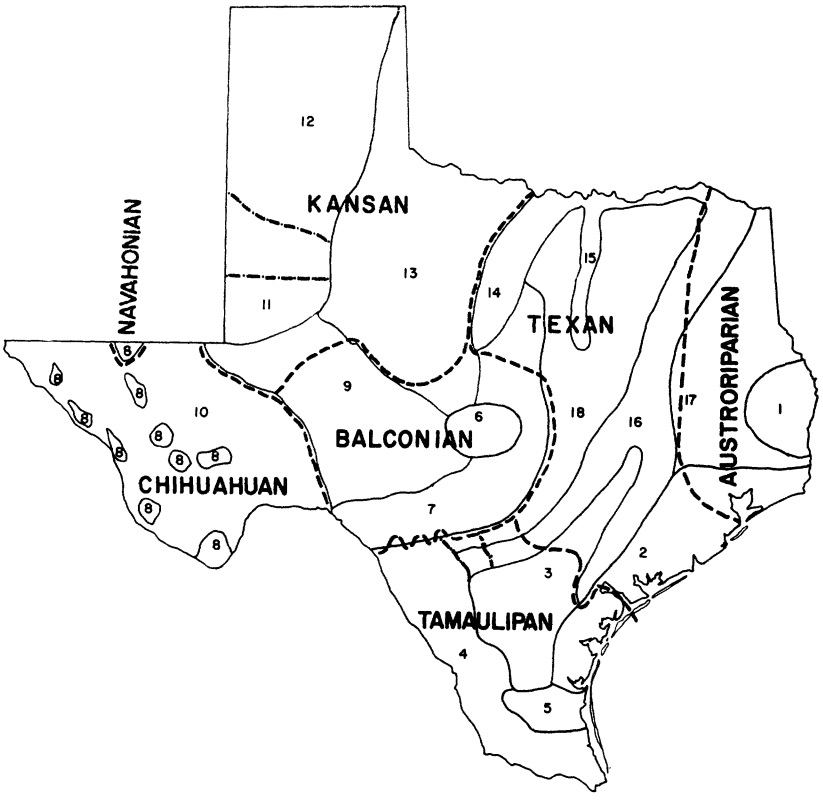

Fig. 1. Comparison of Vegetation Regions and Biologic Provinces in Texas. Compiled from Tharp (1952) and Blair (1949) resepctively. For clarity, sub-divisions are not included. Heavy lines and names show Biologic Provinces. Fine lines and numbers designate Vegetation Regions. (1) Long-leaf Pine, (2) Coastal Prairie, (3) Fayette Prairie and Transition Zone, (4) Mesquite-Chaparral, (5) Mainland Dunes, (6) Oak-Hickory-Mesquite of the Igneous Central Mineral Region, (7) Oak-Juniper of Hilly Marginal Portion of Edwards Plateau, (8) Montane Forests and Oak-Savanna, (9) Liveoak-Mesquite Savanna, (10) Foothills and Mesa Region westward from Pecos River, (11) Sandy South Plains, (12) High Plains, (13) Mesquite Savanna, (14) Western Cross Timbers, (15) Eastern Cross Timbers, (16) Oak-Hickory, (17) Mixed Pine-Oak, (18) Blackland Prairie.

sional hunting excursions into the Texan. The Karankawa Indians inhabited the Coastal Prairie west of the Austroriparian (perhaps not so far inland as mapped by Tharp). The Tonkawa Indians inhabited the Texan north of the Coastal Prairie before being partially replaced by Wichita Indian groups. The Tamaulipan Biotic Province was inhabited by Coahuiltecan Indians. The Indians inhabiting the Balconian before 1500 may have been Coahuiltecan but this has yet to be demonstrated. The rest of the state was inhabited first by Apache

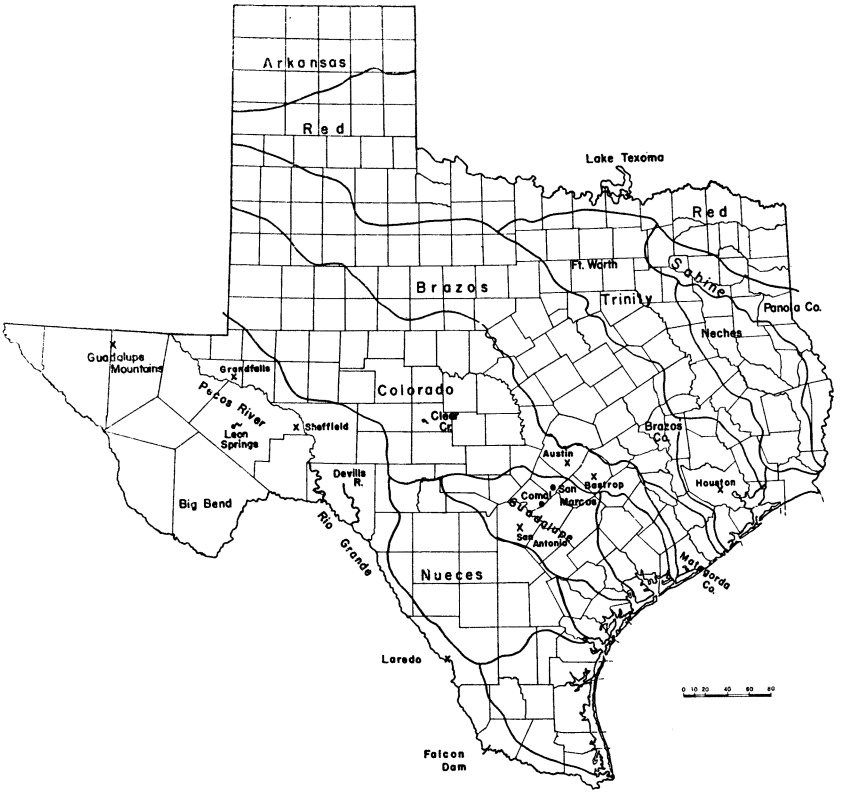

Fig. 2. Major stream systems of Texas.

groups, which were later (after 1700) replaced in Texas by Comanches. Both Apache and Comanche raided in other areas. It is not suprising that Indian groups occupied similar areas as other biologic groups. Moreover, recent cultural groupings likewise appear to have had similar geographic limitations.

Knowledge of the distribution of Texas fresh-water fishes has accumulated for more than 100 years. Naturalists accompanying the Railway and Boundary Surveys in the 1850's collected a few fishes, especially on the wagon road between San Antonio and El Paso (Girard, 1858 and 1859). The next more or less intensive work was done in 1884 (Jordan and Gilbert, 1886) and 1891 (Evermann and Kendall, 1894). Locality data for many of the early collections are either inadequate or inaccurate (Clark Hubbs, 1954; Miller, 1955; and Clark Hubbs and Springer, 1957). Interest lagged again until the 1920's when Carl L. Hubbs, then at the University of Michigan Museum of

Zoology, started intensive studies of North American fresh-water fishes. Many collections from Texas waters were made in conjunction with these studies. Intensive surveys of Texas streams were initiated in 1938 by Dr. Kelshaw Bonham at the A. and M. College of Texas. This work was continued and data gathered by his successors and associates including F. W. Tabor, Cecil Reid, G. W. Soulen, F. T. Knapp, G. K. Reid, Jr., and R. J. Baldauf. Unfortunately most of the collection reports are not published and many of the specimens cannot be located. Field work at The University of Texas began in 1946 under the supervision of W. F. Blair. Since 1949 I have been in charge of this program. At about the same time the Texas Game and Fish Commission began intensive stream surveys at the instigation of Marion Toole. Additional information has been accumulated by Royal D. Suttkus, George A. Moore, Carl D. Riggs, and William J. Koster as part of their studies of adjacent states. Kirby Walker, Gordon Gunter, Henry Hildebrand, and J. L. Baughman have concentrated their studies on marine and brackish water environments.

Four zoogeographic summaries based wholly or in part on the distribution of Texas fresh-water fishes are available. Cope (1880), including few fishes, classified the Texas fauna as nearctic with some neotropical forms. Evermann and Kendall (1894) and Fowler (1945) discussed the forms by stream systems. Unfortunately they did not note that many fish distributions are not primarily limited by stream divides. Knapp (1953) partly escaped this pitfall. He separated the Navasota from other Brazos tributaries because of its eastern faunal affinities. He also separated the Sulphur and Cypress drainages from the other parts of the Red River System on his map but this may be an oversight as in the text he did not mention this separation. Otherwise he mapped the fish distribution by stream systems.

Evaluation of the natural distribution of fishes often is complicated by recent faunal modification. The distribution of such fishes as the basses *(Micropterus)*, crappies *(Pomoxis)*, sunfishes *(Lepomis)*, and catfishes *(Ictalurus)* has been modified by fish-cultural activities. Many species have been widely introduced for food *(Cyprinus carpio)*, by bait release (*Astyanax fasciatus*, *Semotilus atromaculatus*, *Notemigonus crysoleucas*, and other minnows), and by release from home aquaria *(Cichlasoma cyanoguttatum* and *Carassius auratus)*. Moreover, modification of the habitat by Anglo-American cultural activities may have changed many general patterns. As early collection records are often scanty, many of the conclusions are based on data obtained since 1950.

SPECIES LIMITED PRIMARILY BY STREAM SYSTEM

Stream divides obviously can limit the geographic range of fishes. Nevertheless only 35 species in Texas are exclusively or in large part limited to certain stream systems. Several ranges are in part based on stream divides. For obvious reasons such boundaries are less noticeable in terrestrial organisms. It is not surprising that the Rio Grande-Nueces and Red River-Sabine divides limit the largest number of species. The main streams are most widely separated geographically and downstream flood connections are less likely to occur (Fig. 2).

RIO GRANDE-NUECES DIVIDE:

Notropis jemezanus and *N. braytoni* occur in the Rio Grande and tributaries, the latter west through the Big Bend region only.

Rhinichthys cataractae and *Notropis simus* occur in the Rio Grande east to near Laredo.

Notemigonus crysoleucas, *Opsopoeodus emiliae*, *Ictalurus melas*, and *Etheostoma gracile* occur widely over Texas, especially in the lower Nueces but are probably not native to the lower Rio Grande (*I. melas* has been recorded there, probably a result of introductions). *Etheostoma grahami* is found only in the Devil's River and adjacent San Felipe Creek in Texas. Hubbs and Strawn (1957) questioned whether this form is specifically distinct from the allopatric *E. lepidum*. *Notropis proserpinus* (also in Lower Pecos), *Dionda diaboli* (also in Las Moras Creek), and an undescribed species of *Cyprinodon* (only in Devil's River) also are limited to this region in Texas. Their boundaries may be considered to be correlated with either stream divides or biotic areas.

NUECES-GUADALUPE DIVIDE:

Notropis volucellus, *Hadropterus scierus*, *Etheostoma spectabile*, and *Percina caprodes* are abundant in the Guadalupe system and northern streams but absent from the Nueces. The *Percina*, however, also inhabits Rio Grande tributaries near the Devil's River. The cause of the range discontinuity is not known.

GUADALUPE DISJUNCT POPULATION:

Hadropterus shumardi is known in Texas only from the Guadalupe system east of the Balcones escarpment as well as east Texas. The cause of the range discontinuity is not known.

COLORADO DISJUNCT POPULATION:

Phenacobius mirabilis is limited chiefly to the part of the Colorado River east of the Balcones escarpment. It also occurs in northeast Texas. The cause of the range discontinuity is not known.

BRAZOS-TRINITY DIVIDE:

Moxostoma congestum is found in the Brazos east to the Coastal Prairie but is absent from collections from the adjacent part of the Trinity. It also occurs over much of south and central Texas.

TRINITY-NECHES DIVIDE:

Notropis sabinae, N. roseus, and *Hadropterus shumardi* are common east and absent west of this divide, which roughly corresponds with the eastern edge of the Austroriparian Biotic Province or mixed Pine-Oak Vegetation Region. The latter two species are also common in the lower Colorado, Guadalupe and Nueces systems and in the lower Guadalupe System, respectively. The causes of the range discontinuities are not known.

NECHES-SABINE DIVIDE:

Notropis chalybaeus has been taken occasionally east and not west of this divide.

RED RIVER-SABINE DIVIDE:

Esox niger, Moxostoma erythrurum, Notropis cornutus, N. ortenburgeri, Menidia audens, Stizostedion canadense, and *Etheostoma barratti* occur in the Red River System east of Lake Texoma and are absent from the Sabine and elsewhere in Texas.

Campostoma anomalum and *Etheostoma spectabile* have been taken in the Red River Drainage of eastern Texas but not from the Sabine. Both are common in limestone waters to the west.

Hiodon alosoides, Hybopsis storeriana, Notropis deliciosus, and *Notropis bairdi* are known from most of the Red River Drainage of Texas but not from the systems immediately adjacent to the south. *Notropis bairdi* and *N. buccula* are here considered specifically distinct. *Notropis deliciosus* is also found on the limestone hills of the Balconian Biotic Province as well as in northern Mexico.

RED RIVER-ARKANSAS DIVIDE:

Hybopsis gracilis and *Notropis girardi* are known from Texas only in the Canadian River and its tributaries, all of which drain into the Arkansas River (Cross, Dalquest, and Lewis, 1955).

COASTAL SPECIES

Fish distributional data logically support a major coastal biologic area. Many salt water forms invade fresh waters for varying distances (Gunter, 1945), but many of these distances are similar. Probably the distance inland fluctuates directly with the amount of salt water.

During the past several years of pronounced drought this area has been slightly narrower than Tharp's Coastal Prairie, and on the central coast corresponds rather closely with Campbell's outline of the range of the Karankawa Indians. The primarily marine species that occupy this area include *Elops saurus*, *Harengula pensacolae*, *Anchoa mitchilli*, *Bagre marinus*, *Galeichthys felis*, *Adinia xenica*, *Fundulus similis*, *F. grandis*, *F. pulvereus*, *F. jenkinsi*, *Mugil curema*, *Membras martinica*, *Gobionellus shufeldti*, *Microgobius gulosus*, *Gobiosoma bosci*, *Trinectes maculatus*, and *Achirus lineatus*. Most of the primarily fresh-water fishes do not penetrate into this brackish water area. A few do enter the habitat and occur there with forms that are primarily marine. Other primarily marine forms may extend farther into fresh waters. *Strongylura marina* has been taken as far up the Colorado River as Bastrop. *Cyprinodon variegatus*, *Menidia beryllina*, and *Lucania parva* are often found in the Rio Grande above Falcon Dam. Perhaps they occupy most of the Tamaulipan Biotic Province. *Lucania parva* has also been taken in the Pecos River.

SPECIES NOT PRIMARILY FOLLOWING TERRESTRIAL BIOTIC AREAS

Three distribution patterns that have not been mentioned by Blair or Tharp are apparent in fresh-water fishes. These distributions cross the boundary between the Texan and Austroriparian Provinces. I can find no geologic or meteorologic correlations with these patterns.

Lake Texoma to Panola County:

Ichthyomyzon castaneus, *Notropis maculatus*, and *Etheostoma histrio* are found north of this line, including parts of the upper Sabine, but not in the adjacent area to the south.

Upper Red River to Panola County:

Lepisosteus platostomus, *Ictiobus cyprinellus*, and *Notropis blennius* are found in the same general region as the previous group and also extend to near the Texas Panhandle in the Red River System. Gunter and Knapp's (1951) record of *L. platostomus* from near Port Lavaca is unconfirmed and is here considered dubious. Likewise, reports of *L. platostomus* from the Pecos (Evermann and Kendall, 1894, and Meek, 1904) are probably based on Girard's (1858) description of *Cylindraceus latirostris* which is probably a synonym of *L. spatula* (Carl L. Hubbs, personal communication, 1957). *Phenacobius mirabilis* occurs in this part of northern Texas and the lower Colorado System.

FORT WORTH TO HOUSTON:

Minytrema melanops, *Notropis umbratilis*, *Schilbeodes nocturnus*, *Labidesthes sicculus*, and *Etheostoma radiosum* are found north and east of this line but not south and west of it. This line approximates that drawn by Knapp (1953) to divide his eastern and central geographic areas. It also approximates the line drawn by Kroeber (1939) for the western limits of the Caddoan Indians.

SPECIES THAT PRIMARILY FOLLOW TERRESTRIAL BIOTIC AREAS

The ranges of 79 fish species are entirely or in large part limited to the Biotic Areas based on the distribution of terrestrial organisms. Many of these fishes are common species the ranges of which are not likely to be modified by fishermen.

AUSTRORIPARIAN:

Fundulus notti, *Centrarchus macropterus*, *Elassoma zonatum*, *Morone interrupta*, and *Etheostoma proeliare* all have ranges that correspond with the western limit of the Austroriparian. With the exceptions of *M. interrupta* and possibly *C. macropterus*, they are forms not likely to be moved by fishermen. *Hybognathus hayi* probably has a similar range but records are scanty. The range of *Erimyzon oblongus* also corresponds with the Austroriparian; previous western records (Clark Hubbs, Kuehne, and Ball, 1953; and Clark Hubbs, 1954) are based on *E. sucetta*. *Notropis atherinoides* appears to range through the Austroriparian of Texas; however, confusion with a western form, *N. percobromus*, makes its range less certain. *Semotilus atromaculatus* also is abundant within the Austroriparian but seldom elsewhere in Texas. Western records in Texas, such as those so reported by Jurgens (1954), and a report from Lake Texoma have undoubtedly resulted from bait release.

The range of *Fundulus chrysotus* in Texas corresponds within the Austroriparian except along the coast, where it is found slightly farther west, to Matagorda County.

MIXED PINE-OAK—OAK HICKORY LINE:

In Texas seven species, *Ichthyomyzon gagei*, *Polyodon spathula*, *Moxostoma poecilurum*, *Fundulus olivaceus*, *Lepomis marginatus*, *Ammocrypta vivax*, and *Etheostoma parvipinne*, reach western limits the correspond with the western limit of the Mixed Pine Oak Region (No. 17 on Fig. 1), which extends slightly east of the western border of the Austroriparian in the northern corner of the state. *Ammocrypta*

clara appears to have a similar range but records are too scanty for a definite allocation of limits for this species. *Lepomis symmetricus* also occupies the same area to the north but on the coast it is found west to Matagorda County. These patterns are hardly significant deviations from the Austroriparian patterns.

OAK-HICKORY—BLACKLAND PRAIRIE LINE:

Amia calva, *Esox americanus*, *Notropis atrocaudalis*, and *Aphredoderus sayanus* reach western limits near this line (between regions 16 and 18, Fig. 1). All are limited on the southwest by a line between Brazos and Matagorda Counties. They therefore moderately transgress the Austroriparian.

Notropis fumus and *N. amnis* have similar western limits, but toward the southwest extended to the northern edge of the Tamaulipan Biotic Province.

The eastern limit of the range of *Pimephales promelas* coincides with this line north of San Antonio. This species is absent also in the Balconian Biotic Province (except for one specimen which was probably released as bait) and from the Rio Grande System of Texas (except in the Big Bend region).

EASTERN CROSS TIMBERS AND EDWARDS PLATEAU—BLACKLAND PRAIRIE LINE:

The western limit of *Etheostoma chlorosomum*, *Opsopoeodus emiliae*, and *Lepisosteus spatula* approximates this line, which cuts through the Texan Province in northcentral Texas (the northwestern tongue of the Blackland Prairie (No. 18 of Fig. 1) is not here included). On the south *E. chlorosomum* is absent in the Tamaulipan Biotic Province. *Opsopoeodus emiliae* occupies all but the Rio Grande drainage of the Tamaulipan in Texas. *Lepisosteus spatula* occurs throughout the Tamaulipan of Texas, and ranges farther.

In Texas *Campostoma anomalum* and *Etheostoma spectabile* reach their eastern limits on this line. The former occupies the entire Balconian Biotic Province and parts of the Rio Grande System. The latter is excluded from the Nueces System. On the west both are excluded from the Kansan Biotic Province in Texas. The eastern limits of *C. anomalum* are slightly obscured by occasional eastern records, but that of *E. spectabile* is remarkably precise. West of the Balcones escarpment it is usually the most abundant riffle-inhabiting fish. No specimens are taken in extensive collections as little as 10 miles east (downstream).

TEXAN BIOTIC PROVINCE:

Blair was unable to list any endemics for this primarily transitional Biotic Province. Three fishes, *Notropis oxyrhynchus*, *N. brazosensis*, and *N. potteri* are limited to this area. These species were originally thought to be limited entirely or almost entirely to the Brazos River System (Carl L. Hubbs and Bonham, 1951), but have since been taken in adjacent systems (Jurgens, 1954). *Notropis buccula* is also found only here, but is absent in the Red River System, where it is replaced by *N. bairdi*, with which it may be conspecific.

Three species, *Schilbeodes gyrinus*, *Fundulus notatus*, and *Micropterus punctulatus* occupy both the Austroriparian and Texan in Texas.

Four species, *Lepisosteus productus*, *Signalosa petenensis*, *Etheostoma gracile*, and *Mugil cephalus* occupy the Texan, Austroriparian, and Tamaulipan biotic provinces in Texas. *Etheostoma gracile* is absent in the Rio Grande drainage of the Tamaulipan. *Mugil cephalus* is primarily marine but its freshwater records closely approximate the listed geographic area.

Notropis venustus, *Ictalurus natalis*, and *Lepomis punctatus* occupy the Texan, Austroriparian, and Balconian biotic provinces in Texas. In Texas *Notropis volucellus* has the same limit, except that it is absent in the Nueces River Drainage. *Hadropterus scierus* also occupies the three biotic provinces but is absent in the Nueces System and on the coastal part of the Texan.

BALCONIAN BIOTIC PROVINCE:

A number of fishes are entirely or chiefly limited to this Biotic Province, which is limited on the south and east by the Balcones Escarpment. The range of *Etheostoma lepidum* nearly coincides, if *Etheostoma grahami* is specifically distinct. If *E. grahami* and *lepidum* are conspecific, the Texas range of *E. lepidum* equals the Balconian. *Notropis amabilis* in Texas is limited to the Balconian. Established populations of the introduced *Lepomis auritus* are chiefly limited to this area, though some are found elsewhere, especially in farm ponds. A disjunct part of the range of *Notropis deliciosus* corresponds with the Balconian; other specimens are from northern Mexico and the Red River and northern drainages in the United States. *Notropis lepidus* and *Micropterus treculi* occupy the southern and northern halves of the Balconian, respectively. Both are essentially allopatric to closely related species *(lutrensis* and *punctulatus)*.

Moxostoma congestum in Texas is chiefly limited to the Balconian, but does extend into the Chihuahuan and Texan to the Coastal Prairie and Brazos-Trinity divide.

Dionda episcopa is essentially restricted to the Balconian and Chihuahuan regions of Texas.

The Balconian fauna, like the Texan, is essentially transitional. It does include, however, more endemics. Five species are limited to small fractions of the Balconian and are discussed below.

KANSAN BIOTIC PROVINCE:

Only one fish, *Cyprinodon rubrofluviatilis*, is typically Kansan in Texas. It is restricted to the Mesquite Plains Vegetation Region (No. 13). The Kansan is essentially depauperate in fish fauna.

TAMAULIPAN BIOTIC PROVINCE:

Three fishes, *Cichlasoma cyanoguttatum*, *Mollienisia latipinna*, and *M. formosa* are essentially limited to the Tamaulipan. *M. formosa* is restricted to the extreme southern tip of the state. *Mollienisia latipinna* also occupies the coastal plain and has been introduced elsewhere (Brown, 1953).

The native range of *Astyanax fasciatus* in Texas is essentially limited to the Tamaulipan and Chihuahuan. It has been widely introduced elsewhere by bait release (Miller, 1952, Brown, 1953, and Riggs, 1954).

CHIHUAHUAN BIOTIC PROVINCE:

Fundulus zebrinus, *Lucania parva*, and another undescribed species of *Cyprinodon* occur abundantly in the saline waters of the Pecos but not in the nearby less saline habitats in Texas. Salinities as high as 25.1 parts per thousand and a yearly average of 12.6 ppt have been recorded from the Pecos at Grandfalls (Ireland, 1956). Although those are extreme values, annual averages in excess of 10 ppt are often reported. The Pecos is less saline south of Sheffield and contains a fish fauna similar to that of adjacent parts of the Rio Grande. *Fundulus zebrinus* may be conspecific with *F. kansae* (Miller, 1955). The former recently has been taken in the Big Bend region at Garden Springs, the mouth of Tornillo Creek, and the mouth of Terlingua Creek. As all three locations have been collected extensively (Carl L. Hubbs, 1940, and by the author) prior to collections containing large numbers of *F. zebrinus*, bait release seems the most likely source.

Three species, *Notropis chihuahua*, *Pimephales promelas*, and *Campostoma ornatum*, live in clear tributaries in the Big Bend region but not in adjacent streams. All three are commonly taken in the state of Chihuahua. *Pimephales promelas* also occurs in many other parts of the United States.

In Texas, *Cyprinodon elegans* and *Gambusia nobilis* have inhabited springs in the western tributaries of the Pecos River. The latter also

occurs in similar tributaries in New Mexico. Probably due to drought and competition with the introduced *G. geiseri*, the two species are decreasing in abundance in the eastern part of their ranges. Neither could be found at Comanche Springs during a visit in 1956.

Two species, *Chaenobryttus gulosus* and *Lepomis microlophus*, have been found throughout the state, except in the Chihuahuan Biotic Province. Both have been extensively introduced, and their native range in Texas is indeterminate.

NAVAHONIAN BIOTIC PROVINCE:

One species, the introduced *Salmo gairdneri*, is restricted to the Navahonian in Texas. As this species has been widely introduced, its survival only in McKittrick Canyon in the Guadalupe Mountains (Knapp, 1953) indicates the area to be biologically unique. Trout have been reported elsewhere in Texas but the reports are either unverified or based on extremely artifical conditions, *i.e.*, feeding, winter, survival, etc. The best hearsay accounts are for the Pecos River, prior to use of the non-saline headwaters for irrigation, when the river was more suitable for fish life. The fish described appears to be *Salmo clarki*. The specimen of *Gila nigrescens* from "Texas" may well have been from the Navahonian, a region it naturally inhabits. The exclusion of the Navahonian from Texas by Mecham (1955), based on herpetofauna, is not supported by fish distribution.

MISCELLANEOUS:

Nine species have distributional patterns that fit the terrestrial biotic areas, but do not belong in any of the above categories. *Percina caprodes* occupies the Austroriparian, Texan, Kansan, and Balconian (except the Nueces River drainage) biotic provinces. The disjunct population in the Devil's River area is probably native, as this fish is difficult to transport and little used as bait. *Pimephales vigilax* is known throughout Texas except for the Chihuahuan Biotic Province and high plains. The natural ranges of *Notemigonus crysoleucas* and *Ictalurus melas* occupy the Texan, Kansan, Austroriparian and Tamaulipan (except Rio Grande Drainage) biotic provinces. As both have been widely introduced, occasional specimens are found elsewhere. *Cycleptus elongatus* and *Anguilla rostrata* occupy the large rivers in the Tamaulipan, Texan, Chihuahuan, and Austroriparian biotic provinces. *Erimyzon sucetta* has been taken in the Austroriparian and Balconian provinces and on the Coastal Prairie. It is now exceedingly rare in the latter and probably will become extinct there due to drought and misuse of the land. Its preferred habitat there (shallow waters upstream from the main springs) is rapidly disappearing.

Stream courses through the Texan undoubtedly connected the Balconian and Coastal Prairie populations. *Lepomis humilis* ranges through the Kansan, Texan, and Austroriparian provinces to the Coastal Prairie, and also occurs in the Llano Uplift (No. 6, Fig. 1) of the Balconian Province. *Fundulus kansae* occurs in the Llano Uplift, the Cross Timbers(No. 14 and 15, Fig. 1) and the Kansan Province. A population in Waller Creek in Austin, now extinct, probably came downstream from the Llano area.

LOCAL ENDEMICS

Seven species have extremely small ranges. They can be considered restricted to stream systems or biotic areas.

Satan eurystomus and *Trogloglanis pattersoni* are blind catfishes known only from artesian wells near San Antonio (Carl L. Hubbs and Bailey, 1947).

Etheostoma fonticola and *Gambusia geiseri* naturally occur in Comal and San Marcos springs and adjacent waters downstream. Those are the two largest springs along the Balcones Escarpment. The former fish has not been collected elsewhere. The latter has been found elsewhere probably as a result of mosquito control introductions (Clark Hubbs and Springer, 1957).

Gambusia heterochir occurs in the headwaters of Clear Creek, Menard County. Clark Hubbs (1957) correlated its distribution with the abundance of a species of *Ceratophyllum.* During a recent trip (July, 1957) pH readings were made at several stations in Clear Creek. Readings from 6.2 to 6.7 (mean 6.4) were made where *G. hetrochir* abounds; readings of 6.4 to 6.6 (mean 6.5) were made where the fish is rare; and readings of 6.8 to 7.4 (mean 7.0) were made where *G. heterochir* has not been found. These pH's are extremely low for spring waters from the carboniferous limestone of the area. Perhaps the low pH's are correlated with the Permian inliers (Sellards, Adkins, and Plummer, 1933) that occur nearby.

Cyprinodon bovinus is known only from Leon Springs (Miller, 1951) and it apparently now is extinct.

Gambusia gaigei is now known only in Graham Ranch Spring in the Big Bend (Clark Hubbs and Springer, 1957). It formerly occupied a nearby spring at Boquillas (Carl L. Hubbs, 1940).

WIDE-RANGING SPECIES

A few fishes occur throughout Texas. The boundaries of those species cannot, therefore, be correlated with distributional patterns

within Texas. However, infraspecific groupings may be correlated in those forms studied. *Notropis lutrensis* from the Balconian have slenderer bodies than those from elsewhere. Populations of *Gambusia affinis* with strongly marked color patterns occur in the Nueces tributaries within the Balconian but not in downstream waters of the Tamaulipan. Two ranges of races of *Pimephales vigilax* are separated by stream divides in Texas by Carl L. Hubbs and Black (1947). These authors listed the races as *Ceratichthys vigilax* and *C. perspicuus*.

CONCLUSIONS

The distribution patterns of fresh-water fishes resemble closely those of terrestrial organisms. A large proportion of the ranges of the fishes end at approximately the same place as do those of terrestrial organisms. Additional species have very restricted ranges. Although distributional details may change with the accumulation of additional data, the pattern is expected to be consistent.

Deviations from the terrestrial pattern characterize the distribution of several fishes, including: (1) those limited entirely or partly by stream divides; (2) marine and freshwater forms that contact near the coast; and (3) a group of fishes the ranges of which in northeastern Texas include, in addition to the Austroriparian Province, triangles of varying sizes of other biotic provinces. The limitation to stream systems was expected, but its infrequency is notable. Headwater stream capture and downstream connections during flooding must have been frequent. The second category is typical of the distribution of coastal aquatic organisms. The third category is at present inexplicable; the data are too extensive to attribute the deviation in distributional patterns to incomplete records.

The agreement between the distribution of aquatic and terrestrial organisms is probably based on climatological and geological factors, which may be expected to determine the properties of the water. Waters in western Texas are more saline than those in the east. Waters from the limestones of the Balconian Province have moderate amounts of dissolved salts and have proportionally more Ca^{++}, Mg^{++}, and CO_3^{--} ions, whereas the waters of the Texan region are intermediate in salinity. Perhaps the increased endemism in the Balconian is associated with these factors.

Difficulties in rearing Austroriparian fishes in Austin, in water of Balconian origin, illustrates the basic significance of water chemistry. Similar high mortalities of Balconian species in waters with low pH (and probably few salts) support this hypothesis.

METHODS AND ACKNOWLEDGEMENTS

The nomenclature follows that of Moore (1957) with two exceptions: *Percina* and *Hadropterus* are considered distinct genera (Clark Hubbs and Strawn, 1957) and *Chaenobryttus gulosus* replaces *C. coronarius* (Bailey, 1956). Described ranges have been outlined from spot maps of each species. Questionable records and problem species are so indicated. Species with few records are not discussed if no distributional pattern is apparent.

Many workers have aided in assembling the data included in this report. Those mentioned in the all-too-brief historical accounts are only a few. W. Frank Blair, T. N. Campbell, and B. C. Tharp of the University of Texas, R. R. Miller and R. M. Bailey of the University of Michigan, G. A. Moore of Oklahoma A. and M. College, and Carl L. Hubbs of the University of California have read and criticized this manuscript. I thank them for their helpful suggestions. The conclusions, however, are my own.

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