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*** START OF THE PROJECT GUTENBERG EBOOK FISHES OF CHAUTAUQUA, COWLEY AND ELK COUNTIES, KANSAS ***

[Cover]

UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Volume 11, No. 6, pp. 345-400, 2 plates, 2 figs. in text, 10 tables

————— **May 6, 1959** —————

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Fishes of Chautauqua, Cowley and Elk Counties, Kansas

[Pg 347]

BY

ARTIE L. METCALF

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INTRODUCTION

Aims of the distributional study here reported on concerning the fishes of a part of the Arkansas River Basin of south-central Kansas were as follows:

- (1) Ascertain what species occur in streams of the three counties.
- (2) Ascertain habitat preferences for the species found.
- (3) Distinguish faunal associations existing in different parts of the same stream.
- (4) Describe differences and similarities among the fish faunas of the several streams in the area.
- (5) Relate the findings to the over-all picture of east-west distribution of fishes in Kansas. [Pg 348]
- (6) List any demonstrable effects of intermittency of streams on fish distribution within the area.

Cowley and Chautauqua counties form part of the southern border of Kansas, and Elk County lies directly north of Chautauqua. The following report concerns data only from those three counties unless otherwise noted. They make up an area of 2,430 square miles having a population of 50,960 persons in 1950 (55,552 in 1940, and 60,375 in 1930). The most populous portion of the area is western Cowley County where Arkansas City with 12,903 inhabitants and Winfield with 10,264 inhabitants are located. Each of the other towns has less than 2,000 inhabitants. In the Flint Hills, which cross the central portion of the area surveyed, population is sparse and chiefly in the valleys.

Topographically, the area is divisible into three general sections: the extensive Wellington formation and the floodplain of the Arkansas River in western Cowley County; the Flint Hills in the central part of the area; and the "Chautauqua Hills" in the eastern part. The drainage pattern is shown in Figure 1.

The Wellington formation, which is devoid of sharp relief, borders the floodplain of the Arkansas River through most of its course in Cowley County. A short distance south of Arkansas City, however, the Arkansas is joined by the Walnut River and enters a narrow valley walled by steep, wooded slopes. Frye and Leonard (1952:198) suggest that this valley was originally carved by the Walnut River, when the Arkansas River flowed southward west of its present course. They further suggest that during Nebraskan glacial time the Arkansas probably was diverted to the rapidly downcutting Walnut. The Arkansas River has a gradient of 3.0 ft. per mile in Cowley County. This gradient and others cited were computed, by use of a cartometer, from maps made by the State Geological Survey of Kansas and the United States Geological Survey.

Northward along the Walnut, steep bluffs and eroded gulleys characterize both sides of the river, especially in southern Cowley County. Two massive limestones, the Fort Riley and the Winfield, form the bluffs in most places. The well-defined Winfield limestone is persistent on the west bank of the river across the entire county. The Walnut has only a few small tributaries in the southern half of Cowley County (Fig. 1). In the northern half, however, it is joined from the east by Timber Creek and Rock Creek. Timber Creek drains a large level area, formed by the eroded upper portion of the Fort Riley limestone, in the north-central portion of the county. The gradient of Timber Creek is 12.9 feet per mile. The gradient of the Walnut River is only 2.3 ft. per mile from its point of entrance into the county to its mouth. [Pg 349]

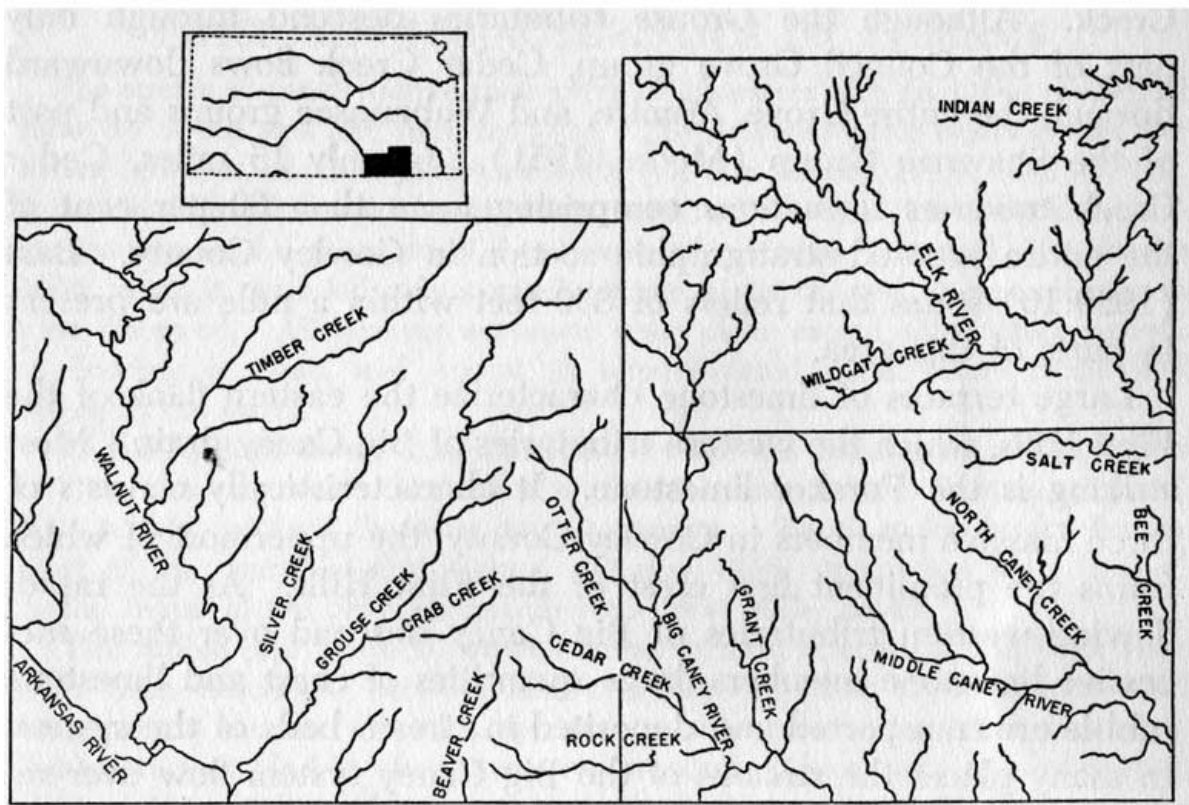


Fig. 1. Map of Cowley, Chautauqua and Elk counties, Kansas, showing the streams mentioned in the text

Fig. 1. Map of Cowley, Chautauqua and Elk counties, Kansas, showing the streams mentioned in the text

Grouse Creek, like the Walnut, has formed a valley of one to three miles in width, rimmed by prominent wooded bluffs. Those on the west side are capped by the Fort Riley limestone with the resistant Wreford and Crouse limestones forming lower escarpments. On the east side the Wreford and Crouse limestones provide the only escarpments along the stream above the Vinton community, except for occasional lower outcrops of Morrill limestone. Below Vinton the Fort Riley limestone again appears, capping the hills above the Wreford limestone. The headwaters of the western tributaries of Grouse Creek are generally in the Doyle shale formation; the eastern tributaries are in the Wreford limestone, Matfield shale, and Barnestone limestone formations. The gradient of Grouse Creek is 9 ft. per mile, of Silver Creek 14.6 ft. per mile, and of Crab Creek 14.4 ft. per mile.

The Big Caney River (Fig. 1), having a gradient of 15.4 ft. per mile in the area studied, drains an area with considerable geological and topographic variation. The main stream and its western tributaries originate in Permian formations, whereas the eastern tributaries originate in Pennsylvanian formations. Cedar Creek is exemplary of western tributaries of Big Caney. This creek arises in the Wreford limestone, as do several nearby tributaries of Grouse Creek. Although the Grouse tributaries descend through only part of the Council Grove group, Cedar Creek flows downward through the entire Grove, Admire, and Wabaunsee groups and part of the Shawnee Group (Moore, 1951). In only 15 miles, Cedar Creek traverses formations comprising more than 60 per cent of the entire exposed stratigraphic section in Cowley County. Bass (1929:16) states that reliefs of 350 feet within a mile are present in parts of this area.

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Large terraces of limestone characterize the eastern flank of the Flint Hills, which the western tributaries of Big Caney drain. Most striking is the Foraker limestone. It characteristically consists of three massive members in Cowley County, the uppermost of which forms the prominent first crest of the Flint Hills. As the rapid-flowing western tributaries of Big Caney descend over these successive limestone members, large quantities of chert and limestone rubble are transported and deposited in stream beds of the system. In many places the streams of the Big Caney system flow over resistant limestone members, which form a bedrock bottom. The eastern tributaries of Big Caney drain, for the most part, formations of the Wabaunsee group of the Pennsylvanian. Most of these streams have lower gradients than those entering Big Caney from the west. The tributaries of Big Caney, along with length in miles and gradient in feet per mile, are as follows: Spring Creek, 7.1, 54.5; Union Creek, 6.3, 42.9; Otter Creek, 14.6, 27.4; Cedar Creek, 11.6, 31.0; Rock Creek, 15.9, 26.5; Wolf Creek, 9.3, 17.2; Turkey Creek, 8.5, 26.4; Grant Creek, 13.9, 23.4; and Sycamore Creek, 8.9, 27.0.

Spring Creek and Union Creek are short and have formed no extensive floodplain. The high gradients of these creeks are characteristic also of the upper portions of several other tributaries such as Cedar Creek and Otter Creek.

Middle Caney Creek (Fig. 1) has its source in the Wabaunsee and Shawnee groups of the Pennsylvanian but its watershed is dominated by the "Chautauqua Hills" of the Douglas Group.

This area is described by Moore (1949:127) as "an upland formed by hard sandstone layers." The rough rounded hills supporting thick growths of oaks differ in appearance from both the Big Caney watershed on the west and the Verdigris River watershed on the east. The gradient of Middle Caney in Chautauqua County is 10.8 feet per mile. Its largest tributary, North Caney Creek, has a gradient of 15.5 feet per mile.

The Elk River Basin resembles the Big Caney River Basin topographically. Elk River has a gradient of 14.4 feet per mile.

PHYSICAL CHARACTERISTICS OF STREAMS

The stream channels derive their physical characteristics from the geological make-up of the area and from land-use. The Arkansas River typically has low banks; however, in a few places, as in the NE ¼ of Section 21, T. 33 S, R. 3 E, it cuts into limestone members to form steep rocky banks. The bottom is predominantly sand. In years of heavy rainfall the river is turbid, but during 1956, when it occupied only a small portion of its channel, it was clear each time observed. All streams surveyed were clear except after short periods of flooding in June, and except in some isolated pools where cattle had access to the water.

In the Walnut River, sand bottoms occur in the lower part of the stream but the sand is coarser than that of the Arkansas River. Upstream, gravel and rubble bottoms become more common. Steep rocky banks border most of the course of the Walnut. During 1956, stream-flow was confined to the center of the channel, remote from these rocky banks.

The rubble and bedrock bottoms found in most streams of the Flint Hills have been described. In the alluvial valleys of their lower courses mud bottoms are found. Gravel is present in some places but sand is absent. Banks are variable but often steep and wooded. Along east- or west-flowing streams the north bank characteristically is low and sloping whereas the south bank is high, rises abruptly, and in many places is continuous with wooded hills. The lower sections of Otter Creek, Cedar Creek, and Rock Creek fit this description (Bass, 1929:19) especially well, as does Elk River near Howard.

Streams in the Chautauqua Hills resemble those of the Flint Hills in physical characteristics, except that a larger admixture of sandstone occurs in the rubble.

CLIMATE

The climate of the area is characterized by those fluctuations of temperature, wind, and rainfall typical of the Great Plains. The mean annual temperature is 58 degrees; the mean July temperature is 81 degrees; the mean January temperature is approximately 34 degrees. The mean annual precipitation is 32.9 in Cowley County, 38.5 in Chautauqua County, and 35.1 in Elk County. Wind movement is great; Flora (1948:6) states that south-central Kansas ranks close to some of the windiest inland areas in the United States.

The area has been periodically subjected to droughts and floods. Such phenomena are of special interest to ichthyological workers in the area. At the time of this study drought conditions, which began in 1952, prevailed. Even in this period of drought, however, flooding occurred on Grouse Creek and water was high in Big Caney River after heavy local rains on the headwaters of these streams on June 22, 1956. Some of the lower tributaries of these same streams (such as Crab Creek and Cedar Creek) did not flow while the mainstreams were flooding. This illustrates the local nature of many of the summer rains in the area.

Table 1 indicates maximum, minimum, and average discharges in cubic feet per second at several stations in the area and on nearby streams. These figures were provided by the U. S. Geological Survey.

TABLE 1.—CUBIC FEET PER SECOND OF WATER DISCHARGED AT GAUGING STATIONS IN CHAUTAUQUA, ELK, MONTGOMERY, AND COWLEY COUNTIES FOR YEARS PRIOR TO 1951.

Gauging station	Drainage area (sq. mi.)	Avg discharge	Maximum discharge	Date	Minimum discharge	Date
Arkansas River at Arkansas City	43,713	1,630	103,000	June 10, 1923	1	October 9, 1921
Walnut River at Winfield	1,840	738	105,000	April 23, 1944	0	1928, 1936, 1939, April

Big Caney River at Elgin	445	264	35,500	10, 1944	0	1940, 1946, 1947
Elk River near Elk City	575	393	39,200	April 16, 1945	0	1939, 1940, 1946
Fall River near Fall River	591	359	45,600	April 16, 1945	0	1939, 1940, 1946
Verdigris River at Independence	2,892	1,649	117,000	April 17, 1945	0	1932, 1934, 1936, 1939, 1940

Something of the effect that drought and flash-flood have had on Big Caney River is shown by the monthly means of daily discharge from October, 1954, to September, 1956, at the stream-gauging station near Elgin, Kansas (Table 2). Within these monthly variations there are also pronounced daily fluctuations; on Big Caney River approximately ¼ mile south of Elgin, Kansas, discharge in cubic feet per second for May, 1944, ranged from .7 to 9,270.0 and for May, 1956, from .03 to 20.0.

TABLE 2.—MONTHLY MEANS OF DAILY DISCHARGE IN CUBIC FEET PER SECOND FOR BIG CANEY RIVER AT ELGIN, KANSAS

<i>Month</i>	<i>1954-55</i>	<i>1955-56</i>
October	103.00	69.60
November	.31	.78
December	.18	1.92
January	.78	1.65
February	4.76	2.08
March	3.37	1.27
April	4.91	.47
May	624.00	7.37
June	51.30	35.20
July	1.20	1.85
August	0.00	0.00
September	.04	0.00

PRESENT FLORA

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The flora of the region varies greatly at the present time. Land-use has altered the original floral communities, especially in the intensively cultivated area of western Cowley County and in the river valleys.

The sandy Arkansas River floodplain exhibits several stages ranging from sparsely vegetated sandy mounds near the river through stages of Johnson grass, willow, and cottonwood, to an elm-hackberry fringe-forest. The Wellington formation bordering the floodplain supports a prairie flora where not disturbed by cultivation; Gates (1936:15) designates this as a part of the mixed bluestem and short-grass region. *Andropogon gerardi* Vitman., *Andropogon scoparius* Michx., *Sorghastrum nutans* (L.), and *Panicum virgatum* L. are important grasses in the hilly pastures. Although much of this land is virgin prairie, the tall, lush condition of the grasses described by early writers such as Mooso (1888:304), and by local residents, is not seen today. These residents speak of slough grasses (probably *Tripsacum dactyloides* L. and *Spartina pectinata* Link.) that originally formed rank growths. These no doubt helped conserve water and stabilize flow in small headwater creeks. Remnants of some of these sloughs can still be found. The streams in the Flint Hills have fringe-forests of elm, hackberry, walnut, ash, and willow.

Eastward from the Flint Hills these fringe-forests become thicker with a greater admixture of hickories and oaks. The north slopes of hills also become more wooded. However, grassland remains predominant over woodland in western Chautauqua and Elk counties, whereas in the eastern one-half of Chautauqua County and the eastern one-third of Elk County the wooded Chautauqua Hills prevail. This is one of the most extensive wooded upland areas in Kansas. Hale (1955:167) describes this woodland as part of an ecotonal scrub-oak forest bordering the Great Plains south through Texas. He found stand dominants in these wooded areas to be *Quercus marilandica* Muenchh., *Quercus stellata* Wang., and *Quercus velutina* Lam.

Few true aquatic plants were observed in the Arkansas River although mats of duckweed were found in shallow backwater pools at station A-3 (Fig. 2) on December 22, 1956. In the Walnut River *Najas guadalupensis* Spreng. was common at station W-2. Stones were usually covered

with algae in both the Arkansas and Walnut rivers. A red bloom, possibly attributable to *Euglena rubra* (Johnson), was observed on a tributary of the Walnut River on July 9, 1956, at station W-4.

Green algae were abundant at all stations in the Caney, Elk, and Grouse systems during May and June, 1956, and reappeared late in September. *Chara* sp. was common in these streams in April and May.

The most characteristic rooted aquatic of streams in the Flint Hills was *Justicia americana* L. At station G-7 on Grouse Creek and Station C-8 on Big Caney River (Fig. 3), *Nelumbo lutea* (Willd.) was found. *Myriophyllum heterophyllum* Michx. formed dense floating mats at a number of stations. Other aquatic plants observed in the Caney, Elk, and Grouse systems included *Potamogeton gramineus* L., *Potamogeton nodosus* Poir., *Potamogeton foliosus* Raf., *Sagittaria latifolia* Willd., *Typha latifolia* L., and *Jussiaea diffusa* Forsk.

HISTORY

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In 1857, a survey was made of the southern boundary of Kansas. Several diaries (Miller, 1932; Caldwell, 1937; Bieber, 1932) were kept by members of the surveying party, which traveled from east to west. These accounts contain complaints of difficulty in traversing a country of broken ridges and gulleys as the party approached the area now comprising Chautauqua County. One account by Hugh Campbell, astronomical computer for the party (Caldwell, 1937) mentions rocky ridges covered with dense growth of "black jack," while another by Col. Joseph Johnson, Commander (Miller, 1932) speaks of "a good deal of oakes in the heights"—indicating that the upland oak forest of the Chautauqua Hills was in existence at that time. On reaching Big Caney River near Elgin, Campbell wrote of a stream with very high banks and of a valley timbered with oak and black walnut. While the party was encamped on Big Caney River some fishing was done. Campbell (Caldwell, 1937:353) described the fish taken as "Cat, Trout or Bass, Buffalo and Garr." Eugene Bandel (Bieber, 1932:152) wrote, "This forenoon we did not expect to leave camp, and therefore we went fishing. In about two hours we caught more fish than the whole company could eat. There were some forty fish caught, some of them weighing over ten pounds." It was noted that the waters of Big Caney and its tributaries were "very clear." Progressing up Rock Creek, Johnson wrote of entering a high rolling plain covered with fine grass, and crossed occasionally by clear wooded streams (probably Big and Little Beaver Creeks and Grouse Creek). The diary of Hugh Campbell (Caldwell, 1937:354) contains a description of the Arkansas River Valley near the Oklahoma border. "The Arkansas River at this point is about 300 yards wide, its waters are muddy, not quite so much so, as those of the Mississippi or Rio Bravo. Its valley is wooded and about two miles in width, the main bottom here, being on the east side. On the west it is a rolling prairie as far as the eye can see, affording excellent grass." Some seining was done while encamped on the Arkansas River and "buffalo, catfish, sturgeons, and gars" were taken (Bieber, 1932:156).

An editorial in the Winfield Courier of November 16, 1899, vigorously registers concern about a direct effect of settlement on fish populations in rivers of the area:

"The fish in the streams of Cowley County are being slaughtered by the thousands, by the unlawful use of the seine and the deadly hoop net. Fish are sold on the market every day, sometimes a tubful at a time, which never swallowed a hook.

"The fish law says it is unlawful to seine, snare, or trap fish but some of the smaller streams in the county, it is said are so full of hoop and trammel nets that a minnow cannot get up or down stream. These nets not only destroy what fish there are in the streams but they keep other fish from coming in, they are not operated as a rule by farmers to supply their own tables but by fellows who catch the fish to sell with no thought or care for the welfare of others who like to catch and eat fish.

"If there is a fishwarden in Cowley County so far as his utility goes the county would be as well off without him and his inactivity has caused many of those interested to get together for the purpose of seeing that the law is enforced.

"Depredations like this work injury in more ways than one. They not only deplete the streams of fish large enough to eat and destroy the source of supply but if the U. S. Fish Commission discovers that the law is not enforced and the fish not protected, there will be no free government fish placed in Cowley County streams. It is useless for the Government to spend thousands of dollars to keep the streams well supplied if a few outlaws are allowed to ruthlessly destroy them. The new organization has its eye on certain parties now and something is liable to drop unexpectedly soon."

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Graham (1885:78) listed 13 species of fish that had already been introduced into Kansas waters prior to 1885 by the State Fish Commission.

These early references indicate that direct effects of settlement on the native flora and fauna were recognized early. Concern such as that expressed in the editorial above persists today; however, it is not clear whether the fish fauna of the streams of the area has been essentially changed by man's predation. The indirect effects through human modifications of the environment seem to be of much importance. Three modifications which have especially affected

streams have been agricultural use, urbanization, and industrialization.

The effect of land-use on streams is closely related to its effect on the flora of the watershed. Turbidity, sedimentation, and the rate, periodicity, and manner of flow all bear some relationship to the land-use of the watershed. Stream-flow in the area has been discussed in the section on climate.

The effects of urbanization are more tangible and better recognized than those of agricultural land-use. Streams that flow through cities and other populous areas undergo some modification, especially of the streamside flora. Another effect of urbanization has been increased loads of sewage discharged into the streams. The combined populations of Arkansas City and Winfield rose from 3,986 in 1880 to 23,167 in 1950. Arkansas City found it necessary to construct a sewage system in 1889; Winfield in 1907.

There are, at the present time, nine towns within the area that have municipal sewage systems. The State Training Home at Winfield also has a sewage system. The Kansas State Board of Health, Division of Sanitation, has provided information concerning adequacy of these systems and certain others in nearby counties as of February 5, 1957. This information is shown in Table 3.

Representatives of the Division of Sanitation, Kansas State Board of Health, expressed the belief that pollution by both domestic sewage and industrial wastes would be largely eliminated in the "lower Arkansas" and in the Walnut watershed by 1959.

Important oil and gas resources have been discovered in each of the three counties. The first producing wells were drilled between 1900 and 1902 (Jewett and Abernathy, 1945:24). The Arkansas River flows through several oilfields in its course across Cowley County (Jewett and Abernathy, 1945:97). A number of producing wells have been drilled in the Grouse Creek watershed since 1939 and many of these wells are near the banks of the creek. In the Big Caney watershed of Cowley and Chautauqua counties there has been little oil production in recent years; however, a few small pools are presently producing in southwestern Elk County.

Clapp (1920:33) stated that "Many of the finest streams of our state are now destitute of fish on account of oil and salt pollution. The Walnut River, once as fine a bass stream as could be found anywhere, and a beautiful stream, too, is now a murky oil run, and does not contain a single fish so far as I know. The Fall and Verdigris rivers are practically ruined. Both the Caney rivers are affected, and may soon be ruined for fishing." Doze (1924:31) noted "Some of the finest streams in the state have been ruined as habitat for wild life, the Walnut River is probably the most flagrant example."

TABLE 3.—SEWAGE DISPOSAL FACILITIES IN SOME SOUTH-CENTRAL KANSAS COMMUNITIES.

Community	Status on February 5, 1957	Remarks
Cowley County:		
Arkansas City	Discharging raw sewage	Adequate plant in design stage.
Geuda Springs	Discharging raw sewage	
Winfield	Inadequate	
State training school	Adequate	
Udall	Adequate	
Chautauqua County:		
Cedar Vale	Inadequate	
Sedan	Adequate	In operation 30 days.
Elgin	Adequate	
Elk County:		
Moline	Inadequate	
Howard	Adequate	
Sumner County:		
Belle Plaine	Discharging raw sewage	Adequate plant under construction.
Mulvane	Discharging raw sewage	Adequate plant under construction.
Oxford	Discharging raw sewage	Construction on adequate plant to start soon.
Butler County:		
Augusta	Adequate	
El Dorado	Discharging raw sewage	Adequate plant under construction.
Douglass	Discharging raw sewage	Adequate plant to go into operation within 30 days.

Pollution by petroleum wastes from refineries has also affected the streams studied. The only refinery within the area is at Arkansas City. In Butler County there are four refineries on the Walnut watershed upstream from the area surveyed. Metzler (1952) noted that "fish-kills" occurred from the mid-1940's until 1952 in connection with wastes periodically discharged from these refineries. However, the largest kill, in 1944, was attributed to excessive brine pollution.

In Arkansas City a meat-packing plant, a large railroad workshop, two flour mills, two milk plants, and several small manufacturing plants contribute wastes which may figure in industrial pollution. There are milk plants and small poultry processing plants at Winfield. In Chautauqua and Elk Counties there is little industrial activity.

CONSERVATION

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In recent years several measures have been implemented or proposed to conserve the water and land resources of the Arkansas River Basin. Droughts and floods have focused public attention on such conservation. Less spectacular, but nevertheless important, problems confronting conservationists include streambank erosion, channel deterioration, silting, recreational demands for water, and irrigation needs.

Congress has authorized the U. S. Corps of Engineers (by the Flood Control Act of 1941) to construct six dam and reservoir projects in the Verdigris watershed. Two of these—Hulah Reservoir in Osage County, Oklahoma, on Big Caney River, and Fall River Reservoir in Greenwood County, Kansas—have been completed. Other reservoirs authorized in the Verdigris watershed include Toronto, Neodesha, and Elk City (Table Mound) in Kansas and Oologah in Oklahoma. Construction is underway on the Toronto Reservoir and some planning has been accomplished on the Neodesha and Elk City projects.

The possibilities of irrigation projects in the Verdigris and Walnut River basins are under investigation by the United States Bureau of Reclamation (Foley, *et al.*, 1955:F18).

An area of 11 square miles in Chautauqua and Montgomery Counties is included in the Aiken Creek "Pilot Watershed Project," a co-operative effort by federal, state, and local agencies to obtain information as to the effects of an integrated watershed protection program (Foley, *et al.*, 1955:131).

PREVIOUS ICHTHYOLOGICAL COLLECTIONS

Few accounts of fishes in the area here reported on have been published. Evermann and Fordice (1886:184) made a collection from Timber Creek at Winfield in 1884.

The State Biological Survey collected actively from 1910 to 1912, but localities visited in the Arkansas River System were limited to the Neosho and Verdigris River basins (Breukelman, 1940:377). The only collection made in the area considered here was on the Elk River in Elk County on July 11, 1912. The total species list of this collection is not known.

In the years 1924-1929 Minna E. Jewell collected at various places in central Kansas. On June 30, 1925, Jewell and Frank Jobes made collections on Timber Creek and Silver Creek in Cowley County.

Hoyle (1936:285) mentions collections made by himself and Dr. Charles E. Burt, who was then Professor of Biology at Southwestern College, Winfield, Kansas. Records in the Department of Biology, Kansas State Teachers College at Emporia, indicate that Dr. Burt and others made collections in the area which have not been published on.

TABLE 4.—COLLECTIONS MADE BY DR. FRANK B. CROSS OF THE STATE BIOLOGICAL SURVEY IN 1955.

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Collection number	Date	River	Location
C-131	April 5, 1955	Elk	Sec. 3, T31S, R11E
C-132	April 5, 1955	Sycamore	Sec. 5, T34S, R10E
C-133	April 5, 1955	Big Caney	Sec. 12, T34S, R8E
C-136	April 6, 1955	Walnut	Sec. 29 or 32, T32S, R4E

Claire Schelske (1957) studied fishes of the Fall and Verdigris Rivers in Wilson and Montgomery counties from March, 1954, to February, 1955.

In the annotated list of species that follows, records other than mine are designated by the following symbols:

- E&F—Evermann and Fordice
 - SBS—State Biological Survey (1910-1912)
 - J&J—Jewell and Jobes (collection on Silver Creek)
 - C—Collection number—Cross (State Biological Survey, 1955)
 - UMMZ—University of Michigan Museum of Zoology
 - OAM—Oklahoma A&M College Museum of Zoology
-

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MATERIALS AND METHODS

Collections were made by means of: (1) a four-foot net of nylon screen; (2) a 10×4-foot "common-sense" woven seine with ¼-inch mesh; (3) a 15×4-foot knotted mesh seine; (4) a 20×5-foot ¼-inch mesh seine; (5) pole and line (natural and artificial baits). At most stations the four-foot, ten-foot, and twenty-foot seines were used; however, the equipment that was used varied according to the size of pool, number of obstructions, nature of bottom, amount of flow, and type of streambank. Usually several hours were spent at each station and several stations were revisited from time to time. Percentages noted in the List of Species represent the relative number taken in the first five seine-hauls at each station.

COLLECTING STATIONS

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Collecting was done at stations listed below and shown in Fig. 2. Each station was assigned a letter, designating the stream system on which the station was located, and a number which indicates the position of the station on the stream. This number increases progressively upstream from mouth to source. Code letters used are as follows: A—Arkansas River; W—Walnut River System; B—Beaver Creek System; C—Big Caney River System; G—Grouse Creek System; M—Middle Caney Creek System; E—Elk River System. All dates are in the year 1956.

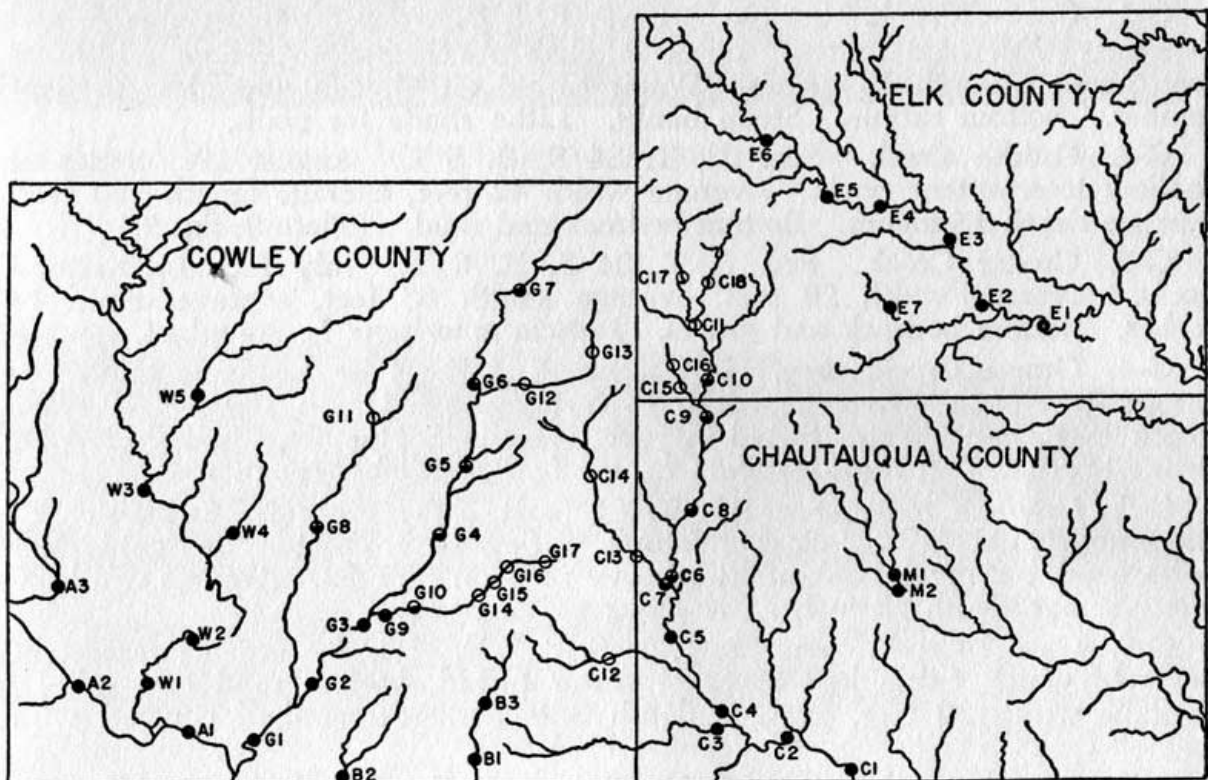


Fig. 2. Map of Cowley, Chautauqua and Elk counties, Kansas, showing stations at which collecting was done.

Fig. 2. Map of Cowley, Chautauqua and Elk counties, Kansas, showing stations at which collecting was done.

A-1. Arkansas River. Sec. 2 and 3, T. 35 S, R. 4 E. June 14 and August 20. Braided channel with sand bottom. Water slightly turbid, with layer of oil sludge on bottom.

A-2. Arkansas River. Sec. 22, T. 34 S, R. 3 E. August 25. Flowing through diverse channels. Average depth 12 inches. Bottom sand. (Plate 9, fig. 1.)

A-3. Arkansas River. Sec. 21, T. 33 S, R. 3 E. August 27 and December 22. Flowing over fine sand. Average depth 11 inches. Some areas of backwater with oil sludge on bottom.

W-1. Walnut River. Sec. 20, T. 34 S, R. 4 E. July 7. Flowing rapidly, with large volume, because of recent rains. Average width 300 feet. Bottom gravel. Water turbid.

W-2. Walnut River. Sec. 11, T. 34 S, R. 4 E. July 20. Rubble riffles and large shallow pools with gravel bottoms. Average width, 100 feet. Water clear.

W-3. Walnut River. Sec. 29, T. 32 S, R. 4 E. July 17. Pools and riffles below Tunnel Mill Dam at Winfield. Water clear.

W-4. Badger Creek. Sec. 6, T. 33 S, R. 5 E. July 17. Small pools. Average width 7 feet, average length 40 feet, average depth 8 inches. Water turbid and malodorous. Bottoms and banks mud. Much detritus present.

W-5. Timber Creek. Sec. 35, T. 31 S, R. 4 E. June 6. Intermittent pools, widely separated. Average width 9 feet, average depth 8 inches. Bottom mud and gravel. [Pg 360]

B-1. Big Beaver Creek. Sec. 8, T. 35 S, R. 7 E. May 28. Isolated pools. Average width 10 feet, average depth one foot. Water turbid. Bottom rubble.

B-2. Little Beaver Creek. Sec. 18, T. 35 S, R. 6 E. July 21. Intermittent pools. Average width 10 feet, average length 35 feet, average depth 10 inches. Bottoms rubble, mud, and bedrock.

B-3. Big Beaver Creek. Sec. 28, T. 34 S, R. 7 E. July 22. Series of small turbid pools.

G-1. Grouse Creek. Sec. 5, T. 35 S, R. 5 E. May 30, September 5, and September 24. Intermittent pools in close succession. Average width 22 feet, average depth 16 inches. Water turbid on May 30 but clear in September. Bottom rubble. Steep banks. Little shade for pools.

G-2. Grouse Creek. Sec. 23, T. 34 S, R. 5 E. August 29. Series of shallow intermittent pools. Average width 42 feet, average length 120 feet, average depth 15 inches. Bottom bedrock and mud. (Plate 9, fig. 2.)

G-3. Grouse Creek. Sec. 6, T. 34 S, R. 6 E. July 12. Intermittent pools. Average width 20 feet, average length 65 feet, average depth 14 inches. Bottom bedrock and gravel. *Justicia americana* L. abundant.

G-4. Grouse Creek. Sec. 12, T. 33 S, R. 6 E. June 1 and September 7. Intermittent pools. Average width 15 feet, average length 100 feet, average depth 18 inches. Water turbid in June, clear in September. *Najas guadalupensis* Spreng., and *Myriophyllum heterophyllum* Michx. common.

G-5. Grouse Creek. Sec. 19, T. 32 S, R. 7 E. July 2. Succession of riffles and pools. Water clear. Volume of flow approximately one cubic foot per second, but creek bankful after heavy rains on June 22. Average width 20 feet, average depth 18 inches.

G-6. Grouse Creek. Sec. 32, T. 31 S, R. 7 E. July 8. Small intermittent pools to which cattle had access. Water turbid, bottom mud and rubble. Average width 10 feet, average depth 8 inches. Stream-bed covered with tangled growths of *Sorghum halepense* (L.).

G-7. Grouse Creek. Sec. 34, T. 30 S, R. 7 E. July 8. Stream flowing slightly. Water clear. Average width of pools 30 feet; average depth 20 inches. Bottom bedrock and gravel. *Myriophyllum heterophyllum* Michx., *Nelumbo lutea* (Willd.), and *Justicia americana* L. common in shallow water.

G-8. Silver Creek. Sec. 1, T. 33 S, R. 5 E. July 17. Intermittent pools. Average width 30 feet, average length 120 feet, average depth 12 inches. Water clear.

G-9. Silver Creek. Sec. 4, T. 32 S, R. 6 E. July 17. Small upland brook with volume less than one-half cfs. Average width 12 feet, average depth 10 inches. Water clear, bottom mostly rubble.

G-10. Crab Creek. Sec. 33, T. 33 S, R. 6 E. June 24. Intermittent pools, showing evidence of having flowed after rains on June 22. Average width 15 feet, average depth 16 inches.

G-11. Crab Creek. Sec. 35, T. 33 S, R. 6 E. July 16. Small intermittent pools. Average width 13 feet, average length 55 feet, average depth 11 inches. Water clear. Bottom rubble and mud.

G-12. Crab Creek. Sec. 28, T. 33 S, R. 7 E. June 2 and July 20. Isolated pools. Average width 18 feet, average depth one foot. Water turbid. Bottom bedrock and rubble. *Myriophyllum heterophyllum* and *Justicia americana* abundant.

G-13. Crab Creek. Sec. 21, T. 33 S, R. 7 E. July 29. Isolated pools 300 feet by 24 feet. Average depth 12 inches. Water turbid.

G-14. Unnamed creek (hereafter called Grand Summit Creek). Sec. 26, T. 31 S, R. 7 E. August 30. Intermittent pools. Average width 15 feet, average length 45 feet, average depth 11 inches. Water clear. Bottom rubble.



1. Station A-2. Arkansas River. (Cowley County, Section 22, T. 34 S, R. 3 E.)



2. Station G-2. Grouse Creek. (Cowley County, Section 23, T. 34 S, R. 5 E.)

1. Station A-2. Arkansas River. (Cowley County, Section 22, T. 34 S, R. 3 E.)
2. Station G-2. Grouse Creek. (Cowley County, Section 23, T. 34 S, R. 5 E.)

PLATE 10



1. Station C-12. Cedar Creek. (Cowley County, Section 17, T. 34 S, R. 8 E.)



1. Station C-12. Cedar Creek. (Cowley County, Section 17, T. 34 S, R. 8 E.)

1. Station C-12. Cedar Creek. (Cowley County, Section 17, T. 34 S, R. 8 E.)

2. Station C-16. Spring Creek. (Elk County, Section 26, T. 31 S, R. 8 E.) Volume of flow of this small creek is indicated by riffle in foreground.

G-15. Unnamed creek (same as above). Sec. 17, T. 31 S, R. 8 E. July 27. Small upland creek bordered by bluestem pastures. Pools with average width of 10 feet, average length 30 feet, average depth 9 inches. Water slightly turbid. Bottom rubble and mud. [Pg 361]

G-16. Crab Creek. Sec. 22, T. 33 S, R. 7 E. July 25. Small isolated pools. Average width 17 feet, average length 58 feet, average depth 9 inches. Water turbid.

G-17. Crab Creek. Sec. 23, T. 33 S, R. 7 E. July 25. Upland brook bordered by bluestem pastures. Unshaded intermittent pools. Average width 7 feet, average length 40 feet, average depth 9 inches. Water turbid.

C-1. Big Caney River. Sec. 16, T. 33 S, R. 10 E. July 19. Intermittent pools. Average width 47 feet, average length 90 feet, average depth 13 inches. Bottom rubble and bedrock. Water clear to slightly turbid.

C-2. Big Caney River. Sec. 1, T. 35 S, R. 9 E. September 5. Series of intermittent pools. Bottom rubble and large stones.

C-3. Big Caney River. Sec. 29, T. 34 S, R. 9 E. June 17. Large shallow pool below ledge 3 feet high forming "Osro Falls." Bottom bedrock.

C-4. Big Caney River. Sec. 32, T. 34 S, R. 9 E. June 3. Three large pools (50 feet by 300 feet) with connecting riffles. Water turbid. Bottom bedrock and rubble.

C-5. Big Caney River. Sec. 11 and 12, T. 34 S, R. 8 E. May 27, May 29, June 11, June 18, June 19, and June 27. From a low-water dam, 6 feet high, downstream for ¼ mile. Pools alternating with rubble and bedrock riffles. Collecting was done at different times of day and night, and when stream was flowing and intermittent.

C-6. Big Caney River. Sec. 26, T. 33 S, R. 8 E. June 16. Intermittent pools with bedrock bottom. Water slightly turbid. Average width 16 feet, average depth 10 inches.

C-7. Otter Creek. Sec. 26, T. 33 S, R. 8 E. June 16. Pools and riffles. Water clear. Algae abundant. Average width 10 feet, average depth 10 inches.

C-8. Big Caney River. Sec. 1, T. 33 S, R. 8 E. June 10. Intermittent pools. Average width 10 feet, average depth 14 inches. Water clear. Bottom rubble and gravel. Aquatic plants included *Chara* sp., *Sagittaria latifolia* Willd., *Jussiaea diffusa* Forsk., and *Nelumbo lutea* (Willd.).

C-9. Big Caney River. Sec. 6 and 7, T. 32 S, R. 9 E. June 27. Clear, flowing stream, 20 feet wide, volume estimated at 5 cfs. Bottom gravel and rubble. Extensive gravel riffles.

C-10. Big Caney River. Sec. 29 and 32, T. 31 S, R. 9 E. June 27. Water clear and flowing rapidly, volume estimated at 5-6 cfs. Bottom rubble with a few muddy backwater areas.

C-11. Big Caney River. Sec. 7, T. 31 S, R. 9 E. July 26. Flowing, with less than 1 cfs. Average width 20 feet, average depth 22 inches. Water extremely clear. Bottom gravel and rubble. *Myriophyllum heterophyllum*, *Potamogeton foliosus*, and *Justicia americana* common.

C-12. Cedar Creek. Sec. 17, T. 34 S, R. 8 E. March 10, April 2, June 1, June 6, and August 24. Pools and riffles along ¼ mile of stream were seined in the early collections. In August only small isolated pools remained. Bottom bedrock and rubble. Much detritus along streambanks. (Plate 10, fig. 1.)

C-13. Otter Creek. Sec. 16, T. 33 S, R. 8 E. June 15. Flowing, less than 1 cfs. Pools interspersed with rubble riffles. Water clear.

C-14. Otter Creek. Sec. 30, T. 32 S, R. 8 E. May 31, and September 3. Series of small pools. Average width 10 feet, average depth 15 inches. Shallow rubble riffles. Water extremely clear. Temperature 68° at 6:30 p.m. on May 31; 78° at 2:00 p.m. on September 3.

C-15. Spring Creek. Sec. 35, T. 31 S, R. 8 E. June 28. Small, clear, upland brook with rubble bottom. Pools 10 feet in average width and 11 inches in average depth. Numerous shallow rubble riffles. [Pg 362]

C-16. Spring Creek. Sec. 26, T. 31 S, R. 8 E. July 9. Small intermittent pools. Average width 10 feet; average depth 8 inches. Bottom gravel. (Plate 10, fig. 2.)

C-17. West Fork Big Caney River. Sec. 36, T. 30 S, R. 8 E. July 27. Small pool below low-water dam. Pool 20 feet by 30 feet with average depth of 20 inches.

C-18. East Fork Big Caney River. Sec. 31, T. 30 S, R. 9 E. July 27. Isolated pool 25 feet by 25 feet with an average depth of 15 inches.

M-1. Middle Caney Creek. Sec. 23, T. 33 S, R. 10 E. July 4. Intermittent pools. Average width 45 feet, average depth 15 inches. Water stained brown. Oil fields nearby but no sludge or surface film of oil noted. Bottom rubble and bedrock.

M-2. Pool Creek. Sec. 25, T. 33 S, R. 10 E. May 26. Pool 120 feet by 40 feet below limestone ledge approximately 12 feet high forming Butcher's Falls. Other smaller pools sampled. Water clear. Bottom bedrock and rubble.

E-1. Elk River. Sec. 12, T. 31 S, R. 11 E. July 9. Four intermittent pools seined. Average width 32 feet, average depth 13 inches. Bottom bedrock, rubble, and mud. Water turbid.

E-2. Elk River. Sec. 3, T. 31 S, R. 11 E. June 28. Intermittent pools below and above sandstone ledge approximately 6 feet high forming "falls" at Elk Falls. Average width 33 feet, average depth 15 inches. Bottom bedrock, rubble and mud. Water slightly turbid.

E-3. Elk River. Sec. 21, T. 30 S, R. 11 E. June 28. Two small pools, 10 feet by 30 feet with average depth of 6 inches. Bottom bedrock.

E-4. Elk River. Sec. 12, T. 30 S, R. 10 E. June 28. One long pool 500 feet by 50 feet with a variety of depths and bottom conditions ranging from mud to bedrock. Average depth 18 inches. Water turbid and pools unshaded.

E-5. Elk River. Sec. 32, T. 29 S, R. 10 E. August 30. Intermittent pools. Average width 21 feet, average depth 20 inches. Bottom rubble. Water clear.

E-6. Elk River. Sec. 23, T. 29 S, R. 9 E. August 30. Small isolated pools. River mostly dry. Bottom bedrock. Water slightly turbid with gray-green "bloom."

E-7. Wildcat Creek. Sec. 11, T. 31 S, R. 10 E. Volume of flow less than one cfs. Average width 20 feet, average depth 18 inches. Domestic sewage pollution from town of Moline suspected.

ANNOTATED LIST OF SPECIES

Lepisosteus osseus oxyurus (Linnaeus): Stations A-1, W-2, W-3, G-2, G-3, G-4, C-1, C-2, C-3, C-5, C-8.

Of 34 longnose gar taken, 27 were young-of-the-year. The latter were from shallow isolated pools (bedrock bottom at C-1, C-3, C-4; gravel bottom at C-6). At station W-1 in moderate flood conditions several young-of-the-year were found in the most sheltered water next to the banks.

The longnose gar was found only in the lower parts of the streams surveyed (but were observed by me in smaller tributaries of these streams in years when the streams had a greater volume of flow). A preference for downstream habitat is suggested in several other surveys: Cross (1950:134, 1954a:307) on the South Fork of the Cottonwood and on Stillwater Creek; Cross and Moore (1952:401) on the Poteau and Fourche Maline rivers; Moore and Buck (1953:21) on the Chikaskia River.

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Lepisosteus platostomus Rafinesque: One shortnose gar (K. U. 3157) has been taken from the Arkansas River in Cowley County. This gar was taken by Mr. Richard Rinker on a bank line on April 10, 1955, at station A-3.

Dorosoma cepedianum (Le Sueur): Stations W-3, G-4, C-4, C-5, M-1, E-1, E-4.

In smaller streams such as the Elk and Caney rivers adult gizzard shad seemed scarce. They were more common in collections made in larger rivers (Walnut, Verdigris, and Neosho). In impoundments of this region shad often become extremely abundant. Schoonover (1954:173) found that shad comprised 97 per cent by number and 83 per cent by weight of fishes taken in a survey of Fall River Reservoir.

Carpiodes carpio carpio (Rafinesque): Stations A-1, A-2, A-3, W-3, G-1, C-3.

Hubbs and Lagler (1947:50) stated that the river carpsucker was "Mostly confined to large silty rivers." Of the stations listed above C-3 least fits this description being a large shallow pool about ½ acre in area having bedrock bottom and slightly turbid water. The other stations conform to conditions described by Hubbs and Lagler (*loc. cit.*).

Carpiodes velifer (Rafinesque): SBS. Three specimens of the highfin carpsucker (K. U. 177-179) were collected on July 11, 1912, from an unspecified location on Elk River in Elk County.

Ictiobus bubalus (Rafinesque): Stations W-3, G-1, G-2, C-1, C-3, C-4, C-6, E-1, E-2, E-3.

The smallmouth buffalo shared the downstream proclivities of the river carpsucker. In half of the collections (G-2, C-1, E-1, E-2, E-3) only large juveniles were taken; in the other half only young-of-the-year were found. In one pool at station C-1 hundreds of young buffalo and gar were observed. This large shallow pool was 100 × 150 feet, with an average depth of 8 inches. The bottom consisted of bedrock. Station C-6 was a small pool with bedrock bottom, eight feet in diameter, with an average depth of only 4 inches. Station E-3 was also a small isolated pool with bedrock bottom and an average depth of 6 inches.

Ictiobus niger (Rafinesque): Station C-5.

Only two specimens of the black buffalo were taken. An adult was caught on spinning tackle, with

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doughballs for bait. The second specimen was a juvenile taken by seining one mile below Station C-5 on September 22.

Ictiobus cyprinella (Valenciennes): Station G-2.

Two juvenal bigmouth buffalo were taken in a shallow pool, along with several juvenal smallmouth buffalo.

Moxostoma aureolum pisolabrum Trautman and ***Moxostoma carinatum*** (Cope): SBS.

Two specimens of *Moxostoma aureolum pisolabrum* (K. U. 242-243) and one specimen of *Moxostoma carinatum* (K. U. 223) were taken from an unspecified locality on Elk River in Elk County on July 11, 1912. There are no other records for any of these fish in the collection area. *M. aureolum pisolabrum* has been taken in recent years in eastern Kansas (Trautman, 1951:3) and has been found as far west as the Chikaskia drainage in northern Oklahoma by Moore and Buck (1953:21). That occasional northern redhorse enter the larger rivers of the area here reported on seems probable.

M. carinatum has been reported only a few times from Kansas. The only recent records are from the Verdigris River (Schelske, 1957:39). Elkins (1954:28) took four specimens of *M. carinatum* from cutoff pools on Salt Creek in Osage County, Oklahoma, in 1954. This recent record suggests that occurrences in southern Kansas are probable.

Moxostoma erythrurum (Rafinesque): Stations G-5, G-7, G-10, G-12, C-4, C-5, C-6, C-8, C-10, C-11, C-12, C-13, C-15, E-1, E-2, E-4 (C-131, C-133, C-136).

The golden redhorse was common in several of the streams surveyed, and utilized the upland parts of streams more extensively than any of the other catostomids occurring in the area. *M. erythrurum* and *Ictiobus bubalus* were taken together at only two stations. In no case was *I. bubalus* taken from a tributary of Grouse Creek or of Big Caney River. In contrast *M. erythrurum* reached its greatest concentrations in such habitat, although it was always a minor component of the total fish population. Stations C-5 and E-2 were the lowermost environments in which this redhorse was taken.

The largest relative number of golden redhorse was found at station G-12 on Crab Creek where 7.5 per cent of the fishes taken were of this species. This station consisted of intermittent pools averaging one foot in depth. Bottoms were bedrock and rubble and the water was clear and shaded. The fish were consistently taken in the deeper, open part of the pool where aquatic vegetation, which covered most of the pool, was absent.

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Another station at which *M. erythrurum* was abundant was C-12 on Cedar Creek. Here a long, narrow, clear pool was the habitat, with average depth of 17 inches, and bottom of bedrock.

Minytrema melanops (Rafinesque): Stations G-10, C-4, C-12, E-1.

Occurrences of the spotted sucker were scattered. At stations C-4 and G-10 single specimens were taken. At station E-1 (July 9) one specimen was taken at the mouth of a small tributary where water was turbid and quiet. This specimen (K. U. 3708) was the largest (9³/₈ inches total length) found, and possessed pits of lost tubercles.

Cyprinus carpio Linnaeus: Stations A-1, W-1, W-2, W-3, W-4, G-3, G-4, G-6, G-8, C-3, C-5, E-4.

Carp were taken most often in downstream habitat. No carp were taken above station C-5 on Big Caney River.

The earliest date on which young were taken was July 7, when 46 specimens, approximately ½ inch in total length, were taken from the Walnut River at station W-1. The small carp showed a preference for small shallow pools; adults were found in deeper pools.

Hybopsis aestivalis tetranemus (Gilbert): Station A-3.

Only one specimen of the speckled chub was taken. The species has been recorded from nearby localities in the Arkansas River and its tributaries both in Kansas and Oklahoma. Its habitat seems to be shallow water over clean, fine sand, and it occurs in strong current in mid-channel in the Arkansas River. Suitable habitat does not occur in other parts of the area covered by this report.

Notropis blennioides (Girard): Stations A-1, A-2, A-3.

The river shiner was taken only in the Arkansas River and in small numbers. In all instances *N. blennioides* was found over sandy bottom in flowing water. Females were gravid at station A-1 on June 14. To my knowledge there are no published records of this shiner from the Arkansas River Basin in Kansas. In Oklahoma this species prefers the large, sandy streams such as the Arkansas River. Cross and Moore (1952:403) found it in the Poteau River only near the mouth.

Notropis boops Gilbert: Stations G-5, G-7, C-3, C-5, C-8, C-9, C-10, C-11, C-12, C-15, C-16, E-4, E-5, M-1, M-2.

Widespread occurrence of the bigeye shiner in this area seems surprising. Except for this area it is known in Kansas only from the Spring River drainage in the southeastern corner of the state (Cross, 1954b:474). *N. boops* chose habitats that seemed most nearly like Ozarkian terrain. The largest relative number of bigeye shiners was taken at C-11 in a clear stream described in the

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discussion of *Notropis rubellus*. At this station *N. boops* comprised 14.11 per cent, and *N. boops* and *N. rubellus* together comprised 24.78 per cent of all fish taken.

At station G-7 on Grouse Creek the percentage of *N. boops* was 7.15. Here, as at station C-11, water was clear. At both stations *Myriophyllum heterophyllum* was abundant and at G-7 *Nelumbo lutea* was also common. At G-7 *N. boops* seemed most abundant in the deeper water, but at C-11 most shiners were found in the shallower part of a large pool.

Two other collections in which *N. boops* were common were from Spring Creek. It is a small, clear Flint Hills brook running swiftly over clean gravel and rubble. It had, however, been intermittent or completely dry in its upper portion throughout the winter of 1955-'56 and until June 22, 1956. In collections at C-15 on June 28, *N. boops* formed 6.5 per cent of the fish taken. Farther upstream, at C-16 on July 9, in an area one mile from the nearest pool of water that existed prior to the rains of June 22, *N. boops* made up 7.2 per cent of the fish taken.

In streams heading in the hilly area of western Elk County, the relative abundance of *Notropis boops* decreased progressively downstream. On upper Elk River percentages were lower than on upper Grouse Creek and upper Big Caney River.

Hubbs and Lagler (1947:66) characterize the habitat of this species as clear creeks of limestone uplands. There are numerous records of the bigeye shiner from extreme eastern Oklahoma. It has been reported as far west as Beaver Creek in Osage County, Oklahoma. Beaver Creek originates in Cowley County, Kansas, near the origin of Cedar Creek and Crab Creek. Drought had left a few pools of water in Beaver Creek in Kansas at the time of my survey. The fish-fauna seemed sparse and *N. boops* was not among the species taken. Of interest in considering the somewhat isolated occurrence of the bigeye shiner in the Flint Hills area of Kansas is a record of it by Ortenburger and Hubbs (1926:126) from Panther Creek, Comanche County, Oklahoma, in the Wichita Mountain area of that state.

Notropis buchanani Meek: Stations G-1, E-4 (C-131).

At station G-1 the ghost shiner was taken in small numbers in the shallow end of a long pool (150 × 40 feet.) The three individuals taken at station E-4 were in an isolated pool (50 × 510 feet) averaging 1½ feet in depth. Water was turbid, and warm due to lack of shade.

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The habitat preferences of this species and of the related species *N. volucellus* have been described as follows by Hubbs and Ortenburger (1929b:68): "It seems probable that *volucellus* when occurring in the range of *buchanani* occupies upland streams, whereas *buchanani* is chiefly a form of the large rivers and adjacent creek mouths." The results of this survey and impressions gained from other collections, some of which are unpublished, are in agreement with this view. A collection on the Verdigris River at Independence, Kansas, directly downstream from the mouth of the Elk River, showed *N. buchanani* to be common while *N. volucellus* was not taken. At station E-5 upstream from E-4, however, *N. volucellus* was taken but *N. buchanani* was not found.

In the upper Neosho basin, Cross (1954a:310) took *N. volucellus* but not *N. buchanani*. Other collections have shown *N. buchanani* to be abundant in the lower Neosho River in Kansas. Moore and Paden (1950:85) observe that *N. buchanani* was found only near the mouth of the Illinois River in Oklahoma and was sharply segregated ecologically from *N. volucellus* that occupied a niche in the clear main channels in contrast to the more sluggish waters inhabited by *N. buchanani*.

Notropis camurus (Jordan and Meek): Stations C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, E-1, E-5 (C-131).

Highest concentrations of the bluntface shiner were found close to the mouths of two tributaries of Big Caney River: Rock Creek and Otter Creek. On Rock Creek (Station C-4) this shiner was abundant in a shallow pool below a riffle where water was flowing rapidly. Many large males in breeding condition were taken (June 3). The species formed 20.2 per cent of the fish taken.

On Otter Creek (Station C-13) the species was common in shallow bedrock pools below riffles. It formed 12.1 per cent of the fish taken.

At station C-5, *N. camurus* was characteristically found in an area of shallow pools and riffles. At station C-10 it was found in clear flowing water over rubble bottom and in small coves over mud bottom. At C-11 (July 26) *N. camurus* was taken only in one small pool with rapidly flowing water below a riffle. In this pool *N. camurus* was the dominant fish. At station C-12, on April 2, *N. camurus* was abundant in the stream, which was then clear and flowing. On August 24, it was not taken from the same pool, which was then turbid and drying.

The frequent occurrence of this species in clear, flowing water seems significant. Cross (1954a:309) notes that the bluntface shiner prefers moderately fast, clear water. Hall (1952:57) found *N. camurus* only in upland tributaries east of Grand River and not in lowland tributaries west of the river. Moore and Buck (1953:22) took this species in the Chikaskia River, which was at that time a clear, flowing stream. They noted that in Oklahoma it seems to be found only in relatively clear water.

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N. camurus did not seem to ascend the smaller tributaries of Big Caney River as did *N. rubellus* and *N. boops* even when these tributaries were flowing.

Notropis deliciosus missouriensis (Cope): Stations A-1, A-2, A-3, W-1, W-2, W-3 (C-136).

Sand shiners seemed to be abundant in the Arkansas River, rare in the Walnut River and absent from other streams surveyed. This shiner was most abundant in shallow, flowing water in the Arkansas River; in backwaters, where *Gambusia affinis* prevailed, *N. deliciosus* formed only a small percentage of the fish population.

Notropis girardi Hubbs and Ortenburger: Stations A-2 and A-3.

At station A-2 the Arkansas River shiner made up 14.6 per cent of all fish taken. At A-2, it was found only in rapidly-flowing water over clean sand in the main channels. It was absent from the shallow, slowly-flowing water where *N. deliciosus missouriensis* was abundant. At A-3 *N. girardi* made up 22 per cent of the total catch, and again preferred the deeper, faster water over clean-swept sand. Failure to find *N. girardi* at station A-1 is not understood.

Females were gravid in both collections (August 25 and 27). In neither collection were young-of-the-year taken. Moore (1944:210) has suggested that *N. girardi* requires periods of high water and turbidity to spawn. Additional collecting was done at station A-3 on December 22, 1957. A few adults were taken in flowing water but no young were found.

In this area, *N. girardi* showed no tendency to ascend tributaries of the Arkansas River. Not far to the west, however, this pattern changes as shown by Hubbs and Ortenburger (1929a:32) who took this fish at seven of ten stations on the Cimarron, Canadian, and Salt Fork of the Arkansas. *N. girardi* was taken only in the lowermost stations on both Stillwater Creek (Cross, 1950:136) and the Chikaskia River (Moore and Buck, 1953:22). In the next major stream west of the Chikaskia, the Medicine River, *N. girardi* seems to occur farther upstream than in the Chikaskia. (Collection C-5-51 by Dr. A. B. Leonard and Dr. Frank B. Cross on Elm Creek near Medicine Lodge on July 20, 1951.)

Notropis lutrensis (Baird and Girard): Stations A-1, A-2, W-1, W-2, W-3, W-4, G-1, G-2, G-4, G-5, G-8, G-9, G-10, G-11, G-12, G-13, G-14, G-15, G-16, B-1, B-2, B-3, C-1, C-2, C-3, C-4, C-5, C-6, C-9, C-10, C-11, C-12, C-13, C-14, M-1, E-1, E-2, E-4, E-7 (E&F, C-131, C-133, C-136).

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The red shiner was taken in every stream surveyed. The relative abundance seemed to be greatest in two types of habitat which were separated geographically. The first habitat was in large rivers such as the Arkansas and Walnut. In the Arkansas River the red shiner consistently made up 20 per cent to 25 per cent of the catch. On the Walnut River percentages ranged from 10 per cent (station W-3) to 45 per cent (station W-2).

The second habitat in which numbers of *N. lutrensis* reached high proportions was in the upper parts of the most intermittent tributaries. At the uppermost station in Silver Creek this species formed 30 per cent of the fish taken. In Crab Creek the following percentages were taken in six collections from mouth to source: 20.6%, 26.1%, 25%, 85%, 14.6%, and 1%. In the mainstream of Grouse Creek the highest percentage taken was 19.27 near the mouth at station G-1. In middle sections of Grouse Creek this species was either absent or made up less than 2 per cent of the fish taken.

At no station on Big Caney River was the red shiner abundant. The smallest relative numbers were found at upstream stations, in contrast to collections made on tributaries of Grouse Creek. This distributional pattern possibly may be explained by the severe conditions under which fish have been forced to live in the upper tributaries of Grouse Creek. Water was more turbid, and pools were smaller than in Big Caney. These factors possibly decimate numbers of the less hardy species permitting expansion by more adaptable species, among which seems to be *N. lutrensis*. In the upper tributaries of Big Caney River conditions have not been so severe due to greater flow from springs and less cultivation of the watershed in most places. Under such conditions *N. lutrensis* seems to remain a minor faunal constituent.

Notropis percobromus (Cope): Stations A-1, A-2, W-1, W-2, W-3, G-1.

At station W-1 the plains shiner constituted 20 per cent of the fish taken. The river was flowing rapidly with large volume at the time of this collection, and all specimens were taken near the bank in comparatively quiet water over gravel bottom. At station W-3, below Tunnel Mill Dam at Winfield, *N. percobromus* comprised 18.7 per cent of the fish taken, second only to *Lepomis humilis* in relative abundance. Immediately below the west end of the dam, plains shiners were so concentrated that fifty or more were taken in one haul of a four-foot nylon net. The amount of water overflowing the dam at this point was slight. Water was shallow (8-12 inches) and the bottom consisted of the pitted apron or of fine gravel. At the east end of the dam where water was deeper (1-3 feet) and the flow over the dam greater, large numbers of *Lepomis humilis* were taken while *N. percobromus* was rare.

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In the Arkansas River smaller relative numbers of this shiner were obtained. At station A-2, it formed 4.68 per cent of the total. At this station *N. percobromus* was taken with *N. lutrensis* in water about 18 inches deep next to a bank where the current was sluggish and tangled roots and detritus offered some shelter.

At station G-1 on Grouse Creek the plains shiner made up 7.68 per cent of the fish taken. The habitat consisted of intermittent pools with rubble bottoms at this station, which was four miles upstream from the mouth of the creek. The plains shiner seems rarely to ascend the upland streams of the area.

Notropis rubellus (Agassiz): Stations C-3, C-5, C-6, C-7, C-8, C-10, C-11, C-12, C-13, C-14 (J&J).

No fish in these collections showed a more persistent preference than *Notropis rubellus* for clear, cool streams. All collections of the rosyface shiner were in the Big Caney River system, but at only four stations in this system was it common. At station C-11 the highest relative numbers (10.6 per cent) were obtained. This site possessed the most limpid water of any station on the mainstream of Big Caney. Aquatic plants (*Myriophyllum heterophyllum* and *Potamogeton nodosus*) were common. Other fishes that flourished at this station were *N. boops*, *N. camurus*, *Campostoma anomalum*, and *Etheostoma spectabile*. The water temperature was 86° at surface and 80° at bottom whereas air temperature was 97°.

N. rubellus was common at all stations in Otter Creek, the clear, upland character of which has been discussed. In May and June only adults were found. On September 1, examination of several pools in upper Otter Creek revealed numerous young-of-the-year in small spring-fed pools.

Literature is scarce concerning this shiner in Kansas. Cross (1954a:308) stated that it was abundant in the South Fork of the Cottonwood River and was one of those fishes primarily associated with the Ozarkian fauna, rather than with the fauna of the plains. Elliott (1947) found *N. rubellus* in Spring Creek, a tributary of Fall River which seems similar to Otter Creek in physical features. Between the Fall River and Big Caney River systems is the Elk River, from which there is no record of the rosyface shiner. Perhaps its absence is related to the intermittent condition of this stream at present. The Elk River is poor in spring-fed tributaries, which seem to be favorite environs of the rosyface shiner.

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N. rubellus was taken by Minna Jewell and Frank Jobes in Silver Creek on June 30, 1925 (UMMZ 67818). The shiner was not found in any stream west of the Big Caney system in my collections.

In Oklahoma, Hall (1952:57) found *N. rubellus* in upland tributaries on the east side of Grand River and not in the lowland tributaries on the west side. Martin and Campbell (1953:51) characterize *N. rubellus* as preferring riffle channels in moderate to fast current in the Black River, Missouri. It is the only species so characterized by them which was taken in my collections. Moore and Paden (1950:84) state "*Notropis rubellus* is one of the most abundant fishes of the Illinois River, being found in all habitats but showing a distinct preference for fast water...."

Notropis topeka (Gilbert): Two specimens (formerly Indiana University 4605) of the Topeka shiner labeled "Winfield, Kansas" are now at the University of Michigan Museum of Zoology. Collector and other data are not given. Evermann and Fordice (1886:185) noted that two specimens of *N. topeka* were taken from Sand Creek near Newton in Harvey County, but do not list it from Cowley County near Winfield. They deposited their fish in the museum of Indiana University.

Notropis umbratilis (Girard): Stations G-1, G-3, G-4, G-7, G-8, G-9, G-12, G-14, B-2, B-3, C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, C-15, C-16, E-1, E-2, E-4, E-5, M-1, M-2 (J&J, C-131, C-132).

The redbfin shiner flourished in all the streams surveyed except the Arkansas and Walnut Rivers. *N. umbratilis* has been found in upland tributaries of the Walnut River, some of which originate in terrain similar to that in which Elk River, Big Caney River, and Grouse Creek originate. (Collection C-26-51 by Cross on Durechon Creek, October 7, 1951.) This suggests downstream reduction in relative numbers of this species, a tendency which also seemed to exist on both Big Caney River and Grouse Creek. *N. umbratilis* was the most abundant species in Big Caney River except at the lowermost stations where it was surpassed in relative abundance by *N. lutrensis* and *Gambusia affinis*.

N. umbratilis was a pool-dweller, becoming more concentrated in the deeper pools as summer advanced. In May and early June, large concentrations of adult *N. umbratilis* were common in the shallow ends of pools together with *N. rubellus*, *N. boops*, *Pimephales notatus*, and *Pimephales tenellus*. By July and August, only young of the year were taken in shallow water, and adults were scarcely in evidence.

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Notropis volucellus (Cope): Stations G-5, G-8, C-3, C-5, C-7, C-8, C-9, C-10, M-1, E-4, E-5.

The mimic shiner was a minor element in the fauna, 2.02 per cent at station C-5 being the largest percentage taken. In the Big Caney River system *N. volucellus* was taken only in the main stream. In the Grouse Creek drainage it was found at two stations in the upper part of the watershed, where water is clearer, gradient greater, and pools well-shaded and cool.

In the Elk River the mimic shiner was taken only in the upper part of the main stream. The dominant shiner in situations where *N. volucellus* was taken was, in all cases, *N. umbratilis*. Elliott (1947) found *N. volucellus* in Spring Creek, a tributary of Fall River. Farther north in the Flint Hills region, *N. volucellus* was reported by Cross (1954a:310).

Notemigonus crysoleucas (Mitchell): Station W-5.

This isolated record for the golden shiner consisted of nine specimens collected on June 6 in Timber Creek, a tributary of the Walnut River. Most of the creek was dry. *N. crysoleucas* was taken in one pool with dimensions of 8 feet by 4 feet with an average depth of 4 inches. This creek is sluggish and silt-laden, even under conditions of favorable precipitation. Hubbs and

Ortenburger (1929b:89) observed that the golden shiner prefers sluggish water. Hall (1952:58) took the golden shiner only in the lowland tributaries west of Grand River and not east of the river in upland tributaries.

Phenacobius mirabilis Girard: Stations W-3, C-3.

In no case was the suckermouth minnow common; it never comprised more than 1 per cent of the fish population.

Pimephales notatus (Rafinesque): Stations W-4, G-5, G-7, G-9, G-12, G-13, B-3, C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, C-15, C-16, C-17, C-18, M-1, M-2, E-1, E-2, E-4, E-5, E-7 (J&J, C-131, C-132, C-133).

This was much the most abundant of the four species of *Pimephales* in this area. It was taken at 33 stations as compared with 10 for *P. tenellus*, 8 for *P. promelas*, and 3 for *P. vigilax*.

The bluntnose minnow was taken almost everywhere except in the main stream of the Arkansas and Walnut rivers and in lower Grouse Creek. *P. notatus* seemed to prefer clearer streams of the Flint Hills part of my area. There was a marked increase in percentages taken in the upland tributaries of both Caney River and Grouse Creek. In the Elk River, too, higher concentrations were found upstream.

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The highest relative numbers of bluntnose minnows were taken at station G-12 on Crab Creek, station C-12 on Cedar Creek and station C-16 on Spring Creek. At G-12, this minnow was abundant in the deeper isolated pools. Males in breeding condition were taken on June 9. In Cedar Creek the population of bluntnose minnows was observed periodically in one pool in which they were dominant. This pool was 100 feet by 50 feet, shallow, and with bedrock bottom. At its upper end, however, there was a small area of heavily-shaded deeper water. Throughout the spring bluntnose minnows were found in large schools in the shallow area. As the summer progressed they were no longer there, but seining revealed their presence in the deeper, upper end.

At station C-16 on Spring Creek on July 9 male *P. notatus* were taken in extreme breeding condition, being light brick-red in color and with large tubercles.

Pimephales tenellus (Girard): Stations G-1, C-2, C-3, C-5, C-6, C-7, C-8, M-1, E-2, E-4 (C-131 C-133).

The mountain minnow was never taken far from the mainstream of Big Caney, Middle Caney, or Elk River. In this respect it differed from *P. notatus*, which reached large concentrations in the small upland tributaries. On the other hand, *P. tenellus* was not so abundant as *P. vigilax* in the silty larger streams. In no collection was the mountain minnow common. The highest percentages were 2.4 per cent (Station C-5), and 2.1 per cent (Station C-7) on Big Caney River. These stations consisted of clear, flowing water over rubble bottoms. Males at C-7 (June 16) were in breeding condition.

Moore and Buck (1953:23) reported finding this species among rocks in very fast water rather than in the quiet backwaters frequented by *P. vigilax*. Other records of the mountain minnow from the Flint Hills indicate that it seeks areas of maximum gradient and flow; in this distributional respect it is like *Notropis camurus*. The two species are recorded together from other streams in this region such as the Chikaskia (Moore and Buck, 1953:23), Cottonwood (Cross, 1954a:310), and Spring Creek, tributary of Fall River (Elliott, 1947). It is conceivable that a preference for flowing water might explain its restriction to the medium-sized, less intermittent streams in this area. The only tributary which the species seemed to ascend to any extent was Otter Creek, which is seldom intermittent downstream.

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Pimephales vigilax perspicuus (Girard): Stations A-3, C-1, C-4.

The parrot minnow was found only in downstream habitats. Collection C-4 (June 3) on Rock Creek was made about ½ mile from the mouth of this tributary of Big Caney and the creek here had almost the same character as the river proper. The presence of other channel fishes such as *Ictiobus bubalus* indicates the downstream nature of the creek. Some males of *P. vigilax* in breeding condition were taken in this collection.

At C-1, only one specimen was found in a turbid, isolated pool with bedrock bottom. At A-1 only one parrot minnow was taken; it was in deep, fairly quiet water near the bank.

Other collections outside the three-county area revealed the following: In the Neosho River, several parrot minnows were found in quiet backwaters and in shallow pools. In the Verdigris River three were taken directly under water spilling over the dam at this station, while others were found, together with *P. promelas*, in the mouth of a small creek that provided a backwater habitat with mud bottom.

Cross and Moore (1952:405) found this species only at stations in the lower portion of the Poteau River. Farther west the minnow may ascend the smaller sandy streams to greater distances. Moore and Buck (1953:23) took parrot minnows at six of 15 stations on the Chikaskia River and found the species as far upstream as Drury, Kansas. Elliott (1947), in comparing the South Ninescah and Spring Creek fish faunas, found only *P. vigilax* and *P. promelas* on the sandy, "flatter" Ninescah and only *P. notatus* and *P. tenellus* on Spring Creek, an upland, Flint Hills stream in Greenwood County.

Pimephales promelas Rafinesque: Stations A-2, A-3, W-3, W-4, G-9, B-1, M-1, E-4 (E&F, C-136).

Occurrences of the fathead minnow were scattered, but included all streams sampled except Big Caney.

Three of the collections were in small intermittent streams where conditions were generally unfavorable for fishes and in one instance extremely foul. Two of these stations had turbid water and all suffered from siltation.

In Middle Caney Creek the species was rare but in the Elk River (June 28) more than 100 specimens, predominantly young, were taken. This station consisted of a large isolated pool with a variety of bottom types. Water was turbid and the surface temperature was high (93° F.). In different parts of the pool the following numbers of specimens were taken in single seine-hauls: 15 over shallow bedrock; 35 over gravel (1½ feet deep); 50 over mud bottom (1 foot deep).

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P. promelas was found also in the large, flowing rivers: Arkansas, Walnut, Verdigris, and Neosho. The species was scarce in the Arkansas River, and was found principally in muddy coves. In the Walnut (W-3), this minnow comprised 7.65 per cent of the fish taken and was common in quiet pools.

Campostoma anomalum Rafinesque: Stations W-4, G-4, C-1, C-3, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, C-15, C-16, C-17, C-18, B-3 (E&F, C-131, C-136).

Although the stoneroller was found in most streams surveyed, it was taken most often in the Big Caney system, where it occurred at 16 of the 18 stations. In contrast, it was represented at only one of 17 stations on Grouse Creek. High percentages were found in three creeks—Cedar, Otter, and Spring. As noted above, these streams are normally clear, swift and have steep gradients and many rubble and gravel riffles. On these riffles young stonerollers abounded. Station C-16 on Spring Creek typifies the habitat in which this species was most abundant. The stream has an average width of 10 feet and depth of a few inches. The volume of flow was less than 1 cubic foot per second but turbulence was great. Water was clear and the bottom was gravel and rubble. Following rains in June, stonerollers quickly occupied parts of Spring Creek (upstream from C-16) that had been dry throughout the previous winter.

On April 2 many *C. anomalum* and *Etheostoma spectabile* were taken in shallow pools and riffles in an extensive bedrock-riffle area on Cedar Creek near station C-12. Most of the females were gravid and the males were in breeding condition. On June 6 these pools were revisited. Flow had ceased and the pools were drying up. Young-of-the-year of the two species were abundant, but only a few mature stonerollers were taken. On August 24, prolonged drought had drastically altered the stream and all areas from which stonerollers and darters had been taken were dry. Seining of other pools which were almost dry revealed no stonerollers.

Collections on May 31, June 15, and June 16 in Otter Creek revealed large numbers of stonerollers. They were found in riffle areas, in aquatic vegetation, and especially in detritus alongside banks. Most of the specimens were young-of-the-year.

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Anguilla bostoniensis (Le Sueur): An American eel was caught by me in Grouse Creek in 1949.

Gambusia affinis (Baird and Girard): Stations A-1, A-2, A-3, W-1, W-2, W-3, W-4, W-5, G-1, G-2, G-3, G-4, G-5, G-7, G-8, G-9, C-1, C-2, C-3, C-4, C-6, C-15, E-1.

Mosquitofish occurred widely but in varied abundance. Huge populations were in the shallow sandy backwaters and cut-off pools of the Arkansas River. In the shallow pools of several intermittent streams such as station G-8 on Silver Creek this fish also flourished.

G. affinis was taken at every station in the Arkansas, Walnut and Grouse systems except those stations on two upland tributaries of Grouse Creek (Crab Creek and Grand Summit Creek). The mosquitofish was not observed in the clear upland tributaries of Big Caney, nor on upper Big Caney River itself in May, June, and July. On September 3, however, *Gambusia* were taken at station C-15 on Otter Creek and others were seen at station C-14 on the same date.

Hubbs and Ortenburger (1929b:99) and Cross and Moore (1952:407) observed that *G. affinis* usually was absent from small upland tributaries, even though it was abundant in lower parts of the same river systems.

Fundulus kansae (Garman): Stations A-2, A-3, Evermann and Fordice as *Fundulus zebrinus*.

At station A-2, seven plains killifish were taken together with a great many *Notropis deliciosus* and *Gambusia affinis* in a shallow, algae-covered channel with slight flow and sand bottom. At station A-3 many young killifish were taken in small shallow pools on December 22. *Fundulus kansae* has been found in the lower part of the Walnut River Basin, especially where petroleum pollution was evident. Eastward from the Walnut River plains killifish have not been taken.

Fundulus notatus (Rafinesque): Stations B-1, G-1, G-2, G-3, G-4, G-5, G-7, G-8, G-10, G-11, G-14, C-1, M-1, E-1, Evermann and Fordice as *Zygonectes notatus*.

The black-banded topminnow was not taken in the Arkansas River but was common in the Walnut and Grouse systems. It was common also in Middle Caney, but in Big Caney and Elk River it was taken only at the lowermost stations.

This species did not seem to ascend far into smaller tributaries of Grouse Creek. In Crab Creek it

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was taken at the lower two of six stations and in Grand Summit Creek at the lower of two stations.

The highest relative numbers were taken at stations G-3 (17.5 per cent), G-4 (24 per cent), G-10 (25.75 per cent) and G-11 (41.52 per cent), on Crab Creek and Grouse Creek. Both upstream and downstream from these stations, which were within five miles of each other, the relative abundance dropped off sharply. The bottoms at these stations were mostly rubble and mud, and water was turbid at three of the stations. At G-10 (June 24) and G-11 (July 16) young-of-the-year were abundant.

Ictalurus melas (Girard): Stations W-2, W-3, W-4, W-5, B-1, B-2, B-3, G-1, G-2, G-3, G-4, G-5, G-8, G-9, G-11, G-12, G-13, G-14, G-17, C-1, C-9, C-11, C-12, C-14, C-15, C-17, C-18, E-1, E-2, E-4, E-5, E-6, N-1, Evermann and Fordice as *Ameiurus melas* (C-133).

The black bullhead was taken at slightly more than half of the stations, and probably was present at others. Larger numbers were taken in Grouse Creek than in any other stream system. In many small, shallow pools in the Grouse Creek system young black bullheads shared dominance with *Gambusia affinis* in the late summer. *I. melas* was also abundant in isolated pools at the extreme upper ends of Crab Creek, Beaver Creek and Grand Summit Creek. *I. melas* was most common in areas with silty bottoms. The species seemed scarce in the main stream of Big Caney River but was common in some of its tributaries.

Pylodictis olivaris (Rafinesque): Stations A-3, G-1, C-5.

Flathead catfish were taken by angling at stations A-3 and C-5. At station G-1 (September 5) a flathead catfish five inches long was taken in the four-foot nylon net.

Ictalurus punctatus (Rafinesque): Stations A-3, W-2, W-3, G-2, C-5, E-4.

Channel catfish from stations W-3, A-3, and C-5 were taken on hook and line. At station G-2 (August 29) twenty young-of-the-year were seined from the shallow narrow end of a large pool. All collections of both *I. punctatus* and *P. olivaris* were in the larger streams surveyed.

Ictalurus natalis (LeSueur): Stations G-1, G-2, G-3, G-4, G-8, G-11, C-12, C-14, C-15.

The yellow bullhead was taken at only 9 stations, compared with 33 stations for the black bullhead. *I. natalis* was represented in 7 of 17 stations in the Grouse Creek system but in only 3 of 18 stations in the Big Caney system. Of the seven records from Grouse Creek four were from the main stream. At every station where yellow bullheads were taken, black bullheads were found also and were abundant, usually several times more abundant than *I. natalis*.

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At G-11 on Crab Creek (July 16), *I. natalis* made up 3.8 per cent of the fish taken. All were young-of-the-year, existing in a tiny, gravelly pool containing not more than five gallons of water, and were the only fish present. Young yellow bullheads were also found in small pools with gravel bottoms at station G-4 on September 7.

Labidesthes sicculus (Cope): Stations G-1, G-2, G-3, G-7, G-10, B-2, C-1, C-2, C-3, C-4, C-5, C-12, E-1, E-2, E-3, E-7, M-1 (E&F, C-131).

The brook silversides was taken, sometimes abundantly, in all stream systems except the Walnut and Arkansas. At station G-7 on July 8, 41.8 per cent of the fish taken were of this species. *L. sicculus* was most abundant in large pools where the bottom was predominantly bedrock and gravel. The highest concentrations were in the mainstreams of Big Caney, Grouse, and Elk Rivers. Brook silversides were taken rarely in the smaller tributaries of these streams.

Percina phoxocephala (Nelson): Stations C-2, C-3, C-5, G-1 (C-133).

Slenderhead darters were scarce, and were found only over gravel bottoms. Specimens were taken from flowing and quiet water, and from both shallow and deep water.

Larger numbers of *P. phoxocephala* were taken by the writer in other collections made during 1956 on the Neosho and Verdigris Rivers over bottoms of rubble or gravel. Restriction of this darter to the larger streams follows a pattern observed by Cross (1954a:313) who noted it was absent from smaller riffles in minor tributaries. Elliott (1947), however, took one specimen of *P. phoxocephala* in Spring Creek, a tributary of Fall River.

Percina caprodes carbonaria (Baird and Girard): Stations G-3, G-4, G-7, G-12, C-5, C-6, C-7, C-9, C-12, C-13, C-14 (J&J, C-131, C-133).

The logperch was generally distributed in the Caney, Elk, and Grouse systems. This species usually comprised less than 1 per cent of the fish taken; however, at station G-12 it formed 3.76 per cent of the total.

In many instances the logperch was taken over submerged gravel bars, often along the edges of the larger pools. At 8 of 13 stations where the logperch was taken, the golden redhorse was also found. At every station where logperch were found, *Notropis umbratilis* was taken and *Pimephales notatus* also occurred at all but three of these stations.

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Percina copelandi (Jordan): Stations C-4, C-5, C-6, C-8, G-1 (C-131, C-133, J&J).

Channel darters were collected over bottoms of rubble or gravel, both in flowing streams and in isolated pools. Although *P. copelandi* was found only in Big Caney River and at the lowermost

station on Grouse Creek (G-1) in this survey, this species has been taken previously from Elk River (K. U. 3463 and K. U. 3197) and from Silver Creek. *Notropis camurus* occurred everywhere that *H. copelandi* was found. In several instances the two species were taken in the same seine-haul.

Etheostoma spectabile pulchellum (Girard): Stations W-4, G-1, G-4, G-5, C-6, C-9, C-11, C-12, C-13, C-14, C-15, C-16, C-17, C-18, E-1, E-5. Evermann and Fordice as *Etheostoma coeruleum* (C-131, C-132).

The habitat preferences of the orangethroat darter seemed similar to those of *Campostoma anomalum*. There were sixteen stations at which both species were taken, seven where only *E. spectabile pulchellum* was taken and six where only *C. anomalum* was taken. The largest relative numbers of both species were found in the same small, clear upland tributaries of Big Caney River. On May 31, collections from riffles at station C-15 (upper Otter Creek) consisted almost entirely of these two species. On September 1 at this station the stream was intermittent, but even the tiniest pools abounded with young darters and stonerollers.

Gravid females and males in breeding condition were taken in riffles in Cedar Creek on April 2. During June numerous young and adult orangethroat darters were taken in Cedar Creek, in partly decayed leaves which lined the banks. On June 15 in Otter Creek young darters were abundant in streamside detritus and in clear, shallow, rubble riffles. At station C-11 a few darters were taken on rubble riffles; however, large numbers were found inhabiting thick mats of *Potamogeton foliosus* Raf., which grew in shallow water. Many darters (*Etheostoma spectabile pulchellum* and *Percina phoxocephala*) were taken in September along gravelly banks at stations C-2 and C-3 by disturbing small rocks and leaf-litter along the shores. Young orangethroat darters seemed to seek out sheltered areas and in some cases were found in sluggish, even foul, water (Stations W-4, B-1 and G-12). Moore and Buck (1953:26) note that the orangethroat darter is able to thrive in Oklahoma in rather sluggish and even intermittent waters which reach quite high summer temperatures.

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Unlike other darters taken in this survey, the orangethroat darter was common to abundant at several stations and was found at a great many more stations than any other darter. The comparatively great tolerance of this species to varying habitats, suggested by this survey, is also reflected by its widespread distribution in Kansas.

Micropterus salmoides salmoides (Lacepede): Stations B-1, G-4, G-5, G-7, G-12, C-1, C-3, E-1, E-2, E-3.

Most of the largemouth bass taken were young-of-the-year. In Big Caney River this species seemed rare, being found at only two downstream stations compared with eight stations at which *M. punctulatus* was taken.

Many ponds in the Flint Hills have been stocked with largemouth bass. At present largemouth bass are frequently caught by hook and line in Crab Creek (Station G-12); however, Mr. A. C. Metcalf, who has fished this stream for approximately 45 years, states that he took no bass in the creek prior to the building and stocking of large ponds on nearby ranches.

Micropterus punctulatus (Rafinesque): Stations C-4, C-5, C-6, C-7, C-8, C-10, C-14, C-15, E-2, E-5 (C-133).

The spotted bass was taken only in tributaries of the Verdigris River, where it seemed more numerous than the preceding species. It has been reported from other Verdigris tributaries such as Fall River (Elliott, 1947) and is common eastward from the Verdigris Basin. A spotted bass (K. U. 3467) was taken by Cross on the Little Walnut River in Butler County on April 5, 1955. This seems to be the only record of this species from the Walnut River Basin at the present time.

Pomoxis annularis (Rafinesque): Stations W-3, W-5, G-1, G-2, G-5, G-10, G-11, G-12, C-1, C-2, C-4, C-5, C-6, M-1, E-1, E-2, E-4, E-5 (C-136).

White crappie were found in almost all habitats and were taken in all rivers except the Arkansas. The relative abundance of this species was greater at downstream than at upstream stations on Grouse Creek, Big Caney, and Elk River. Schools of young crappie were frequently found and the factor of chance in taking or failing to take a school of crappie prevented confident appraisal of abundance. White crappie usually sought quiet waters. Often they were found in backwaters and many times schools were taken over bottoms where mud and detritus had been deposited. It was not uncommon to take *Pomoxis annularis* and *Ictalurus melas* in the same seine-haul in such areas.

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Pomoxis nigromaculatus (LeSueur): Station C-1.

Black crappie were taken in Otter Creek on May 29 and September 3. Several ponds in eastern Cowley County are stocked with black crappie, but none was taken from streams into which these ponds drain.

Lepomis cyanellus (Rafinesque): Stations W-3, W-4, W-5, B-1, B-2, B-3, G-1, G-2, G-3, G-4, G-5, G-8, G-9, G-10, G-12, G-13, G-14, G-15, G-16, G-17, C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-14, C-16, C-17, C-18, E-1, E-4, E-5, E-6, E-7, M-2 (C-131, C-132, C-133, C-136, E&F).

The green sunfish was taken at 45 of 60 stations, which is the greatest number recorded for one

species. The only stream from which it was not obtained was the Arkansas River. Green sunfish constituted a minor but consistent part of the fauna in Big Caney River except for some intermittent pools on small tributaries, where it was high in relative abundance. It usually comprised approximately 4 per cent of the fish taken at stations on Grouse Creek. In some intermittent tributaries of Grouse Creek and Elk River percentages also were high.

Funk and Campbell (1953:74) observed that *L. cyanellus* held a definite but minor place in all collections made on the Black River in Missouri. This pattern was also observed by the writer in collections made on the Neosho and Spring Rivers in southeastern Kansas. This seems to indicate that the Big Caney River populations (exclusive of the upstream stations in intermittent streams) follow a pattern commonly found in southeastern Kansas and probably in the Ozark region.

Lepomis humilis (Girard): Stations A-3, W-2, W-3, W-4, W-5, G-1, G-2, G-3, G-4, G-5, G-7, G-8, G-9, G-10, G-11, G-12, G-14, G-15, C-1, C-2, C-3, C-4, C-5, C-6, C-7, C-8, C-9, C-10, C-11, C-12, C-13, C-16, C-17, B-2, B-3, E-1, E-2, E-4, E-5, E-6, E-7, M-1. (C-131, C-132, C-133, C-136, J&J, E&F.)

The orangespotted sunfish was found in every stream surveyed, although only one specimen was taken from the Arkansas River.

The largest relative number of this species (44.6) was taken at station G-1. Percentages at other stations on Grouse Creek and its tributaries progressively declined in an upstream direction.

In Big Caney River representation of *L. humilis* in collections varied from 1.56 per cent at station C-1 to 23.47 per cent at station C-7. This sunfish was usually the dominant species in collections made from the Elk River, where the relative abundance ranged from 10 to 30 per cent.

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The orangespotted sunfish is widespread in Kansas and seems to be a diagnostic constituent of the Plains Fauna. Moore and Buck (1953:26) found it "very common" in the Chikaskia River in Kansas and Oklahoma. Cross (1950:140) noted that in Stillwater Creek it seemed to be the most tolerant and consequently the most abundant of the stream's centrarchids. Moore and Paden (1950:91) note that *L. humilis* is most common in muddy waters and found in overflow pools, backwaters, and oxbow lakes. This species is frequently found in farm ponds in the area surveyed, which further suggests a wide range of habitat tolerance.

Lepomis megalotis breviceps (Baird and Girard): Stations W-3, W-4, W-5, B-1, B-2, G-1, G-4, G-5, G-7, G-8, G-9, G-10, G-11, G-12, G-13 (all Big Caney River stations except C-18), E-1, E-2, E-3, E-4, E-5, E-6, M-1, M-2 (C-131, C-132, C-133, J&J, E&F).

In Big Caney River the longear sunfish shared dominance with the redbfin shiner (*Notropis umbratilis*) at almost every station. The average of its relative abundance at all stations in the Big Caney system was 16.5 per cent. It was also abundant at several stations on Grouse Creek and made up 43.25 per cent of all fish taken at station G-4.

Cross (1950:140) observed that *L. megalotis breviceps* increased in Stillwater Creek probably as a result of clearer water and stabilized water level.

In collections made west of the area treated here (Moore and Buck, 1953:26; Elliott, 1947) the longear sunfish is less abundant than in Big Caney River and Grouse Creek.

Lepomis macrochirus (Rafinesque): Stations W-3, G-3, G-4, G-5, C-3, C-5, E-1, E-2 (C-131, C-132, C-133).

The bluegill was, in all cases, a minor constituent in the fish fauna. No clear pattern of habitat preference can be deduced. In the Verdigris River at Independence (collection AM-53, August 22, 1956) bluegills were common in quiet pools and coves below a low-water dam. Moore and Paden (1950:91) note that *L. macrochirus* prefers quiet waters and Hubbs and Lagler (1947:94) state that it is "generally restricted to the quieter pools."

The bluegill is widely-stocked in impoundments of the area treated here.

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Aplodinotus grunniens (Rafinesque): Stations C-4, E-2.

The dearth of stations from which the freshwater drum is reported may indicate difficulty in taking this species with seines, rather than scarcity. Both collections were at downstream stations. At station C-4 three half-grown drum were taken. Fishermen take "drum" at least as far upstream as station C-5 on Big Caney River. In the Elk River one specimen was taken in a 20-foot seine below a dam at Elk Falls.

FISHES OF DOUBTFUL OR POSSIBLE OCCURRENCE

In addition to the species listed above, the following species have been reported nearby and may occur within the area surveyed.

Lepisosteus productus (Cope)—This gar has not been reported from Kansas. It has been taken at several points in the northern half of Oklahoma and as far west as Canton Reservoir by Buck and Cross (1951). A specimen of the spotted gar was taken by Elkin (1954:28) in Salt Creek in Osage County, Oklahoma.

Polyodon spathula (Walbaum)—The paddlefish has never been reported from the Arkansas River system in Kansas. Several reports by fishermen were traced by the writer, but authentication was not achieved. One mounted specimen was examined in a sporting goods store in Arkansas City. This fish was said to have been taken on the Arkansas River south of Arkansas City but information on the date and method of capture were vague. Mr. Darrell Wheat of Arkansas City reported taking four paddlefish below a dam at Oxford, Kansas, in 1948 and 1949.

Hiodon alosoides (Rafinesque)—One specimen (K. U. 3095) of the goldeye was taken in 1953 on the Arkansas River near Oxford in Sumner County. Fishermen also report taking this fish occasionally in the Walnut River in Cowley County.

Noturus flavus (Rafinesque)—The stonecat was taken in the Verdigris system by R. D. Lindsay in 1911 (K. U. 2058) and more recently by Cross in Montgomery County (C-120) and Schelske (1957:46) in Wilson and Montgomery Counties. The close proximity of these collection areas to lower portions of the Elk River indicate probable occurrence in Elk River and other Verdigris tributaries.

Noturus nocturnus (Jordan and Gilbert)—The freckled madtom has been taken on all sides of the area studied making its occurrence therein highly probable. This madtom has been taken in Beaver Creek in Osage County, Oklahoma (OAM 4771); from a tributary of the Walnut River in Sedgwick County by Cross (1954); from the Chikaskia River (Moore and Buck, 1953:24); and from several localities on the Verdigris River (Schelske, 1957:47).

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Etheostoma cragini (Gilbert)—One Cragin's darter (K. U. 3470) was taken by Cross in the Arkansas River near the Sumner-Cowley county line (Sec. 25, T31S, R2E). Records of this darter are few and widely scattered geographically. Several collections from north-eastern Oklahoma are noted by Moore and Cross (1950:144).

Etheostoma whipplii (Girard)—Schelske (1957:38) reports the redfin darter from the Verdigris River three miles southeast of Benedict, Kansas. Dr. George Moore of Oklahoma A. & M. College states that it has been taken in the Verdigris drainage in Oklahoma at several locations.

Etheostoma zonale arcansanum (Jordan and Gilbert)—Two banded darters (K. U. 3213) have been reported by Schelske (1957:49) from Fall River near Neodesha, Kansas. Because a tributary of Fall River enters Elk County its presence in this and other Verdigris tributaries in the area seems possible. This darter has been reported from only one other stream in Kansas, Shoal Creek in Cherokee County, where it has been collected often.

Roccus chrysops (Rafinesque)—The white bass has been stocked in Hulah Reservoir on Big Caney River in Oklahoma. To date it has not been reported from the Big Caney in Kansas. White bass are common in many reservoirs of Kansas and Oklahoma and have been taken in rivers in both states. Mr. Clement Gillespie of Arkansas City, Kansas Forestry, Fish and Game Commission wildlife protector for the area, states that two hundred young of *R. chrysops* were released in Grouse Creek several years ago under auspices of the Commission. The fish has not been reported by fishermen since that time to the knowledge of Mr. Gillespie or of the writer.

Lepomis microlophus (Gunther)—One redear sunfish was taken on Salt Creek in Osage County, Oklahoma, by Elkin (1954:28). Because this species has been stocked widely in Oklahoma its eventual occurrence in Kansas seems probable.

Chaenobryttus gulosus (Cuvier)—The warmouth has been taken south of the collection area in Osage County on Salt Creek by Elkin (1954:28).

FAUNAL COMPARISONS OF DIFFERENT STREAMS

The faunas of Elk River, Big Caney River, and Grouse Creek were generally similar. These streams and most of their tributaries originate in the same hilly area of eastern Cowley County and western Elk and Chautauqua counties; their similarities and differences have been pointed out.

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The following species were taken in all of these streams:

Lepisosteus osseus
Dorosoma cepedianum
Ictiobus bubalus
Moxostoma erythrurum
Minytrema melanops
Cyprinus carpio
Campostoma anomalum
Notropis boops
Notropis lutrensis
Notropis umbratilis
Notropis volucellus
Pimephales notatus
Pimephales tenellus

Fundulus notatus
Gambusia affinis
Ictalurus melas
Ictalurus punctatus
Etheostoma spectabile
Percina caprodes
Micropterus salmoides
Pomoxis annularis
Lepomis cyanellus
Lepomis humilis
Lepomis megalotis
Lepomis macrochirus
Labidesthes sicculus

No species was found in Elk River to the exclusion of Big Caney and Grouse Creek. Fish taken exclusively in Grouse Creek were *Ictiobus cyprinella* at station G-2 and *Notropis percobromus* at station G-1. The following species were taken only in Big Caney River: *Ictiobus niger*, *Notropis rubellus*, *Phenacobius mirabilis*, *Pimephales vigilax*, and *Pomoxis nigromaculatus*.

Notropis buchmanii and *Pimephales promelas* were taken in Grouse Creek and Elk River, but not in Big Caney River, although the watershed of Big Caney lies largely between these two streams. Three species, *Notropis camurus*, *Micropterus punctulatus*, and *Aplodinotus grunniens*, were found in Elk River and Big Caney but not in Grouse Creek. *Ictalurus natalis*, *Pylodictis olivaris*, and *Percina phoxocephala* were taken in Big Caney River and Grouse Creek but not in Elk River. *Percina copelandi* was taken by Cross on Elk River in 1954 and 1955 (K. U. 3464 and K. U. 3197).

Forty species were taken in Big Caney River, 35 in Grouse Creek and 31 in Elk River. Collections were made from only six stations on Elk River as compared with 18 from Big Caney and 17 from Grouse Creek.

Twenty-four species were taken in the Walnut River system, only one of which (*Notemigonus crysoleucas*) was taken exclusively there.

In the Arkansas River 18 species were found, four of which did not occur elsewhere. These were *Hybopsis aestivalis*, *Notropis blennius*, *N. girardi*, and *Fundulus kansae*.

Table 5 lists the number of stations in each of the streams surveyed from which each species was taken.

TABLE 5.—SPECIES OF FISHES COLLECTED AND NUMBER OF STATIONS IN EACH STREAM SYSTEM AT WHICH EACH SPECIES WAS FOUND.

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Total number of stations	Arkansas River 3 stations	Walnut River 5 stations	Grouse Creek 17 stations	Big Caney River 18 stations	Elk River 6 stations	Middle Caney 2 stations	Beaver Creek 3 stations
<i>L. osseus</i>	1	3	3	6	Seen		
<i>D. cepedianum</i>	Seen	1	1	3	2	1	
<i>Carpionodes carpio</i>	2	1	1	1			
<i>I. bubalus</i>		1	2	4	3		
<i>I. cyprinella</i>			1				
<i>I. niger</i>				2			
<i>M. erythrum</i>			4	10	3		
<i>M. melanops</i>			1	3	1		
<i>Cyprinus carpio</i>	1	4	4	2	1		
<i>C. anomalum</i>		1	1	14	2		1
<i>H. aestivalis</i>	1						
<i>N. blennius</i>	2						
<i>N. boops</i>			2	14	2	2	
<i>N. buchmanii</i>			1		1		
<i>N. camurus</i>				13	2		
<i>N. deliciosus</i>	3	3					
<i>N. girardi</i>	2						
<i>N. lutrensis</i>	3	4	13	14	5	1	3
<i>N. rubellus</i>				11			
<i>N. percobromus</i>	3	3	1				
<i>N. umbratilis</i>			8	18	4	2	2
<i>N. volucellus</i>			2	5	2	1	
<i>N. crysoleucas</i>		1					
<i>H. placita</i>	3	2					
<i>P. mirabilis</i>		1		1			
<i>P. notatus</i>		1	6	18	5	2	1
<i>P. promelas</i>	2	2	1		1	1	1

<i>P. vigilax</i>	1			3		1	
<i>P. tenellus</i>			1	7	1	2	
<i>F. notatus</i>		4	10	1	1		1
<i>F. kansae</i>	2						
<i>G. affinis</i>	3	5	8	8	1		
<i>I. melas</i>	1	4	12	9	5		3
<i>I. natalis</i>			6	3			
<i>I. punctatus</i>	1	2	1	5	1		
<i>P. olivaris</i>	1		1	1			
<i>E. spectabile</i>		1	4	17	2		1
<i>P. copelandi</i>			1	5			
<i>P. phoxocephala</i>			1	4			
<i>P. caprodes</i>			5	8	1		
<i>M. salmoides</i>			4	2	3		1
<i>M. punctulatus</i>				7	1		
<i>P. annularis</i>		2	7	1	4	1	
<i>P. nigromaculatus</i>				1			
<i>L. cyanellus</i>		3	14	17	5	1	3
<i>L. humilis</i>	1	4	13	17	6	1	2
<i>L. megalotis</i>		3	9	18	6	2	2
<i>L. macrochirus</i>		1	3	3	2		
<i>A. grunniens</i>				1	1		
<i>L. sicculus</i>			5	7	4	1	1

DISTRIBUTIONAL VARIATIONS WITHIN THE SAME STREAM

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An analysis of faunal variations in different parts of the same stream system was made for Big Caney River and Grouse Creek. Collecting was more extensive in these streams, and sampling was done over a wider range of habitat, than in the Arkansas and Walnut rivers.

The fish taken in the first five seine hauls at each station were counted and the number of each species was recorded as a percentage of the total number of fish taken. These percentages were calculated for the main stream and for each tributary in an attempt to discern possible intra-stream faunal patterns. In Table 6 lower, middle, and upper segments of each stream have been segregated and the average of all stations within each segment is shown.

The results are subject to several sources of error, some of which are discussed below:

(1) Seining techniques could not be entirely standardized. One station might present a series of long narrow riffles and narrow, shallow pools in which only a small seine could be used effectively; another station might consist of a large, deep, isolated pool in which a larger seine was needed for effective sampling. In practice, the five seine hauls were made with any of several seines ranging from ten to twenty feet in length.

(2) Seines are species-selective, due partly to the preference of certain fishes for special habitat niches. Fishes that are often found under stones or in weedy pools require special collecting techniques and frequently were not represented in the initial five hauls. If work subsequent to the first five hauls indicated that such fish were a prominent part of the fauna at a particular station, these results were considered before percentages were calculated.

(3) Temporal variations occur in populations at the same station. There were both seasonal and diurnal differences in relative numbers of species taken in these collections. This was noted especially at station C-5 where collecting was done both at night and by day. Spawning by certain species during the course of the study complicated estimates of their relative abundance.

(4) In tabulating percentages of fishes obtained an arbitrary element is often unavoidable in deciding whether a station, especially a station on a tributary, should be considered as part of the lower, middle, or upper segment of a river system.

Despite these disadvantages it is felt that table 6 has factual basis permitting some reliable interpretation.

TABLE 6.—RELATIVE ABUNDANCE IN PER CENT OF FISHES IN COLLECTIONS FROM THREE STREAM SEGMENTS.

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	Big Caney River			Grouse Creek		
	Lower	Middle	Upper	Lower	Middle	Upper
<i>L. osseus</i>	.7	.5		.6	.02	
<i>D. cepedianum</i>	.3				.02	

<i>Carpoides carpio</i>	.06			1.0		
<i>I. bubalus</i>	.6	.45		1.4		
<i>I. cyprinella</i>				.1		
<i>I. niger</i>	.01					
<i>M. erythrurum</i>	.2	1.1	1.0	.03	.5	1.1
<i>M. melanops</i>	.1	.01			.1	
<i>Cyprinus carpio</i>	.7			1.3	.2	
<i>C. anomalum</i>	.6	5.9	18.0		.1	
<i>N. boops</i>	.6	.6	5.1		1.3	
<i>N. buechanani</i>				.01		
<i>N. camurus</i>	6.4	5.5	.4			
<i>N. lutrensis</i>	8.8	1.0	.5	6.4	11.4	15.2
<i>N. percobromus</i>				1.1		
<i>N. rubellus</i>	.4	1.4	3.9			
<i>N. umbratilis</i>	17.6	28.3	15.4	2.5	3.9	5.5
<i>N. volucellus</i>	.3	.4			.3	
<i>P. mirabilis</i>	.3					
<i>P. notatus</i>	3.5	5.7	13.0		.9	6.6
<i>P. vigilax</i>	.8					
<i>P. promelas</i>						2.9
<i>P. tenellus</i>	.7	.5		.01		
<i>G. affinis</i>	14.6	.4	.4	20.8	10.2	1.0
<i>F. notatus</i>	.1			6.6	17.2	1.4
<i>I. melas</i>	.9	2.2	2.4	5.6	2.3	18.0
<i>I. natalis</i>			.5	.5	.8	
<i>P. olivaris</i>	.01			.01		
<i>I. punctatus</i>	.3			.4		
<i>E. spectabile</i>	1.9	4.9	18.0	.4	.3	.3
<i>P. copelandi</i>	.8	.1		.01		
<i>P. phoxocephala</i>	.1			.1		
<i>P. caprodes</i>	.4	.6	.2	.2	.2	.4
<i>M. salmoides</i>	.06				1.1	.3
<i>M. punctulatus</i>	.5	1.7	.4			
<i>P. annularis</i>	3.9	.8		2.9	4.2	.3
<i>L. cyanellus</i>	3.4	.8	6.6	5.2	1.8	30.5
<i>L. humilis</i>	10.6	13.1	1.8	31.4	17.7	14.8
<i>L. megalotis</i>	12.4	22.3	12.0	3.6	14.0	1.7
<i>L. macrochirus</i>	.3			.2	1.3	
<i>A. grunniens</i>	.1					
<i>L. sicculus</i>	7.1	1.6	.4	7.7	10.2	

Big Caney River

The "lower segment" of Big Caney River is immediately upstream from Hulah Reservoir, and is not the lowermost portion of the entire river basin, but merely the lower part of the river in the area studied. A conspicuous characteristic of the lower segment was the general restriction of the deep-bodied suckers and the carp to this part of the stream. Other fishes that were most common in the lower section were *Pimephales vigilax*, *Percina phoxocephala*, *Gambusia affinis*, and *Aplodinotus grunniens*. *Labidesthes sicculus* and *Lepisosteus osseus* ranged into the middle section of the stream, but were present in larger numbers downstream. *Ictalurus punctatus*, *Pomoxis annularis*, and *Lepomis macrochirus* were taken chiefly in downstream habitats; however, stocking has confused the distributional pattern of these species. *Notropis lutrensis*, although found throughout the system, progressively declined in numbers taken in the middle and upper sections. Approximately 18 species were usually taken in downstream collections.

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No species were found exclusively in the middle section of the Big Caney system. *Micropterus punctulatus*, *Notropis umbratilis*, and *Lepomis megalotis* tended to be most common in the middle section of the main stream. These three species were taken together at stations C-5, C-6, C-8, and C-10.

The upper section yielded no species that did not occur also in another section. Fishes most abundant in the upper section included: *Campostoma anomalum*, *Etheostoma spectabile*, *Notropis boops*, *Notropis rubellus*, *Pimephales notatus*, and *Lepomis cyanellus*. *Ictalurus natalis* also seemed more common upstream than in lower parts of the basin.

Campostoma anomalum was one of the most common fishes taken at many of the stations on small upland tributaries. In downstream collections its relative abundance was less, although it was often concentrated on riffles.

In the Big Caney system as a whole *Notropis umbratilis* was the most abundant species. Several species were present throughout the system in proportions varying, sometimes greatly, from

station to station. *Lepomis megalotis* and *Lepomis humilis* were erratic in occurrence, and the numbers of *Notropis camurus* and *Ictalurus melas* varied without pattern.

Grouse Creek

The fauna of the main stream of Grouse Creek fluctuated more in number and kinds of fish from station to station than did the fauna of Big Caney River. Again, the deep-bodied suckers showed downstream proclivities. In addition, *Notropis buechanani*, *Pimephales tenellus*, *Percina copelandi*, *Percina phoxocephala*, *Notropis percobromus* and *Pylodictis olivaris* were taken only at the lowermost station (G-1). At stations G-2 and G-3 the creek is sluggish and often turbid, meandering between high mud banks in a flood plain. At these stations *Fundulus notatus*, *Gambusia affinis*, *Labidesthes sicculus*, *Ictalurus melas*, and *Lepomis humilis* were the most common fishes. Shiners (*Notropis* spp.) and *Lepomis megalotis* were rarely taken. Hall (1953:36) states that *Gambusia affinis*, *Fundulus notatus*, and *Labidesthes sicculus* are usually associated with overflow pools, oxbows, and vegetated backwaters.

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Those fishes mentioned in the preceding paragraph remained common in the middle section of the stream. In addition *Notropis lutrensis*, *Notropis umbratilis*, and *Lepomis megalotis* were important members of the fauna.

In the uppermost section shiners (*Notropis* spp.) were common. In the few upstream stations that were still in good condition with clear flowing water, the fauna resembled that of the upstream stations on Big Caney River. Most upstream stations on Grouse Creek were located on highly intermittent streams that are treated below.

FAUNAS OF INTERMITTENT STREAMS

Because of severe, protracted drought, most of the streams studied had ceased to flow by the close of the survey period. However, the duration of intermittency varied greatly in different streams, as did its effect in terms of the number and sizes of residual pools, water temperatures, pollution, and turbidity. Crab Creek, Beaver Creek, and a small unnamed tributary of Grouse Creek were severely affected by intermittency. Their faunas are discussed below.

In Crab Creek six collections were made from points near the mouth to the uppermost pool in which water was found. Pools near the mouth were as large as thirty feet in width and ninety feet in length, while those that were uppermost were shallow puddles averaging ten feet in length and five feet in width. The uppermost station was situated in bluestem pasture without benefit of shade from trees.

The species taken and their relative abundances based on five seine hauls at each station are shown in Table 7. At the uppermost pool (G-17) only small green sunfish were found. At G-16, next downstream, this species was joined by large numbers of black bullheads and a few redbfin shiners and red shiners. G-13 was similar to G-16, but two additional species occurred there. G-12 was a clear, deep pool much larger than any at the stations upstream. Here, seven species were added to the fauna, and the percentages of *Ictalurus melas* and *Lepomis cyanellus* were much less. At G-10 *Fundulus notatus*, *Labidesthes sicculus*, and *Minytrema melanops* appeared. Nevertheless, fewer species (10) were captured here than at station G-12 upstream.

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TABLE 7.—PERCENTAGES OF FISHES TAKEN ON CRAB CREEK.

Stations	G-10	G-11	G-12	G-13	G-16	G-17
<i>Minytrema melanops</i>	8.7					
<i>Labidesthes sicculus</i>	20.0	1.0				
<i>Fundulus notatus</i>	25.7	41.0				
<i>Ictalurus natalis</i>		3.8	.43			
<i>Pomoxis annularis</i>	8.8	11.8	1.9			
<i>Lepomis humilis</i>	15.45	9.9	8.5			
<i>Micropterus salmoides</i>			1.9			
<i>Etheostoma spectabile</i>	1.0		1.9			
<i>Percina caprodes</i>			3.8			
<i>Moxostoma erythrurum</i>	1.0		7.0			
<i>Lepomis megalotis</i>	5.7	2.3	7.0	2.0		
<i>Pimephales notatus</i>		34.0	9.0			
<i>Ictalurus melas</i>	5.3	.5	29.0	49.0		
<i>Notropis umbratilis</i>		4.7	9.0	1.0		
<i>Notropis lutrensis</i>	20.6	26.0	25.0	14.0	1.0	
<i>Lepomis cyanellus</i>	1.0		1.9	34.0	49.0	100.0

TABLE 8.—FISH TAKEN IN NINE POOLS ON UPPER BEAVER CREEK (PROGRESSING FROM DOWNSTREAM TO UPSTREAM).

	<i>Notropis umbratilis</i>	<i>Notropis lutrensis</i>	<i>Lepomis humilis</i>	<i>Lepomis cyanellus</i>	<i>Ictalurus melas</i>
Pools:		4 adults			
1	5 adults	7 young	adults abundant	young abundant	1 juvenile
2	2 adults	4 adults	6 adults	young abundant	
3		1 adult	7 adults	3 juveniles	2 juveniles
4			4 adults	young abundant	young abundant
5			2 adults		
6				28 young	
7					
8					1 adult
9					1 adult

A series of collections similar to that on Crab Creek was carried out along 1½ miles of Beaver Creek on July 22, 1956. Nine pools were sampled (Table 8) of which number nine was the uppermost point where water was found (except for farm ponds). Mainly young of *Lepomis cyanellus* and *Ictalurus melas* were found in the uppermost stations, as on Crab Creek. Only adults of *Notropis lutrensis* and *Notropis umbratilis* were taken.

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In another small intermittent tributary of Grouse Creek two collections (G-14 and G-15) were made. One was from several isolated pools near the source of the creek and the other was 1½ miles upstream from the mouth. The two stations were approximately four miles apart. Table 9 indicates approximate percentages of fish taken in five seine hauls at these stations.

TABLE 9.—FISHES TAKEN IN A TRIBUTARY OF GROUSE CREEK.

Species	Upstream station	Downstream station
<i>Ictalurus melas</i>	45%	
<i>Lepomis humilis</i>	48%	40%
<i>Notropis lutrensis</i>	5%	30%
<i>Lepomis cyanellus</i>	2%	20%
<i>Fundulus notatus</i>		10%

At two other stations, only *Lepomis cyanellus* was found. One of these stations consisted of several small spring-fed pools in a dry arroyo tributary to Little Beaver Creek. Around these small "oases" rushes and smartweeds grew and blackbirds were nesting in the rushes. Although green sunfish up to eight inches in length were common in the shallow pools, no other species was found. The second station (C-17) on the East Fork Big Caney River is of special interest. The pool was isolated, had dimensions of about 25×25 feet, and had an average depth of 15 inches. The water was foul; cows had been fed fodder in a sheltered area above the pool during the preceding winter and the entire bottom was covered to a depth of 6 inches to 1 foot with a detritus of decomposing fodder, cattle feces, and leaves. The water became almost inky in consistency when the bottom was stirred and its odor was offensive. A thick gray-green bloom lay on the surface. This bloom was full of bubbles indicating gases rising from the bottom muds. One hundred fifty-three green sunfish, all less than 5 inches in length, were taken in one seine-haul at this station.

EAST-WEST DISTRIBUTION

In the Arkansas River system in Kansas there are marked differences between fish faunas of the western and eastern parts of the state. This can be illustrated by comparison of Spring River in Cherokee County with the Cimarron River in southwestern Kansas. Single collections from Spring River or its tributaries usually contain 25 or more species of fish. Collections from the Cimarron rarely contain more than five or six species. Many of those fishes found in Spring River are characteristic of an Ozarkian fauna, and some are endemic to the Ozark uplands. Fish found in the Cimarron or Arkansas in western Kansas are members of a plains fauna of wide distribution. There is mingling of these two faunal groups across the state, with the number of Ozarkian species diminishing westward, and certain plains species diminishing eastward. A number of species such as *Moxostoma duquesnii* and *Notropis spilopterus* are limited, on the basis of present records, to Spring River and its tributaries in Kansas. Others have not been taken west of the Neosho drainage. The Verdigris River provides the next major avenue of westward dispersal followed by Caney River, Grouse Creek, and the Walnut River. West of the Walnut River system Ozarkian species have been almost always absent from collections. The Chikaskia River is somewhat exceptional. Moore and Buck (1953) reported from this river several species that seem more typical of eastern faunal associations. Table 10 indicates the stream system in which the present westernmost records are located for a number of fishes found in the Arkansas River system in Kansas.

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TABLE 10.—PRESENT WESTERNMOST RECORDS OF SOME FISHES IN THE ARKANSAS RIVER BASIN IN KANSAS.

Spring River

Cottus carolinae
Dionda nubila
Etheostoma blennioides
Etheostoma gracile
Etheostoma nigrum nigrum
Etheostoma punctulatum
Etheostoma saxatile
Hypentelium nigricans
Moxostoma duquesnii
Notropis spilopterus
Noturus exilis

Neosho River

Cycleptus elongatus
Etheostoma chlorosomum
Etheostoma flabellare lineolatum
Hybopsis amblops
Hybopsis biguttata
Hybopsis x-punctata
Notropis zonatus pilsbryi

Verdigris River

Etheostoma whipplii
Etheostoma zonale arcansanum
Percina copelandi
Moxostoma carinatum
Notropis boops
Notropis volucellus
Noturus miurus

Chikaskia River

Ictalurus natalis
Percina phoxocephala
Labidesthes sicculus
Lepomis megalotis breviceps
Micropterus punctulatus
Moxostoma aureolum pisolabrum
Moxostoma erythrurum
Notropis camurus
Pimephales notatus
Pimephales tenellus
Noturus nocturnus

The westernmost records for seven species are in the area studied.

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1. *Lepisosteus platostomus*.
2. *Carpionides velifer*.
3. *Moxostoma carinatum*.
4. *Minytrema melanops*. One specimen taken at station G-10 near the mouth of Crab Creek constitutes the present westernmost record. A specimen has been taken by Cross (C-24-51) in the headwaters of the Walnut River.
5. *Notropis boops*. The westernmost record is station G-5 on Grouse Creek. This fish has been reported slightly west of this in Oklahoma on Big Beaver Creek in Kay County (number 4776, Oklahoma A & M College Museum of Zoology).
6. *Notropis volucellus*. Two specimens were taken at station G-8 on Silver Creek.
7. *Percina copelandi*. The westernmost record is from station G-1, two miles above the mouth of Grouse Creek.

The easternmost occurrences of four species are in the area studied. These species are *Hybopsis aestivalis tetranemus* (Station A-2), *Notropis blennioides* (Station A-1), *Notropis girardi* (Station A-2), and *Fundulus kansae* (Station A-2 and Walnut River). These fish are associated with the Arkansas River proper and its sandy western tributaries. In Oklahoma, these fish are found in the Arkansas River as it proceeds eastward and in the downstream portions of some of its tributaries. These fish show little tendency to ascend the streams of the Flint Hills.

The fish fauna of the area studied is transitional between the Ozarkian and Great Plains faunas.

Fluctuation in water level seemed especially important in determining distribution of fishes in the area studied. Variable climate characteristic of the region studied causes recurrent floods and intermittency in streams. Both of these conditions have probably been accentuated by man's modifications of the habitat. The effects of intermittency were most strikingly demonstrated in small creeks of the uplands. The number of species of fish in the highly intermittent streams was small—especially in the uppermost pools sampled—but the actual number of fish was often high even though the number of species was low. In several instances the only fishes found in these isolated pools were *Lepomis cyanellus* and *Ictalurus melas*. This phenomenon of concentrated numbers of individuals of a few species would indicate the presence of limiting factors that allow only those species most tolerant of the particular factor to flourish.

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Soon after rains restored flow in these intermittent creeks *L. cyanellus* and *I. melas* appeared in parts of the channels that had previously been several miles from the nearest water. Rapid upstream movements of other species after rains was also noted.

It was impossible to ascertain the precise effects of gradient and bottom-type on distribution, but certain species such as *Notropis blennioides*, *Notropis girardi*, and *Fundulus kansae* were taken only in streams with sandy bottoms. *Notropis deliciosus* and *Hybognathus placita* were most abundant over sandy bottoms.

The high gradient of upland tributaries in the Flint Hills area produced turbulence and bottoms predominantly of rubble. A fauna of which *Etheostoma spectabile* and *Campostoma anomalum* were characteristic existed in these waters while they were flowing. As flow decreased and intermittency commenced, qualitative and quantitative changes in the fish faunas were observed. Gradient did not change during drought, but turbulence did. Because turbulence varies with water level as well as gradient, the effect of gradient on fish distribution ultimately is linked to climate.

Probably the small number of fish taken on the Walnut River in comparison with other eastern Kansas rivers (Verdigris, Neosho) results, in part, from the long-term pollution of the stream noted by Clapp (1920:33) and Doze (1924). No percid fishes, black bass, or madtom catfish were taken on the Walnut in Cowley County and the species of *Notropis* numbered only three.

Four faunal associations seem to be recognizable in the area.

Arkansas River Fauna

This fauna contained *Notropis girardi*, *Notropis blennioides*, *Hybopsis aestivalis tetranemus*, and *Fundulus kansae* which, in this area, did not seem to wander far from the sandy main stream of the Arkansas. Minnows abounded; *Notropis lutrensis* and *N. deliciosus missouriensis* predominated; and *Notropis girardi*, *N. percobromus*, and *Hybognathus placita* were common. In quiet backwaters, coves, and shallow pools *Gambusia affinis* occurred in great numbers. *Lepisosteus osseus* seemed to be the most important predator.

Lower Walnut River Fauna

The Walnut River in Cowley County supported large populations of deep-bodied suckers, carp, and gar. *Notropis lutrensis* and *N. percobromus* were characteristic minnows. *Lepomis humilis* abounded at some stations. The fauna of the main stream of the Walnut River was somewhat intermediate between that of the Arkansas River and that of the three streams considered below. Fifteen of the species common to the Big Caney, Elk, and Grouse systems were also taken in the Walnut River main stream. Thirteen species were common to the Walnut and Arkansas rivers. Seven species were common to all these streams.

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Caney-Elk-Grouse Main Stream Fauna

This fauna includes fishes living not only in the main streams but also in the lower parts of the larger tributaries of these streams. The fauna was comparatively rich: in the main stream of Big Caney River 39 species were taken, in Grouse Creek 35 species, in the Walnut River main stream 21 species, and in the Arkansas River 19 species. It has been pointed out that large rivers such as the Walnut and Arkansas have been subjected to greater direct and indirect modification by man, possibly resulting in a less diverse fauna than would otherwise occur in these streams. At present, there is a paucity of ecological niches in the upland tributaries and large rivers, as compared with streams of intermediate size. Fishes typical of the Caney-Elk-Grouse association were *Notropis umbratilis*, *Lepomis megalotis*, *Lepomis humilis*, *Labidesthes sicculus*, *Fundulus notatus*, and the two species of *Micropterus* (*Micropterus punctulatus* was not taken in Grouse Creek).

Upland Tributary Fauna

Tributary faunas were divisible into two categories: (1) Those of the Walnut River and Grouse Creek (intermittency was severe, species were few, with *Ictalurus melas* and *Lepomis cyanellus* predominating); (2) those of Big Caney River (stream-flow was more stable, and eastern fishes, some of which have Ozarkian affinities, occurred in greater abundance than in any other part of

the area surveyed). In the latter streams *Campostoma anomalum* and *Etheostoma spectabile* usually were dominant. *Pimephales notatus*, *Notropis volucellus*, *N. camurus*, *N. boops*, and *N. rubellus* characteristically occurred. *Notropis lutrensis* was sparsely represented in flowing tributaries. *Notropis umbratilis*, which seems to prefer habitats intermediate between those of *Notropis lutrensis* and Ozarkian shiners, was usually represented. Deep-bodied suckers and carp were not taken in upland tributaries but *Moxostoma erythrurum* was common and *Minytrema melanops* was taken.

The kinds and numbers of shiners (*Notropis*) taken at different points along Grouse Creek seem significant. *N. lutrensis* and *N. umbratilis* occurred throughout the stream but were rare in sluggish areas where populations of *Gambusia affinis*, *Fundulus notatus*, and *Labidesthes sicculus* flourished. At the lowermost station *Notropis percobromus* and *N. buchanani* were taken; these were not present in other collections. In the uppermost stations where water remained plentiful, *N. boops* and *N. volucellus* were taken, and *N. rubellus* has been recorded.

In the broader distributional sense those fishes that seemed most tolerant of intermittency (*Lepomis cyanellus*, *Lepomis humilis*, *Ictalurus melas*, *Notropis lutrensis*) are widely distributed in the Arkansas River Basin, and are common in the western part of the Arkansas River Basin. Species less tolerant of intermittency are *Notropis boops*, *Notropis camurus*, *Notropis rubellus*, *Notropis volucellus*, and *Pimephales tenellus*; they have not been taken far west of the area studied, and become more common east of it.

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