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August 11, 1961

Fish Populations, Following a Drought, In the Neosho and Marais des Cygnes Rivers of Kansas

BY

JAMES EVERETT DEACON

(Joint Contribution from the State Biological Survey and the Forestry, Fish, and Game Commission)

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JAMES EVERETT DEACON

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INTRODUCTION

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This report concerns the ability of fish-populations in the Neosho and Marais des Cygnes rivers in Kansas to readjust to continuous stream-flow following intermittent conditions resulting from the severest drought in the history of the State.

The variable weather in Kansas (and in other areas of the Great Plains) markedly affects its flora and fauna. Weaver and Albertson (1936) reported as much as 91 per cent loss in the basal prairie vegetative cover in Kansas near the close of the drought of the 1930's. The average annual cost (in 1951 prices) of floods in Kansas from 1926 to 1953 was $35,000,000. In the same period the average annual loss from the droughts of the 1930's and 1950's was $75,000,000 (in 1951 prices), excluding losses from wind- and soil-erosion. Thus, over a period of 28 years, the average annual flood-losses were less than one-half the average annual drought-losses (Foley, Smrha, and Metzler, 1955:9; Anonymous, 1958:15).

Weather conditions in Kansas from 1951 to 1957 were especially noteworthy: 1951 produced a bumper crop of climatological events significant to the economy of the State. Notable among these were: Wettest year since beginning of the state-wide weather records in 1887; highest river stages since settlement of the State on the Kansas River and on most of its tributaries, as well as on the Marais des Cygnes and on the Neosho and Cottonwood. The upper Arkansas and a number of smaller streams in western Kansas also experienced unprecedented flooding (Garrett, 1951:147). This period of damaging floods was immediately followed by the driest five-year period on record, culminating in the driest year in 1956 (Garrett, 1958:56). Water shortage became serious for many communities. The Neosho River usually furnishes adequate quantities of water for present demands, but in some years of drought all flow ceases for several consecutive months. In 1956-'57, the city of Chanute, on an emergency basis, recirculated treated sewage for potable supply (Metzler *et al.*, 1958). The water shortage in many communities along the Neosho River became so serious that a joint project to pump water from the Smoky Hill River into the upper Neosho was considered, and preliminary investigations were made. If the drought had continued through 1957, this program might have been vigorously promoted. Data on stream-flow in the Neosho and Marais des Cygnes (1951-'59) are presented in Tables 1-4.

These severe conditions provided a unique opportunity to gain insight into the ability of several species of fish to adjust to marked changes in their environment. For this reason, and because of a paucity of information concerning stream-fish populations in Kansas, the study here reported on was undertaken. [Pg 364]

Table 1. Stream-flow in Cubic Feet per Second, Neosho River near Council Grove, Kansas. Drainage Area: 250 Square Miles

Water-year[A]	Average flow	Maximum	Minimum
1951	498.0	121,000	3.0
1952	82.1	4,850	.7
1953	5.37	202	.1
1954	8.53	2,720	.1
1955	31.2	6,480	0
1956	10.1	5,250	0
1957	68.5	12,300	0
1958	131.0	5,360	.8
1959	114.0	7,250	8.5

Table 2. Stream-flow in Cubic Feet per Second, Neosho River near Parsons, Kansas. Drainage Area: 4905 Square Miles.

Water-year[B]	Average flow	Maximum	Minimum
1951	8,290	410,000	124.0
1952	2,021	20,500	20.0
1953	173	4,110	.3
1954	430	27,900	.1
1955	645	18,600	0
1956	180	6,170	0
1957	1,774	25,000	0
1958	3,092	27,200	78.0
1959	1,609	22,600	139.0

Table 3. Stream-flow in Cubic Feet per Second, Marais des Cygnes River Near Ottawa, Kansas. Drainage Area: 1,250 Square Miles.

Water-year	Average flow	Maximum	Minimum
1951	2,113	142,000	25.0
1952	542	12,000	.2
1953	36.5	2,690	.2
1954	73.6	5,660	.5
1955	75.7	5,240	.7
1956	26	1,590	.7
1957	442	11,200	.7
1958	775	9,130	5.6

Table 4. Stream-flow in Cubic Feet per Second, Marais des Cygnes River at Trading Post, Kansas. Drainage Area: 2,880 Square Miles. [Pg 365]

Water-year	Average flow	Maximum	Minimum
1951	5,489	148,000	36.0
1952	1,750	20,400	3.0
1953	261	7,590	0
1954	334	12,500	0
1955	786	16,100	.2
1956	202	10,000	0
1957	871	14,700	0
1958	2,453	20,400	120.0
[C]1959	750	10,900	3.4

DESCRIPTION OF NEOSHO RIVER

The Neosho River, a tributary of Arkansas River, rises in the Flint Hills of Morris and southwestern Wabaunsee counties and flows southeast for 281 miles in Kansas, leaving the state in the extreme southeast corner (Fig. 1). With its tributaries (including Cottonwood and Spring rivers) the Neosho drains 6,285 square miles in Kansas and enters the Arkansas River near Muskogee, Oklahoma (Schoewe, 1951:299). Upstream from its confluence with Cottonwood River, the Neosho River has an average gradient of 15 feet per mile. The gradient lessens rapidly below the mouth of the Cottonwood, averaging 1.35 feet per mile downstream to the State line (Anonymous, 1947:12). The banks of the meandering, well-defined channel vary from 15 to 50 feet in height and support a deciduous fringe-forest. The spelling of the name originally was "Neozho," an Osage Indian word signifying "clear water" (Mead, 1903:216).

Fig. 1. Neosho and Marais des Cygnes drainage systems. Dots and circles indicate collecting-stations.

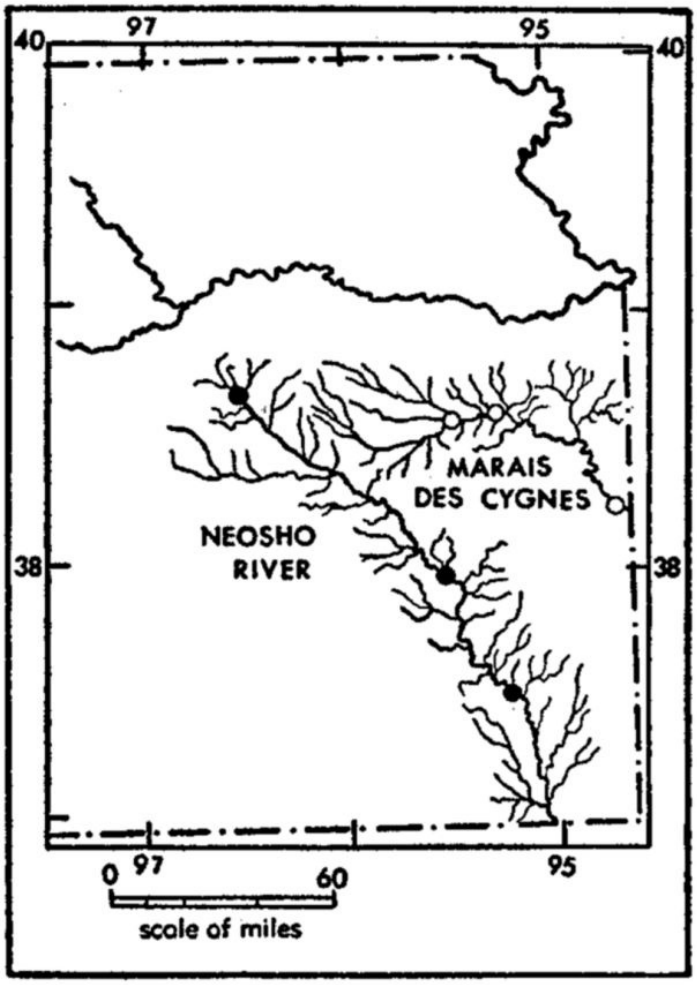

Fig. 1. Neosho and Marais des Cygnes drainage systems. Dots and circles indicate collecting-stations.

Neosho River, Upper Station.—Two miles north and two miles west of Council Grove, Morris County, Kansas (Sec. 32 and 33, T. 15 S., R. 8 E.) (Pl. 28, Fig. 2, and Pl. 29, Fig. 1). Width 20 to 40 feet, depth to six feet, length of study-area one-half mile (one large pool plus many small pools connected by riffles), bottom of mud, gravel, and rubble. Muddy banks 20 to 30 feet high.

According to H. E. Bosch (landowner) this section of the river dried completely in 1956, except for the large pool mentioned above. This section was intermittent in 1954 and 1955; it again became intermittent in the late summer of 1957 but not in 1958 or 1959.

A second section two miles downstream (on land owned by Herbert White) was studied in the summer of 1959 (Sec. 3 and 10, T. 16 S., R. 8 E.) (Pl. 29, Fig. 2 and Pl. 30, Figs. 1 and 2). This [Pg 367] section is 20 to 60 feet in width, to five feet in depth, one-half mile in length (six small pools with intervening riffles bounded upstream by a low-head dam and downstream by a long pool), having a bottom of gravel, rubble, bedrock, and mud, and banks of mud and rock, five to 20 feet in height.

Neosho River, Middle Station.—One mile east and one and one-half miles south of Neosho Falls, Woodson County, Kansas (Sec. 3 and 4, T. 24 S., R. 17 E.) (Pl. 26, Fig. 1). Width 60 to 70 feet, depth to eleven feet, length of study-area two miles (four large pools with connecting riffles),

bottom of mud, gravel and rock. Mud and rock banks 30 to 40 feet high.

According to Floyd Meats (landowner) this section of the river was intermittent for part of the drought.

Neosho River, Lower Station.—Two and one-half miles west, one-half mile north of Saint Paul, Neosho County, Kansas (Sec. 16, T. 29 S., R. 20 E.). Width 100 to 125 feet, depth to ten feet, length of study-area one mile (two large pools connected by a long rubble-gravel riffle), bottom of mud, gravel, and rock. Banks, of mud and rock, 30 to 40 feet high (Pl. 26, Fig. 2).

This station was established after one collection of fishes was made approximately ten miles upstream (Sec. 35, T. 28 S., R. 19 E.). The second site, suggested by Ernest Craig, Game Protector, provided greater accessibility and a more representative section of stream than the original locality.

DESCRIPTION OF MARAIS DES CYGNES RIVER

The Marais des Cygnes River, a tributary of Missouri River, rises in the Flint Hills of Wabaunsee County, Kansas, and flows generally eastward through the southern part of Osage County and the middle of Franklin County. The river then takes a southeasterly course through Miami County and the northeastern part of Linn County, leaving the state northeast of Pleasanton. With its tributaries (Dragoon, Salt, Pottawatomie, Bull and Big Sugar creeks) the river drains 4,360 square miles in Kansas (Anonymous, 1945:23), comprising the major part of the area between the watersheds of the Kansas and Neosho rivers. The gradient from the headwaters to Quenemo is more than five feet per mile, from Quenemo to Osawatomie 1.53 feet per mile, and from Osawatomie to the State line 1.10 feet per mile (Anonymous, 1945:24). The total length is approximately 475 miles (150 miles in Kansas). The river flows in a highly-meandering, well- [Pg 368]
defined channel that has been entrenched from 50 to 250 feet (Schoewe, 1951:294). "Marais des Cygnes" is of French origin, signifying "the marsh of the swans."

Marais des Cygnes River, Upper Station.—One mile south and one mile west of Pomona, Franklin County, Kansas (Sec. 12, T. 17 S., R. 17 E.) (Pl. 27, Fig. 1). Width 30 to 40 feet, depth to six feet, length of study-area one-half mile (three large pools with short connecting riffles), bottom of mud and bedrock. Mud banks 30 to 40 feet high.

According to P. Lindsey (landowner) this section of the river was intermittent for most of the drought. Flow was continuous in 1957, 1958 and 1959.

There are four low-head dams between the upper and middle Marais des Cygnes stations.

Marais des Cygnes River, Middle Station.—One mile east of Ottawa, Franklin County, Kansas (Sec. 6, T. 17 S., R. 20 E.) (Pl. 27, Fig. 2). Width 50 to 60 feet, depth to eight feet, length of study-area one-half mile (one large pool plus a long riffle interrupted by several small pools), bottom of mud, gravel, and rock. Mud and sand banks 30 to 40 feet high.

This section of the river was intermittent for much of the drought. In the winter of 1957-'58 a bridge was constructed over this station as a part of Interstate Highway 35. Because of this construction many trees were removed from the stream-banks, the channel was straightened, a gravel-bottomed riffle was rerouted, and silt was deposited in a gravel-bottom pool.

Marais des Cygnes River, Lower Station.—At eastern edge of Marais des Cygnes Wildlife Refuge, Linn County, Kansas (Sec. 9, T. 21 S., R. 25 E.). Width 80 to 100 feet, depth to eight feet, length of study-area one-half mile (one large pool plus a long riffle interrupted by several small pools), bottom of mud, gravel, and rock. Mud banks 40 to 50 feet high.

This section of the river ceased to flow only briefly in 1956.

METHODS

Electrical Fishing Gear

The principal collecting-device used was a portable (600-watt, 110-volt, A. C.) electric shocker carried in a 12-foot aluminum boat. Two 2 × 2-inch wooden booms, each ten feet long, were attached to the front of the boat in a "V" position so they normally were two feet above the [Pg 369]
surface of the water. A nylon rope attached to the tips of the booms held them ten feet apart. Electrodes, six feet long, were suspended from the tip and center of each boom, and two electrodes were suspended from the nylon rope. The electrodes extended approximately four feet into the water. Of various materials used for electrodes, the most satisfactory was a neoprene-core, shielded hydraulic hose in sections two feet long. These lengths could be screwed together, permitting adjustment of the length of the electrodes with minimum effort. At night, a sealed-

beam automobile headlight was plugged into a six-volt D. C. outlet in the generating unit and a Coleman lantern was mounted on each gunwale to illuminate the area around the bow and along the sides of the boat (Pl. 3a). In late summer, 1959, a 230-volt, 1500-watt generating unit, composed of a 115-volt, 1500-watt Homelite generator was used. It was attached to a step-up transformer that converted the current to 230 volts. The same booms described above were used with the 230-volt unit, with single electrodes at the tip of each boom.

A 5.5-horsepower motor propelled the boat, and the stunned fish were collected by means of scap nets. Fishes seen and identified but not captured also were recorded. On several occasions fishes were collected by placing a 25-foot seine in the current and shocking toward the seine from upstream.

The shocker was used in daylight at all six stations in the three years, 1957-'59. Collections were made at night in 1958 and 1959 at the middle Neosho station and in 1959 at the lower Neosho station.

Seines

Seines of various lengths (4, 6, 12, 15, 25 and 60 feet), with mesh-sizes varying from bobbinet to one-half inch, were used. The 4-, 12-, and 25-foot seines were used in the estimation of relative abundance by taking ten hauls with each seine, recording all species captured in each haul, and making a total count of all fish captured in two of the ten hauls. The two hauls to be counted were chosen prior to each collection from a table of random numbers. Additional selective seining was done to ascertain the habitats occupied by different species.

Trap, Hoop, and Fyke Nets.—Limited use was made of unbaited trapping devices: wire traps 2.5 feet in diameter, six feet long, covered with one-inch-mesh chicken wire; hoop nets 1.5 feet to three feet in diameter at the first hoop with a pot-mesh of one inch; and a fyke net three feet in [Pg 370] diameter at the first hoop, pot-mesh of one inch with wings three feet in length. All of these were set parallel to the current with the mouths downstream. The use of trapping devices was abated because data obtained were not sufficient to justify the effort expended.

Gill Nets

Gill-netting was done mostly in 1959 at the lower Neosho station. Use of gill nets was limited because frequent slight rises in the river caused nets to collect excessive debris, with damage to the nets.

Gill nets used were 125 feet long, six feet deep, with mesh sizes of ¾ inch to 2½ inches. Nets, weighted to sink, were placed at right angles to the current and attached at the banks with rope.

Sodium Cyanide

Pellets of sodium cyanide were used infrequently to collect fish from a moderately fast riffle over gravel bottom that was overgrown with willows, making seining impossible. The pellets were dissolved in a small amount of water, a seine was held in place, and the cyanide solution was introduced into the water a short distance upstream from the seine, causing incapacitated fish to drift into the seine. Most of these fish that were placed in uncontaminated water revived.

Rotenone

Rotenone was used in a few small pools in efforts to capture complete populations. This method was used to check the validity of other methods, and to reduce the possibility that rare species would go undetected. Rotenone was applied by hand, and applications were occasionally supplemented by placing rotenone in a container that was punctured with a small hole and suspended over the water at the head of a riffle draining into the area being poisoned. This maintained a toxic concentration in the pool for sufficient time to obtain the desired kill. Rotenone acts more slowly than cyanide, allowing more of the distressed fish to rise to the surface.

Dyes

Bismark Brown Y was used primarily at the upper Neosho station to stain large numbers of small fish. The dye was used at a dilution of 1:20,000. Fishes were placed in the dye-solution for three [Pg 371] hours, then transferred to a live-box in midstream for variable periods (ten minutes to twelve hours) before release.

Determination of Abundance

In the accounts of species that follow, the relative terms "abundant," "common," and "rare" are used. Assignment of one of these terms to each species was based on analysis of data that are presented in Tables 9-16, (pages 402, 403, 404, 405, 408, 410, 411, 414-415, and 416). The number of fish caught per unit of effort with the shocker (Table 10) and with seines (Table 11) constitute the main basis for statements about the abundance of each species at all stations except the upper Neosho station. Species listed in each Table (10 and 11) are those that were

taken consistently by the method specified in the caption of the table; erratically, but in large numbers at least once, by that method; and those taken by the method specified but not the other method.

For the species listed in Table 10, the following usually applies: abundant=more than three fish caught per hour; common=one to three fish caught per hour; rare=less than one fish caught per hour.

Tables 12-16 list all fish obtained at the upper Neosho station by means of the shocker, seines, and rotenone.

Names of Fishes

Technical names of fishes are those that seem to qualify under the International Rules of Zoological Nomenclature. Vernacular names are those in Special Publication No. 2 (1960) of the American Fisheries Society, with grammatical modifications required for use in the University of Kansas Publications, Museum of Natural History.

ANNOTATED LIST OF SPECIES

Lepisosteus osseus (Linnaeus)
Long-nosed Gar

The long-nosed gar was abundant at the lower and middle Neosho stations and the lower Marais des Cygnes station. Numbers increased slightly in the period of study, probably because of increased, continuous flow. The long-nosed gar was not taken at the upper Neosho station. At lower stations the fish occurred in many habitats, but most commonly in pools where gar often were seen with their snouts protruding above the water in midstream. Gar commonly lie quietly [Pg 372] near the surface, both by day and by night, and are therefore readily collected by means of the shocker. Twice, at night, gar jumped into the boat after being shocked.

Young-of-the-year were taken at the middle and lower stations on both the Neosho and Marais des Cygnes rivers, and all were near shore in quiet water. Many young-of-the-year were seined at the lower Neosho station on 18 June 1959, near the lower end of a gravel-bar in a small backwater-area having a depth of one to three inches, a muddy bottom, and a higher temperature than the mainstream. Forty-three of these young gar averaged 2.1 inches in total length (T.L.).

Comparison of sizes of long-nosed gar taken by means of the shocker and gill nets at the lower and middle Neosho stations revealed that: the average size at each station remained constant from 1957 to 1959; the average size was greater at the lower than at the middle station; and, with the exception of young-of-the-year, no individual shorter than 13 inches was found at the middle station and only one shorter than 16 inches was taken at the lower station (Table 5).

Table 5. Numbers and Sizes of Long-nosed Gar Captured by Shocker and Gill Nets at the Middle and Lower Neosho Stations in 1957, 1958 and 1959.

Location	Date	Number	Average total length (inches)	Range
Middle Neosho	1957	19	22.2	14-32
Middle Neosho	1958	57	22.2	14-40
Middle Neosho	1959	64	21.6	13-43
Lower Neosho	1957	14	29.4	9-45
Lower Neosho	1958	7	25.3	23-28
Lower Neosho	1959	107	26.2	16-43

Because collecting was intensive and several methods were used, I think that the population of gars was sampled adequately. Wallen (*Fishes of the Verdigris River in Oklahoma*, 1958:29 [mimeographed copy of dissertation, Oklahoma State University]) took large individuals in the mainstream of the Verdigris River in Oklahoma and small specimens from the headwaters of some tributaries. Because I took young-of-the-year at the lower Neosho station, it is possible that long-nosed gar move upstream when small and then slowly downstream to the larger parts of rivers as the fish increase in size. This pattern of size-segregation, according to size of river, merits further investigation. [Pg 373]

Ripe, spent, and immature long-nosed gar (38 males and 10 females) were taken in three gill nets, set across the channel, 150 to 500 yards below a riffle, at the lower Neosho station on June 16, 17, and 18, 1959. On 23 June, 1959, 12 males and two females were taken in gill nets set 50, 150, and 400 yards above the same riffle. Operations with the shocker between 24 June and 10 July, 1959, yielded 29 males and three females. The fish were taken from many kinds of habitat in a three-mile section of the river.

Direction of movement as recorded from gill nets shows that of 67 gar taken, 45 had moved downstream and 22 upstream into the nets. Only ten of the above gar were taken from the nets set above the riffle; six of the ten were captured as they moved downstream into the nets.

On one occasion I watched minnows swimming frantically about, jumping out of the water, and crowding against the shore, presumably to avoid a long-nosed gar that swam slowly in and out of view. I have observed similar activity when gar fed in aquaria. Stomachs of a few gar from the Neosho River were examined and found to contain minnows and some channel catfish.

Long-nosed gar have a relatively long life span (Breder, 1936). This longevity and their ability to gulp air probably insure excellent survival through periods of adverse conditions. The population of long-nosed gar probably would not be drastically affected even in the event of a nearly complete failure of one or two successive hatches. Maturity is attained at approximately 20 inches, total length.

Collections at the middle Neosho station in 1958 indicate that the long-nosed gar is more susceptible to capture at night than in daytime (Table 9, p. 402).

Lepisosteus platostomus Rafinesque
Short-nosed Gar

Only one short-nosed gar was taken in 1957, at the lower station on the Neosho River. In 1958 this species was taken at the lower station on the Marais des Cygnes and in 1958 and 1959 at the lower and middle stations on the Neosho. More common in the Neosho than the Marais des Cygnes, *L. platostomus* occurs mainly in large streams and never was taken in the upper portions of either river. Although short-nosed gar were about equally abundant at the middle and lower stations on the Neosho, the average size was greater at the lower station (Table 6). This kind of [Pg 374] segregation by size is shared with long-nosed gar, and was considered in the discussion of that species. Short-nosed gar were taken only in quiet water. Both species were collected most efficiently by means of gill nets and shocker. While shocking, I saw many gar only momentarily, as they appeared at the surface, and specific identification was impossible. The total of all gar seen while shocking indicated that gar increased in abundance from 1957 to 1959 (see Tables 5 and 6). Judging from the gar that were identified, the increase was more pronounced in short-nosed gar than in long-nosed gar.

At the lower Neosho station in 1959, two ripe females and one spent female were taken in gill nets (16, 23 and 17 June, respectively) and were moving downstream when caught. No males were taken in the nets. Subsequently, by means of the shocker (26 June-8 July), two spent and two ripe males were captured in quiet water of the mainstream that closely resembled areas in which the gill nets were set. No females were taken by means of the shocker.

Table 6. Numbers and Sizes of Short-nosed Gar Captured by Shocker and Gill Nets at the Middle and Lower Neosho Stations in 1958 and 1959.

Location	Date	Number	Average total length (inches)	Range
Middle Neosho	1958	6	14.9	13.9-15.5
Middle Neosho	1959	9	13.6	11.0-16.0
Lower Neosho	1958	3	21.0	20.3-21.6
Lower Neosho	1959	5	21.3	18.0-24.5

Dorosoma cepedianum (LeSueur)
Gizzard Shad

Gizzard shad declined in abundance from 1957 to 1959. The largest population occurred at the middle station on the Marais des Cygnes in 1957. Shad were mainly in quiet water; often, when the river-level was high, I found them predominately in backwaters or in the mouths of tributary streams. Examination of nine individuals, ranging in size from seven inches to 13.5 inches T. L., indicated that maturity is reached at 10 to 11 inches T. L. Spawning probably occurred in late June in 1959 ("ripe" female caught on 26 June); young-of-the-year were first recorded in mid-July.

Cycleptus elongatus (LeSueur)
Blue Sucker

The blue sucker was taken rarely in the Neosho River and not at all in the Marais des Cygnes in my study. Cross (personal communication) obtained several blue suckers in collections made in [Pg 375] the mainstream of the Neosho River in 1952; both young and adults occupied swift, deep riffles. The species seemingly declined in abundance during the drought, and at the conclusion of my study (1959) had not regained the level of abundance found in 1952.

Ictiobus cyprinella (Valenciennes)
Big-mouthed Buffalo

Big-mouthed buffalo were found in quiet water at all stations, but were rare. A ripe female, 21.5 inches long, was taken at the lower station on the Neosho on 16 June, 1959.

Ictiobus niger (Rafinesque)
Black Buffalo
and
Ictiobus bubalus (Rafinesque)
Small-mouthed Buffalo

Black buffalo were not taken at the upper station on the Neosho and were rare at other stations. Small-mouthed buffalo were taken at all stations and were common in the lower portions of the two streams. While the shocker was being used, buffalo were often seen only momentarily, thereby making specific identification impossible; both species were frequently taken together, and for this reason are discussed as a unit. Both species maintained about the same level of abundance throughout my study.

The two species were taken most often in the deeper, swifter currents of the mainstream, but were sometimes found in pools, creek-mouths and backwaters. On several occasions in the summer of 1959, buffalo were seen in shallow parts of long, rubble riffles, with the dorsal or caudal fins protruding above the surface. Ernest Craig, game protector, said buffalo on such riffles formerly provided much sport for gig-fishermen. He stated that the best catches were made at night because the fish were less "spooky" then than in daytime. In my collections made by use of the shocker, buffalo were taken more frequently at night (Table 9, p. 402).

On 19 June, 1959, I saw many buffalo that seemed to be feeding as they moved slowly upstream along the bottom of a riffle. The two species, often side by side, were readily distinguishable underwater. Small-mouthed buffalo appeared to be paler (slate gray) and more compressed than the darker black buffalo. To test the reliability of underwater identifications, I identified all [Pg 376] individuals prior to collection with a gig. Correct identification was made of all fish collected on 19 June. The smallest individual obtained in this manner was 18.5 inches T. L. On 26 August, 1959, 16 small-mouthed buffalo were captured and many more were seen while the shocker was in use in the same riffle for one hour and ten minutes. One small-mouthed buffalo was caught while the shocker was being used in the pool below that riffle for one hour and fifty minutes. No black buffalo were taken on 26 August.

Spawning by buffalo was not observed but probably occurred in spring; all mature fish in my earliest collections (mid-June of each year) were spent. Small-mouthed buffalo reach maturity at approximately 14 inches T. L.

Carpiodes carpio carpio (Rafinesque)
River Carpsucker

River carpsucker were abundant throughout the study at all stations. Adults were taken most frequently in quiet water, but depth and bottom-type varied. The greatest concentrations occurred in mouths of creeks during times of high water; occasionally, large numbers were taken in a shallow backwater near the head of a riffle at the middle Neosho station. River carpsucker feed on the bottom but seem partly pelagic in habit. They were taken readily by means of the shocker and gill nets at all depths. The population of *C. carpio* in the Neosho River probably was depleted by drought, although many individuals survived in the larger pools.

When stream-flow was restored, carpsucker probably moved rapidly upstream but had a scattered distribution in 1957. Trautman (1957:239) states that in the Scioto River, Ohio, river carpsucker moved upstream in May and downstream in late August and early September. Numbers found at the middle and lower Neosho stations suggest similar movements in the Neosho River in 1957. In midsummer they were common at the middle station but rare at the lower station; however, they became abundant at the lower station in November. The abundance in late fall at the lower Neosho station might have resulted either from downstream migration or from continued upstream movement into thinly populated areas. No indication of seasonal movement was found in 1958 or 1959.

River carpsucker reach maturity at approximately 11 inches T. L., and spawning occurs in May or [Pg 377] June. A ripe male was taken from a gravel-bottomed riffle, three feet deep, at the middle station on the Neosho station on 10 June 1959.

Fig. 2. Length-frequency of river carpsucker in the Neosho River, 1958 and 1959.

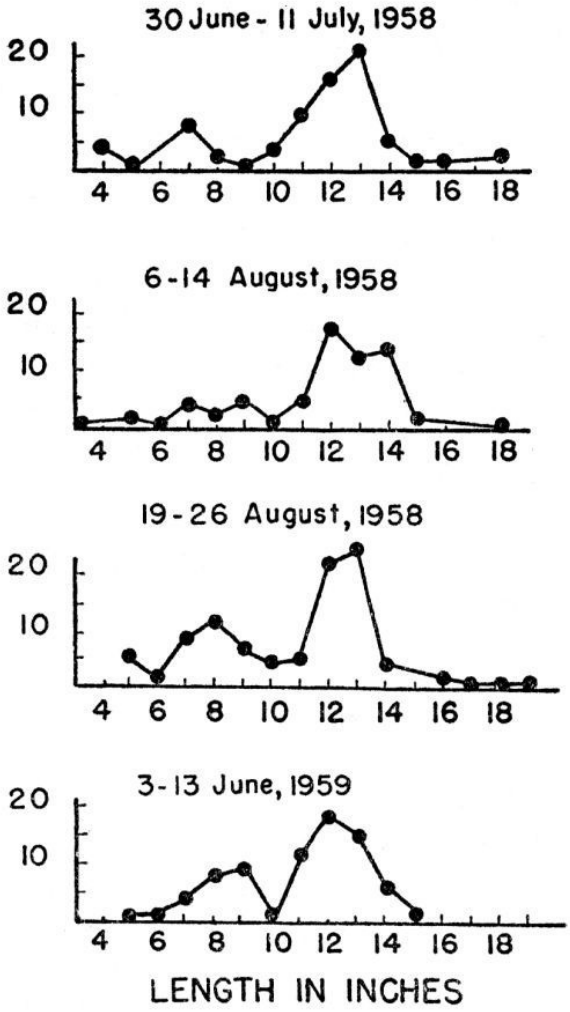

FIG. 2. Length-frequency of river carpsucker in the Neosho River, 1958 and 1959.

The size-distribution of individuals taken at the middle Neosho station is presented in Fig. 2. The collection in early July of 1958 indicates that one size-group (probably the 1957 year-class) had a median length of approximately seven inches. The modal length of this group was nine inches in June, 1959. A second, predominant size-group (Fig. 2) seemed to maintain almost the same median size throughout all the collection periods, although specimens taken in the spring of 1959 were slightly smaller than those obtained in 1958. This apparent stability in size may have been due to an influx of the faster-growing individuals from a smaller size-group, coupled with mortality of most individuals more than 14 inches in length.

Young-of-the-year were taken at every station. Extensive seining along a gravel bar at the lower Neosho station indicated that the young are highly selective for quiet, shallow water with mud bottom. In these areas, young-of-the-year carpsucker were often the most abundant fish.

River carpsucker were collected more readily by use of the shocker after dark than in daylight (Table 9, p. 402).

Carpiodes velifer (Rafinesque)
High-finned Carpsucker

A specimen of *Carpiodes velifer* taken at the lower station on the Neosho in 1958 provided the only record of the species in Kansas since 1924. Many specimens, now in the University of Kansas Museum of Natural History, were taken from the Neosho River system by personnel of the State Biological Survey prior to 1912. The species has declined greatly in abundance in the past 50 years. [Pg 378]

Moxostoma aureolum pisolabrum Trautman
Short-headed Redhorse

The short-headed redhorse occurred at all stations. It was common at the middle and lower stations on the Neosho, rare at the upper station on the Neosho, abundant at the upper station on the Marais des Cygnes in 1957, and rare thereafter at all stations on the Marais des Cygnes. Short-headed redhorse typically occur in riffles, most commonly at the uppermost end where the

water flows swiftly and is about two feet deep. An unusually large concentration was seen on 13 June, 1959, in shallow (six inches), fast water over gravel bottom at the middle station on the Neosho River.

Thirty-nine individuals were marked by clipping fins at the middle Neosho station in 1959. Four were recovered from one to 48 days later: two at the site of original capture (one 48 days after marking), one less than one-half mile downstream, and one about one mile downstream from the original site of capture.

At the middle Neosho station in 1958, this species was taken more readily by use of the shocker at night than by day (Table 9, p. 402).

Moxostoma erythrurum (Rafinesque)
Golden Redhorse

The golden redhorse was abundant at the upper Neosho station, rare at the middle Neosho station, and did not occur in collections at other stations. This species was taken most frequently over gravel- or rubble-bottoms in small pools below riffles, and was especially susceptible to collection by means of the shocker.

Twenty-nine golden redhorse of the 1957 year-class, taken at the upper Neosho station on 9 September 1958, were 6.2 to 8.6 inches in total length (average 7.4 inches); 26 individuals of the same year-class caught on 21 August 1959 were 9.3 to 13.5 inches in total length (average 10.9 inches).

Cyprinus carpio Linnaeus
Carp

The carp decreased in abundance from 1957 to 1959 at the upper and middle Marais des Cygnes station and at the middle and lower Neosho stations. Carp were more abundant in the Marais des [Pg 379] Cygnes than in the Neosho, although the largest number in any single collection was found in one pool at the upper Neosho station in 1958.

Carp were taken most commonly in quiet water near brush or other cover. At the middle Neosho station, collecting was most effective between the hours of 6:30 a.m. and 12:30 p.m. and least effective between 12:30 p.m. and 6:30 p.m. (Table 9, p. 402). Ripe males were taken as early as 19 April (16.1 inches, 19.4 inches T. L.) and as late as 30 July (16 inches T. L.) at the middle Neosho station. Ripe females were taken as early as 19 April at the middle Neosho station (19.2 inches T. L.) and as late as 7 July at the lower Neosho station (16 inches T. L.). Young-of-the-year were taken first at the middle Marais des Cygnes on 8 July 1957. They were recorded on later dates at the upper Marais des Cygnes and at the lower and middle Neosho stations.

Notemigonus crysoleucas (Mitchill)
Golden Shiner

The golden shiner was taken rarely at the upper Marais des Cygnes station in 1958 and 1959 and at the middle Marais des Cygnes station in 1957 and 1958. At the middle Neosho station *Notemigonus* was seined from a pond that is flooded frequently by the river, but never was taken in the mainstream.

Semotilus atromaculatus (Mitchill)
Creek Chub

The creek chub was taken only at the upper stations on both rivers. It increased in abundance at the upper Neosho station from 1957 to 1959, and was not taken in the upper Marais des Cygnes until 1959.

Hybopsis storeriana (Kirtland)
Silver Chub

A single specimen from the lower Marais des Cygnes station provides the only record of the species from the Marais des Cygnes system in Kansas, and is the only silver chub that I found in either river in 1957-1959. The species is taken often in the Kansas and Arkansas rivers. [Pg 380]

Hybopsis x-punctata Hubbs and Crowe
Gravel Chub

The gravel chub, present only at the lower and middle Neosho stations, occupied moderate currents over clean (free of silt) gravel bottom. The gravel chub was not taken in 1957, was rare at both Neosho stations in 1958, became common at the lower Neosho station in part of 1959,

but was never numerous at the middle Neosho station. Dr. F. B. Cross recorded the species as "rare" in 1952 at a collection site near my middle Neosho station, but larger numbers were taken then than in any of my collections at that station. The population was probably reduced by drought, and recovery was comparatively slow following restoration of flow.

Young-of-the-year and adults were common in collections from riffles at the lower Neosho station from 1 July through 8 July, 1959. I obtained only one specimen in intensive collections in the same area on 25, 26, and 27 August. Seemingly the species had moved off shallow riffles into areas not sampled effectively by seining.

Phenacobius mirabilis (Girard)
Sucker-mouthed Minnow

The sucker-mouthed minnow was common at the middle Marais des Cygnes station but was not taken at the upper and lower stations until 1959, when it was rare. At the middle and lower Neosho stations this fish increased in abundance from 1957 to 1959; at the upper station, sucker-mouthed minnows were not taken until 1959 when collections were made on the White farm. There, the species was common immediately below a low-head dam, but was not taken in extensive collections on the Bosch Farm in 1959.

The species was most common immediately below riffles, or in other areas having clean gravel bottom in the current. On 5 June, 1959, many individuals were taken at night (11:30 p.m.) on a shallow gravel riffle (four inches in depth) where none had been found in a collection at 5:00 p.m. on the same date.

Young-of-the-year were taken at the lower Neosho station on 24 June, 1959, and commonly thereafter in the summer.

Notropis rubellus (Agassiz)
Rosy-faced Shiner

In 1958, the rosy-faced shiner was taken rarely at the lower stations on both streams. This species is common in smaller streams tributary to the lower portions of the two rivers, and probably occurs in the mainstream only as "overflow" from tributaries. Possibly, during drought, [Pg 381] rosy-faced shiners found suitable habitat in the mainstream of Neosho and Marais des Cygnes rivers, but re-occupied tributary streams as their flow increased with favorable precipitation, leaving diminishing populations in the mainstream.

Notropis umbratilis (Girard)
Red-finned Shiner

The red-finned shiner, most abundant at the upper Neosho station, occurred at all stations except the upper Marais des Cygnes. This fish seems to prefer small streams, not highly turbid, having clean, hard bottoms. It is a pool-dwelling, pelagic species.

Notropis camurus (Jordan and Meek)
Blunt-faced Shiner

The blunt-faced shiner was taken only in 1957, at the middle Neosho station, where it was rare. This species, abundant in clear streams tributary to the Neosho River (field data, State Biological Survey) may have used the mainstream as a refugium during drought. The few specimens obtained in 1957 possibly represent a relict population that remained in the mainstream after flow in tributaries was restored by increased rainfall.

Notropis lutrensis (Baird and Girard)
Red Shiner

The red shiner, abundant in 1952 (early stage of drought), was consistently the most abundant fish in my collections in the Marais des Cygnes and at the lower and middle Neosho stations. However, the abundance declined from 1957 to 1959 at the two Neosho stations. At the upper Neosho station the species was fourth in abundance in 1957, and third in 1958 and 1959 (Table 12).

The red shiner is pelagic in habit and occurs primarily in pools, though it frequently inhabits adjacent riffles. Collections by seining along a gravel bar at the lower station showed this fish to be most abundant in shallow, quiet water over mud bottom, or at the head of a gravel bar in relatively quiet water. At the lower end of the gravel bar in water one to four feet deep, with a shallow layer of silt over gravel bottom and a slight eddy-current, red shiners were replaced by ghost shiners or river carpsucker young-of-the-year as the dominant fish.

Fifty-nine dyed individuals were released in an eddy at the lower end of a gravel bar at the [Pg 382] middle Neosho station on 5 June, 1959. Some of these fish still were present in this area when a

collection was made 30 hours later. No colored fish were taken in collections from quiet water at the upper end of the gravel bar. A swift riffle intervening between the latter area and the area of release may have impeded their movement. Forty-six individuals, released at the head of the same gravel bar on 10 June, 1959, immediately swam slowly upstream through quiet water and were soon joined by other minnows. These fish did not form a well-organized school, but moved about independently, with individuals or groups variously dropping out or rejoining the aggregation until all colored fish disappeared about 50 feet upstream from the point of release.

Evidence of inshore movement at night was obtained on 8 June, 1959, in a shallow backwater, having gravel bottom, at the head of a gravel bar at the middle Neosho station. A collection made in the afternoon contained no red shiners, but they were abundant in the same area after dark.

In Kansas, red shiners breed in May, June, and July. Minckley (1959:421-422) described behavior that apparently was associated with spawning. Because of its abundance, the red shiner is one of the most important forage fishes in Kansas streams, and frequently is used as a bait minnow.

Notropis volucellus (Cope)
Mimic Shiner

The mimic shiner was taken only rarely at the two lower Neosho stations. This species, like *N. camurus*, is normally more common in clear tributaries than in the Neosho River, and probably frequents the mainstream only during drought.

Notropis buchanani Meek
Ghost Shiner

Field records of the State Biological Survey indicate that the ghost shiner was common in the mainstream of the lower Neosho River during drought. In 1957, the species was abundant at the lower and middle stations on the Neosho River and at the lower Marais des Cygnes station.

Collections at all stations show that the species has a definite preference for eddies—relatively quiet water, but adjacent to the strong current of the mainstream rather than in backwater remote from the channel. The bottom-type over which the ghost shiner was found varied from [Pg 383] mud to gravel or rubble.

Notropis stramineus (Cope)
Sand Shiner

The sand shiner was taken rarely in the Neosho and commonly in the Marais des Cygnes in 1952. In my study the species occurred at all stations, but not until 1959 at the upper and lower Neosho stations. Sand shiners were found with equal frequency in pools and riffles. Spawning takes place in June and July.

Pimephales tenellus tenellus (Girard)
Mountain Minnow

The mountain minnow was common at the lower and middle Neosho stations throughout the period of study, and increased in abundance from 1957 to 1959. It was taken only in 1959 at the upper Neosho station, where it was rare. This species does not occur in the Marais des Cygnes River. The largest numbers were found in 1959 at the lower Neosho station, where this fish occurred most commonly in moderate current over clean gravel bottom. The mountain minnow, like *Hybopsis x-punctata*, was common in late June and early July but few were found in late August, 1959. The near-absence of this species in collections made in late August is responsible for the apparent slight decline in abundance from 1957 to 1959, as shown in Table 11. Metcalf (1959) found mountain minnows most commonly in streams of intermediate size in Chautauqua, Cowley and Elk counties, Kansas. The predilection of this species for permanent waters resulted in an increase in abundance during my study. With continued flow, this species possibly will decrease in abundance in the lower mainstream of the Neosho River. I suspect that the species is, or will be (with continued stream-flow), abundant in tributaries of intermediate size in the Neosho River Basin.

Pimephales vigilax perspicuus (Girard)
Parrot Minnow

The parrot minnow was not taken in the Marais des Cygnes River and was absent at the upper Neosho station until 1959. This species was common at the lower and middle Neosho stations throughout the period of study and increased in abundance from 1957 to 1959. [Pg 384]

At the lower Neosho station, this fish preferred slow eddy-current over silt bottom, along the downstream portion of a gravel bar. The parrot minnow was taken less abundantly in the latter part of the summer, 1959, than in early summer, but the decline was less than occurred in the

mountain minnow.

Pimephales notatus (Rafinesque)
Blunt-nosed Minnow

The blunt-nosed minnow was common, and increased in abundance in both rivers from 1957 to 1959. The largest numbers were found at the upper Neosho station in 1959, and a large population also was present at the lower Neosho station in 1959.

Pools having rubble bottom, bedrock, and small areas of mud were preferred at the upper Neosho station. At the lower Neosho station the fish was most common in quiet water at the lower end of a gravel bar. The parrot minnow also was common in this general area; nevertheless, these two species were seldom numerous in the same seine-haul, indicating segregation of the two. The blunt-nosed minnow was taken frequently in moderate current over clean gravel bottom, especially in late summer, 1959, when *P. notatus* increased in abundance as the mountain minnow decreased.

Pimephales promelas Rafinesque
Fat-headed Minnow

The fat-headed minnow was taken at all stations except at the lower one on the Marais des Cygnes, and was most abundant at the upper Neosho station. Intensive seining at the lower Neosho station indicated that this species preferred quiet water and firm mud bottom.

In the Neosho River in 1957 to 1959, habitats of the species of *Pimephales* seemed to be as follows: *Pimephales tenellus* (mountain minnow) occurred primarily in moderately flowing gravel riffles in the downstream portions of the river. *Pimephales vigilax* (parrot minnow) was mostly in the quiet areas having mud bottom at the downstream end of gravel bars, and less commonly on adjacent riffles, at the lower station. *Pimephales notatus* (blunt-nosed minnow) had a wider range of habitats, occurring in quiet areas and moderate currents both upstream and downstream. *Pimephales promelas* (fat-headed minnow) occurred throughout both rivers but was most abundant in the quiet water at the uppermost stations. [Pg 385]

Campostoma anomalum (Rafinesque)
Stoneroller

The stoneroller was most abundant at the upper Neosho station and was not taken at the lower Marais des Cygnes station. This fish increased in abundance from 1957 to 1959, but was never common at the middle Marais des Cygnes or the middle and lower Neosho stations.

The stoneroller prefers fast, relatively clear water over rubble or gravel-bottom.

Ictalurus punctatus (Rafinesque)
Channel Catfish

The abundance of channel catfish was greatly reduced as a result of the drought of 1952-1956. With the resumption of normal stream-flow in 1957, the small numbers of adult channel catfish present in the stream produced unusually large numbers of young. These young of the 1957 year-class, which reached an average size of about nine inches by September 1959, will provide an abundant adult population for several years.

The reduction in number of channel catfish in streams can be related to the changed environment in the drought. When stream levels were low in 1953 (Tables 1-4), fish-populations were crowded into a greatly reduced area. An example of these crowded conditions was observed by Roy Schoonover, Biologist of the Kansas Forestry, Fish and Game Commission, in October, 1953, when he was called to rescue fish near Iola, Kansas. The Neosho River had ceased to flow and a pool (less than one acre) below the city overflow dam was pumped dry. Schoonover (personal communication) estimated that 40,000 fish of all kinds were present in the pool. About 30,000 of these were channel catfish, two inches to 14 inches long, with a few larger ones. Fish were removed in the belief that sustained intermittency in the winter of 1953-1954 would result in severe winterkill. These conditions almost certainly were prevalent throughout the basin.

In addition to winterkill, crowding probably resulted in a reduced rate of reproduction by channel catfish, and by other species as well. This kind of density-dependent reduction of fecundity is known for many species of animals (Lack, 1954, ch. 7). In fish, it is probably expressed by complete failure of many individuals to spawn, coupled with scant survival of young produced by the adults that do spawn. Reproductive failure of channel catfish in farm ponds, especially in [Pg 386] clear ponds, is well known, and is often attributed to a paucity of suitable nest-sites (Marzolf, 1957:22; Davis, 1959:10).

In the Neosho and Marais des Cygnes rivers, the intermittent conditions prevalent in the drought resulted in reduced turbidity in the remaining pools. Many spawning sites normally used by channel catfish were exposed, and others were rendered unsuitable because of the increased

clarity of the water. In addition, predation on young channel catfish is increased in clear water (Marzolf; Davis, *loc. cit.*), and would of course be especially pronounced in crowded conditions. The population was thereby reduced to correspond to the carrying capacity of each pool in the stream bed.

The return of normal flow in 1957 left large areas unoccupied by fish and the processes described above were reversed. The expanded habitat favored spawning by nearly the entire adult population, and conditions for survival of young were excellent. As a result, a large hatch occurred in the summer of 1957. (Several hundred small channel catfish were sometimes taken by use of the shocker a short distance upstream from a 25-foot seine, set in a riffle). Subsequent survival of the 1957 year-class has been good. By 1959, few of the catfish spawned in 1957 had grown large enough to contribute to the sport fishery, but they are expected to do so in 1960 and 1961.

The 1957 year-class was probably the first strong year-class of channel catfish since 1952. Davis (1959:15) found that channel catfish in Kansas seldom live longer than seven years. The 1952 year-class reached age seven in 1959. The extreme environmental conditions to which these fish were subjected in drought caused a higher mortality than would occur in normal times. The adult population in the two rivers probably was progressively reduced throughout the drought, and the reduction will continue until the strong 1957 year-class replenishes it. For these reasons, fishing success was poor in 1957-1959.

Juvenile channel catfish were more abundant in the Neosho than in the Marais des Cygnes in 1958 and 1959, although both streams supported sizable populations. In the Marais des Cygnes the upper station had fewer channel catfish than the middle and lower stations. In the Neosho, populations were equally abundant both upstream and downstream. The habitat of channel catfish in streams has been discussed by Bailey and Harrison (1948).

I found adults in various habitats throughout the stream, but most abundantly in moderately fast water at the lower and middle Neosho stations. At the upper Neosho station where riffles are shallow, yearlings and two-year-olds were numerous in many of the small pools over rubble-gravel bottom. Cover was utilized where present, but large numbers were taken in pools devoid of cover. Young-of-the-year were nearly always taken from rubble- or gravel-riffles having moderate to fast current at both upstream and downstream stations. [Pg 387]

Collections showed that young of 1957 were abundant on riffles throughout the summer and until 17 November, 1957. Subsequent collections were not made until 11 May, 1958, at which time 1957-class fish still were abundant on riffles at the lower Neosho station; on that date, the larger individuals were in deeper parts of the riffles than were smaller representatives of the same year-class.

In a later collection (2 June, 1958), numbers present on the riffles were greatly reduced and the larger individuals were almost entirely missing. Some of the smaller individuals were still present in the shallower riffle areas. Table 7 compares sizes of the individuals obtained on 2 June with sizes collected from deep riffles at the middle Neosho station on 7 June, 1958. The larger size of the group present in deep riffles is readily apparent. The yearlings almost completely disappeared from subsequent collections on riffles.

A bimodal size-distribution of young-of-the-year was noted also in 1958 and 1959; but, no segregation of the two sizes occurred on riffles in summer. Marzolf (1957:25) recorded two peaks in spawning activity in Missouri ponds. Two spawning periods may account for the bimodal size distribution of young-of-the-year observed in my study.

In 1959, young-of-the-year began to appear in the latter part of June and became abundant by the first part of July. Individuals as small as one inch T. L. were taken in gravel-bottomed riffles on 1 July, 1959.

Yearling individuals at the lower and middle Neosho stations showed a pronounced tendency to move into shallow, moderately fast water over rubble or gravel bottom at night, where they were nearly ten times more abundant than in daytime (Table 9). Adults probably have the same pattern of daily movement as yearlings, except that at night the adults move to deeper riffles. Bailey and Harrison (1948:135-136) demonstrated that channel catfish feed most actively from sundown to midnight. [Pg 388]

Channel catfish (especially two-year-olds and adults) were abundant on a rubble-riffle during the day in some collections at the lower Neosho station in 1959.

Table 7. Length-frequency of Channel Catfish from the Neosho River, 1957, 1958 and 1959. (Numbers in Vertical Columns Indicate the Number of Individuals of a Certain Size Collected on That Date.)

Length in inches	Nov. 2 1957	June 2 1958 (shallow riffle)	June 7 1958 (deep riffle)	Sept. 9 1958	Sept. 11 1959
1.5				1	
2.0	3				
2.5	13	2		1	2

3.0	4	11		3	4
3.5	3	21	7	1	14
4.0		11	12		9
4.5		4	10	1	
5.0		2	11	2	
5.5		1	7	26	
6.0				58	2
6.5			1	32	5
7.0				16	5
7.5			1	4	5
8.0					22
8.5					45
9.0					81
9.5					41
10.0					21
10.5					8
11.0					4
11.5					1
12.0					3
12.5					1
13.0					1

Near the end of the spawning season in 1959, I found spawning catfish at the lower Neosho station. Ripe females were taken between 9 June and 30 June, 1959; and, on 19 June I found a channel catfish nest with eggs (water temp. 79° F.). The nest-site was a hole in the base of a clay bank; the floor was clean gravel with a small mound of gravel at the entrance. The nest-opening, five to six inches in diameter, widened almost immediately into a chamber about two and one-half feet long and one foot wide. Normally the water was about six inches deep in the mainstream as it ran over a riffle adjacent to the catfish nest. When I put my hand into the opening the fish bit vigorously, but became quiescent when I stroked its belly. I then felt the rounded gelatinous mass of eggs on the bottom of the nest. On June 22 (water temp. 86° F.) the fish was removed, struggling, from the nest, and returned to the stream. The next day (23 June 1959, water temp. 84° F.) the eggs had hatched and the young were in a swarm in the nest. The adult did not attempt to bite but left as soon as I put my hand into the hole. [Pg 389]

Marzolf (1957:25) reports that young remain in the nest from seven to eight days after hatching. My seining records show a marked increase in abundance of small young-of-the-year on the first of July. Probably the time of hatching of the nest described above correlated well with hatches of other nests.

One and sometimes two channel catfish were found in other holes in the stream-bank or bottom. The fish occasionally attacked my hand vigorously, but at other times remained quiet or left without attacking. No other channel catfish eggs were found, although one hole under a rock in the middle of the river had one or two individuals in it each time it was checked until 11 July, 1959. A local fisherman informed me of his belief that these holes are occupied only in the spawning season.

Observations that I made in a pond owned by Dr. E. C. Bryan of Erie indicated that channel catfish, when disturbed in the early stages of guarding the eggs, either eat the eggs and abandon the nest or leave the nest exposed to predation by other animals. In the later stages of nesting, the fish, if removed, will return to guard the nest. After the eggs hatch the guarding response probably diminishes and the fish leaves the nest readily.

At the lower Neosho station, several "artificial" holes were dug into the clay bank and two pieces of six-inch pipe were forced into the bank. Nearly all these holes were occupied by catfish for a short period in June; many of the holes were enlarged, either by the current or by fish. I suspect that fish enlarged some holes, because in the spawning season several males were observed that had large abrasions atop their heads, around their lips, and to a lesser extent on their sides. These could have been caused by butting and scraping the sides, roof and floor of a hole. I found it possible to enlarge the holes by rapidly moving my hand while it was inside a hole.

The growth-rate of channel catfish in the Neosho was approximately the same at all stations, and the large 1957 year-class grew to an average size of about nine inches by mid-September, 1959 (Table 7). Channel catfish mature at a total length of 12 to 15 inches. Thus, most individuals of the 1957 year-class in the Neosho River probably will mature in their fourth or fifth summer (1960 or 1961 spawning season).

The sizes attained by young-of-the-year in 1957 differed in the two rivers. Six hundred and thirty-three young taken in the Marais des Cygnes River attained an average size of 4.7 inches (range two to six inches) by mid-September. (Age was determined by length-frequency and verified by examining cross-sections of fin-spines from the larger individuals). One hundred and fifty young from the Neosho River averaged 3.0 inches (range 2 to 3.7 inches) on 2 November. Gross examination of the riffle-insect faunas indicated a larger standing crop in the Neosho than in the Marais des Cygnes River. Thus, the slower growth of young channel catfish in the Neosho [Pg 390]

seemed not to be correlated with food supply. Bailey and Harrison (1948:125-130) found that young channel catfish in the Des Moines River, Iowa, fed almost exclusively on aquatic insect larvae. My observations indicate that this is true in the Neosho and Marais des Cygnes rivers also.

Young produced in 1958 in the Neosho River attained an average total length of three inches by 26 August, and young produced in 1959 attained an average size of 3.5 inches by 11 September. Both groups probably continued growth until October, and may have averaged four inches total length at that time.

The 1958 and 1959 year-classes were much less abundant than were the 1957 young. Therefore, it seems likely that the growth of the 1957 young in the Neosho River was depressed because of crowding. The 1959 year-class was larger than the small 1958 year-class, thus conforming to a general expectation that strong year-classes will be followed by weak year-classes.

Reproduction by channel catfish in 1957 seemed greater in the Neosho River than in the Marais des Cygnes River (Table 10); this coincided with a greater change in volume of flow in the Neosho River than in the Marais des Cygnes River (Tables 1-4). The 1957 year-class seemed more crowded, and grew more slowly, in the Neosho than in the Marais des Cygnes River.

Ictalurus natalis (LeSueur)
Yellow Bullhead

Yellow bullhead were taken only at the middle station on the Marais des Cygnes and upper station on the Neosho. The yellow bullhead is more restricted to streams than is the black bullhead. Both species decreased in abundance during a period of continuous flow (1957 to 1959) following drought at the upper Neosho station. Collections in 1958-'59 indicated an increase in average size. Of four individuals marked and released at the upper Neosho station in 1959, one [Pg 391] was recaptured about three hours after being released. It had not moved from the area of release.

Ictalurus melas (Rafinesque)
Black Bullhead

The black bullhead was abundant at the upper stations on each river, especially in backwaters having mud-bottom. The species was not taken in the mainstream of the lower and middle Neosho stations, but was taken at the middle Neosho station in a pond that is often flooded by the river. Although the fish was common or abundant in nearly all pools at the upper Neosho station, it was most abundant in one pool that had a bottom predominately of mud.

At the middle Marais des Cygnes station, 109 individuals were collected and fin-clipped on 8, 9 and 24 July 1957. Three of the 19 marked on 8 July were recaptured in the same area on 9 July. The area was poisoned on 13 September, 1957, and 130 black bullhead were taken, none of which had been marked.

In 1959, 96 black bullhead were taken at the upper Neosho station (five in Area 1 and 91 at the White Farm). In these collections, 25 were marked (fin-clipped or dyed) and six were recaptured. Four of the six had not left the area of capture one and two days after being released. The fifth fish recaptured was one of five individuals that had been displaced one pool downstream. When recaptured seven days later, this fish had moved upstream over two steep riffles (two to three inches deep, 75 feet and 166 feet long) past the site of original capture to the next pool. The sixth fish, marked at the same time but returned to the original pool, was recaptured nine days after original capture and had moved upstream over a long riffle (two to three inches deep, 166 feet long) and a short riffle into the second pool above the original site of its capture.

Rotenone was applied to a small (.04 acre-feet) backwater ditch having a soft mud bottom at the upper Marais des Cygnes station on 25 July, 1957; 1526 black bullhead, one green sunfish and one white crappie were collected. A sample of 60 bullhead averaged 4.6 inches T.L. (range 3.5 to 6.6 inches) and 540 individuals averaged .7 ounce each. These fish probably represented the 1956 year-class.

The upper Neosho station had a large population of black bullhead, strongly dominated by fish less than four inches T. L. (range 1.5 to 3.8 inches), in the spring of 1957. Most were approximately two inches T. L. and probably represented the 1956 year-class. Growth, according [Pg 392] to length-frequency, following restoration of stream-flow, shows a regular increase in length of this dominant 1956 year-class (Fig. 3). A scarcity of young, especially in 1958 and 1959, is apparent in Fig. 3. This may be due to the fact that a strong year-class usually is followed by one or several weak year-classes. However, it more probably reflects the fact that black bullhead are characteristically pond fish, and as such are not so well adapted to reproduction in flowing streams as are many other species. Metcalf (1959) found this species most abundantly in the intermittent headwaters of Walnut River and Grouse Creek in Cowley County, Kansas.

Fig. 3. Length-frequency of black bullhead at the upper Neosho station, 1957, 1958 and 1959.

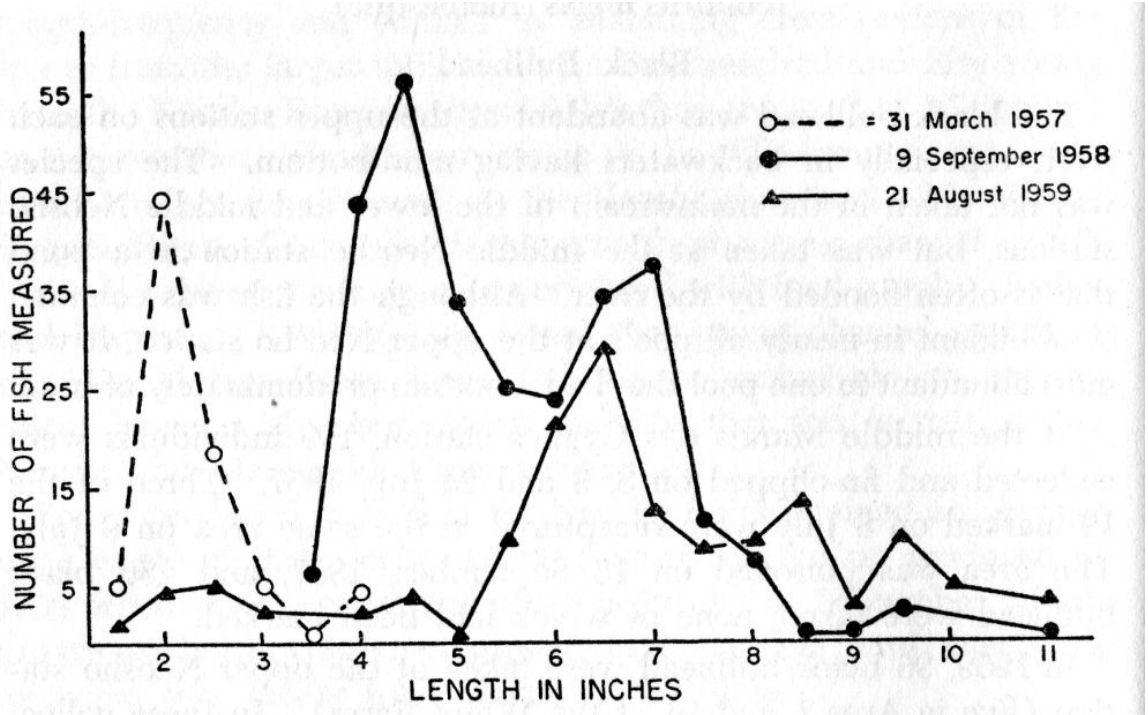

FIG. 3. Length-frequency of black bullhead at the upper Neosho station, 1957, 1958 and 1959.

Pylodictis olivaris (Rafinesque)
Flat-headed Catfish

The flathead is the largest sport-fish occurring in Kansas. Several weighing more than 40 pounds are caught from streams each year, and the species reportedly attains sizes in excess of one hundred pounds. Several aspects of the biology of the flathead in Kansas have been discussed by Minckley and Deacon (1959).

The abundance of flathead declined slightly from 1957 through 1959, counting fish of all sizes. This trend is attributable to a large hatch in 1957; the 1957 year-class strongly dominated the [Pg 393] population throughout my study. Natural mortality in that year-class was compensated by increased average size of the individuals (to six inches in autumn, 1958, and 11 inches in autumn, 1959).

The numbers of flathead caught at the upper stations on the Neosho and Marais des Cygnes rivers differed from the general trend in that the species was rare in 1957 and increased slightly by 1959. Flathead are most numerous in large streams, and in the drought they probably were almost extirpated from the headwaters. After 1957, continuous flow and increased volume of flow were accompanied by a gradual increase in numbers of flathead in the upstream parts of the two rivers. The species was most abundant at the middle and lower Neosho stations, where 10.5 per cent of all fish shocked in 1957 and 1958 were *P. olivaris*.

The habitat of the flathead varied with size of the individuals. Young-of-the-year inhabited swift riffles having rubble bottom; individuals four to 12 inches in total length were distributed throughout the stream; those more than 12 inches in total length were most commonly in pools in association with cover (rocks, or drifts of fallen timber).

Male flathead mature at 15 to 18 inches total length, females at 18 to 20 inches. The spawning season in 1959 probably began in early June and extended to mid-July. I attempted to find spawning fish on 19 June and for one month thereafter. On 19 June nine holes were dug into a 75-yard section of a clay bank adjacent to a long, shallow, rubble riffle. A flathead was first found in one of these holes on 22 June, and others were frequently found in this and one other hole until mid-July. Although channel catfish were often found in nearby holes, that species was never present in the two holes used by flatheads. The holes occupied by flathead (as well as those used by channel catfish) characteristically had silt-free gravel bottoms and a ridge of clean gravel across the entrance.

A nest containing a flathead and eggs was located on 11 July. In checking the hole I first put my foot into the entrance, then slowly advanced my hand into the hole, feeling along the bottom with my fingers until they entered the open mouth of a large catfish. I backed off slowly and then felt beneath the fish. The fish was directly above the egg-mass, seemingly touching the eggs with its belly. As I touched the front of the egg-mass the fish struck viciously, taking my entire fist into its mouth. It continued striking until I removed my hand from the hole after obtaining a small [Pg 394] sample of eggs, which proved to be in an early stage of development (no vascularization evident).

When the nest was checked again on 13 July the eggs and fish were gone. As in the case of channel catfish, I suspect that disturbance of a flathead in the early stages of guarding the nest

results in destruction of the nest either by the guardian fish or by predation resulting from its absence.

The hole occupied by the above fish was one that I had dug seven to nine inches in diameter and extending two and one-half to three feet into the bank. At the time this fish occupied the hole its depth was approximately the same as originally, but the entrance had been enlarged to 14 inches in diameter, and the chamber widened to 32 inches. The holes were checked later in the summer and all were heavily silted or had been undercut by action of the current.

The number of flathead of catchable size was not reduced as severely during my study as was the number of large channel catfish. Flathead have a longer life-span than channel catfish; therefore, it is not surprising that, of flathead and channel catfish that survived the drought, a higher proportion of flathead persisted throughout the next three years, in which my study was made. In drought, when fish were concentrated in residual pools, the piscivorous (fish eating) habit of flatheads may have favored their survival.

The growth rate of flathead taken from the Neosho River in 1957 and 1958 was reported by Minckley and Deacon (1959:351-352). Individuals hatched in 1955 and 1956 and collected in 1957 had attained average sizes of 9.5 inches and 4.8 inches, respectively, by the end of the 1956 growing-season.

Flatheads of the 1956 and 1957 year-classes attained average sizes of 8.7 and 3.2 inches, respectively, by the end of the 1957 growing season. These data indicate that growth was retarded in the summer of 1957. Many species, including *P. olivaris*, had an exceptionally large hatch in 1957, associated with increased water levels in that year. Despite the great increase in amount of water, I suppose that young-of-the-year and yearlings were subjected to crowding resulting from exceptional hatches. This caused reduction in growth of young flathead, and probably in several other species.

Food of flatheads 4.0 inches and shorter was nearly all insect larvae; that of fish 4.1 to 10 inches was insect larvae, fishes and crayfish; and that of larger flatheads was mostly fish and crayfish. [Pg 395] The specific kind of food eaten was correlated with abundance of the food item in the stream (Minckley and Deacon, 1959:350-351).

Noturus flavus Rafinesque
Stonecat

The stonecat was not taken at the upper Marais des Cygnes station, and was less abundant at the middle Marais des Cygnes station than at other stations. The abundance of the stonecat was greatest at the lower Marais des Cygnes station in 1957 and at the upper Neosho station in 1959. The species increased in abundance from 1957 to 1959 in the Neosho River, where the principal habitat was riffles over rubble bottom.

Thirty-three stonecats were marked at the upper Neosho station in 1959. Five of these were recaptured three hours after release, all near the point of release. One individual was taken from a riffle, fin-clipped, and released at the foot of the next riffle downstream. When recaptured four days later, this fish was still in the area of release. Young-of-the-year were taken on July 1, 1959, at the lower Neosho station.

Noturus gyrinus (Mitchill)
Tadpole Madtom

Trautman (1957:444-445) describes the habitat of the tadpole madtom as "low-gradient lowland streams, springs, marshes, oxbows, pothole lakes, and protected harbors and bays of Lake Erie, where conditions were relatively stable, the water was usually clear, the bottom was of soft muck which generally contained varying amounts of twigs, logs, and leaves, and where there usually was an abundance of such rooted aquatics as pondweeds and hornwort. The species seemed to be highly intolerant to much turbidity and rapid silting,..." The tadpole madtom was obtained only at the middle Marais des Cygnes station in a small, deep, mud-bottomed pool in 1957 after water levels, and probably turbidity, had been low for five years. The occurrence provides the westernmost record station in Kansas. Cross and Minckley (1958:106) reported the species from the lower part of the Marais des Cygnes in Kansas.

Noturus nocturnus Jordan and Gilbert
Freckled Madtom

The freckled madtom was taken only at the middle Neosho station on 19 April, 1958. This species occurs most frequently in small streams, and individuals living in the mainstream of the Neosho [Pg 396] probably are "strays" from nearby tributaries. This species may have utilized the mainstream as a refugium in the drought of 1952-'56.

Noturus exilis Nelson
Slender Madtom

The slender madtom was taken only at the middle Marais des Cygnes station in the fall of 1957. This species prefers permanent riffles of clear streams (Deacon and Metcalf, 1961:317). My specimen possibly strayed from a nearby tributary; or, it was a relict from a population living in the mainstream during drought.

Noturus sp.
Neosho Madtom

A description of this species, which is endemic to Neosho River, has been prepared but not yet published by Dr. W. Ralph Taylor. I found the Neosho madtom only at the middle station in 1958 and 1959, and at the lower station in 1959, where the species was common in shallow water having moderate current over clean gravel bottom. Specimens were most effectively collected by digging into the gravel above the seine and allowing the gravel to wash into the seine. In 1952, Cross (1954:311) found this species in abundance in riffles at the confluence of the South Fork and Cottonwood River, and at several other localities in the Neosho mainstream (personal communication). The Neosho madtom is nearly restricted to gravel riffles having moderate flow; therefore, it may be drastically reduced by intermittency of flow. I found none in 1957 and few in 1958. By 1959, the third summer of continuous flow, the Neosho madtom was again common.

Fundulus notatus (Rafinesque)
Black-striped Topminnow

The black-striped topminnow was rare in the mainstream at the lower Marais des Cygnes and the middle and lower Neosho stations, where it was found in quiet water near shore.

Near the middle Neosho station, a large population was present in an oxbow lake that is frequently flooded by the river.

Labidesthes sicculus (Cope)
Brook Silversides

The brook silversides occurred rarely at the lower Marais des Cygnes and at the middle and lower Neosho stations. [Pg 397]

Micropterus dolomieui Lacépède
Small-mouthed Bass

One individual was taken at the lower Neosho station in 1957.

Micropterus punctulatus punctulatus (Rafinesque)
Spotted Bass

The spotted bass occurs in Kansas only in the southeastern part of the state—in southern tributaries of the Osage system, in Spring River drainage, and in relatively clear streams of the Flint Hills. At my stations on the Neosho River, this fish was more abundant in 1957 than in 1958 or 1959.

Spotted bass were taken most frequently over rubble bottom or near boulders in moderate current. Collections made in the evening or early morning more often contained spotted bass than collections made at other times of day (Table 9). Data from a few specimens that were marked, released, and recaptured indicated that the species is relatively sedentary; therefore, the greater abundance in the morning and evening collections probably indicates increased activity during these periods, possibly in connection with feeding. The spawning season in 1957 may have continued as late as 10 July when a ripe female 11.3 inches T. L. was taken. Young-of-the-year were taken on 24 June in moderate current over gravel bottom and in quiet water over mud bottom.

Spotted bass normally form a small part of the game-fish fauna in the lower Neosho River. The species attains greater abundance in smaller, clear streams of the Arkansas River Basin in Kansas (Cross, 1954, and unpublished data of State Biological Survey of Kansas). During the drought, the lower Neosho probably assumed many characteristics of a smaller stream in normal times. Flow was reduced or entirely interrupted and turbidity was lessened. These conditions resulted in faunal changes in which spotted bass were more prominent than in years of normal flow. During this period of reduced flow, some fishermen turned from catfishing to bass-fishing; I think this constitutes evidence for an increase in numbers of bass, accompanied by a decrease in numbers of channel catfish. With the return of continuous flow and a consequent rise in turbidity, bass declined in abundance in the mainstream. [Pg 398]

Micropteras salmoides salmoides (Lacépède)
Large-mouthed Bass

The large-mouth was rare at all stations. It prefers quiet water near cover; to become abundant, the large-mouth probably requires clearer water than is afforded by most Kansas streams. This species, like spotted bass, declined in abundance during the period of study. Nevertheless, young-of-the-year were taken in 1957 and 1958 (earliest date of capture, 7 June in 1958).

Lepomis cyanellus Rafinesque
Green Sunfish

Green sunfish were taken at all stations, but most abundantly at the upper Neosho station where the number captured increased slightly from 1957 to 1959. Young-of-the-year and adults were most common in shallow backwater. At the upper Neosho station green sunfish inhabit quiet pools, where recaptures of marked fish indicated that the species is notably sedentary in habit. Hasler and Wisby (1958) have shown that green sunfish exhibit a homing reaction.

This fish provides some sport for fishermen, especially in the smaller streams, but I found few green sunfish that were larger than six inches T. L. at any station.

Lepomis megalotis (Rafinesque)
Long-eared Sunfish

Long-eared sunfish were taken at all stations but were notably more abundant in the Neosho River, where the largest population occurred at the upper station. In all three years of the study, large samples were obtained by means of rotenone in the same pool at the upper Neosho station. There were fewer long-eared sunfish present each year, and average size increased slightly. Collections in other pools at this station indicated that long-eared sunfish maintained a high level of abundance throughout my study.

Long-eared sunfish occurred in pools having bottoms of gravel or bedrock at the upper Neosho station, or near shore over rubble or gravel in slow to moderate current at the middle Neosho station.

Lepomis humilis (Girard)
Orange-spotted Sunfish

The orange-spotted sunfish occurred at all stations; it was most abundant in the Neosho River, especially at the uppermost station. This fish was taken in a variety of habitats, but was most [Pg 399] common in areas where the current was slack, often over mud or silt bottom.

Lepomis macrochirus Rafinesque
Bluegill

Bluegill were taken at all stations but were rare. This species occurred exclusively in pools, usually near cover (brush or trees in the water). Bluegill are predominately pond-fish in Kansas, and populations in rivers may consist partly of individuals that escaped from ponds in time of overflow. I know of no stream in Kansas that has a population large enough to contribute significantly to the sport fishery.

Pomoxis nigromaculatus (LeSueur)
Black Crappie

This species was represented by only one specimen, taken at the lower Neosho station in 1957.

Pomoxis annularis Rafinesque
White Crappie

White crappie were taken at all stations, but were common only at the upper and middle stations on the Marais des Cygnes and the upper Neosho station. At the last station, this fish was abundant in a single large pool that contained much more water during drought than any other area at this station. There was little dispersal into several smaller pools, below the large pool, which were sampled in 1957, 1958 and 1959. White crappie were not taken in the lower pools until 1959, and then were rare. Most crappie were taken in quiet water near cover or near shore.

Young-of-the-year were found in 1957, 1958 and 1959, but never abundantly. At the lower Neosho station in 1959, ripe individuals were collected on 19 June, a spent female on 24 June, and young-of-the-year on 1 July. The young were present in quiet, shallow water over mud bottom at the lower end of a gravel bar. Large white crappie (10-14 inches T. L.) were common at the middle and lower Neosho stations in 1957 and in April, 1958. Large fish were almost entirely absent from later collections. Average size, maximum size and abundance declined during the period of study.

Percina phoxocephala (Nelson)
Slender-headed Darter

The slender-headed darter was taken at all stations but was more abundant in the Neosho than in the Marais des Cygnes. The lower Marais des Cygnes, however, was the only station with a [Pg 400] relatively large population in 1957. Slender-headed darters were rare in the Neosho River in 1957 and did not become common until 1959.

The largest population was found at the upper Neosho station in 1959. This darter occurs most frequently in swift water over gravel bottom, but was taken in various habitats, including an intermittent pool at the upper Neosho station on 7 September, 1957.

At the middle and lower Neosho stations, considerably greater numbers were taken in June, July, and early August than in May or late August. The abundance in my collections diminished from a peak in early July, to scarcity in late August.

Young-of-the-year were taken at the lower Neosho station on 1 July, 1959 (and subsequently), in moderately fast water over gravel. On 21 August, 1958, a ripe female (eggs stripped easily) was the only slender-headed darter present in a collection from riffles at the middle Neosho station.

Percina caprodes (Rafinesque)
Logperch

Logperch were not taken in the Marais des Cygnes. They were rare in the Neosho, where they were taken most frequently at the upper station in water two to three feet deep, over gravel bottom, in moderate to slight current. This species was present in intermittent pools at the upper Neosho station in 1957.

Percina copelandi (Jordan)
Channel Darter

One specimen was taken at the lower Neosho station in 1959. Because no others ever have been found in the mainstream of the Neosho River, I suspect that my specimen is a "stray" from one of the smaller tributaries, where channel darters are locally common.

Etheostoma flabellare Rafinesque
Fan-tailed Darter

The fan-tailed darter is represented in my collections by one specimen, obtained in the mainstream of the Neosho River at the lower station in 1957. Records of this species in Kansas are almost confined to the smallest, clear, permanent streams of the southeastern part of the state. My specimen may represent a small population that retreated to the mainstream of the Neosho during drought. [Pg 401]

Etheostoma spectabile (Agassiz)
Orange-throated Darter

Orange-throated darters were common at the upper Marais des Cygnes and upper Neosho stations in 1959, rare at the middle and lower Neosho stations, and absent from the middle and lower Marais des Cygnes stations. The species was found almost exclusively on upstream riffles over gravel-rubble bottom. The population in the upper Neosho was decimated by drought, and the fish did not become common until the summer of 1959, the third year after resumption of normal stream-flow.

Deacon and Metcalf (1961:320) indicated that long periods of intermittency result in depletion or elimination of populations of the orange-throated darter in the Wakarusa River, Kansas. A limited number of orange-throated darters probably survived in the few permanent pools in the upper Neosho and provided the brood-stock necessary to repopulate this section of the stream.

Aplodinotus grunniens Rafinesque
Freshwater Drum

Drum were taken at all stations, but were most abundant at the middle and lower Neosho stations. A high level of abundance also was found in 1957 at the middle Marais des Cygnes station. The abundance of drum declined from 1957 to 1959, but the average size increased because of a dominant 1957 year-class that was moderately reduced by natural mortality in 1958-'59. Although the population was composed largely of young-of-the-year and adults in 1957, it was dominated by yearling individuals in 1958. By 1959 the number had declined considerably and the population consisted mostly of juveniles and adults. Fish of the 1957 year-class reached a length of approximately ten inches by mid-summer of 1959 (Table 8).

Adults were taken in a variety of habitats, but most often in quiet water. On the other hand, yearlings were extremely abundant in 1958 near shore in shallow, moderately fast water over rubble bottom at night. Drum were rare in the same areas in daylight (Table 9). Young-of-the-year occur in shallow, quiet water, usually over mud-bottom.

The freshwater drum matures at about 12 inches T. L. Ripe males were taken as late as 23 June 1959; however, the height of the spawning season probably is in May. [Pg 402]

Table 8. Length-frequency of Freshwater Drum from the Middle Neosho Station in 1957, 1958 and 1959.

Total length in inches	Aug. 19 1957	Aug. 19-26 1958	July 27-Aug. 4 1959
2		1	
3	1		
4	4		
5		1	
6		12	
7		21	1
8	3	14	2
9	3	3	2
10	4	6	6
11	2	4	1
12		2	
13			2
14			1

Table 9. Average Number of Individuals Captured per Hour, Using the Shocker, at Different Times of the Day and Night at the Middle Neosho Station in 1958. Numbers in Parentheses Indicate Total Number Captured.

Species	Morning 5 hours of effort expended 6:30 a.m. 12:30 p.m.	Afternoon 6 hours of effort expended 12:30 p.m. 6:30 p.m.	Early night 18 hours of effort expended 6:30 p.m. 12:30 a.m.	Late night 8 hours of effort expended 12:30 a.m. 6:30 a.m.
Long-nosed Gar	0	0.3 (2)	1.2 (21)	1.1 (9)
Short-nosed Gar	0.2 (1)	0	0.2 (3)	0.4 (3)
Gizzard Shad	0.2 (1)	0.3 (2)	0.1 (1)	0.1 (1)
Black Buffalo	0	0.2 (1)	0.1 (1)	0
Small-mouthed Buffalo	0.4 (2)	0.3 (2)	0.8 (14)	0.8 (6)
River Carpsucker	3.4 (17)	3.3 (20)	5.7 (102)	4.9 (39)
Redhorse	0	0.2 (1)	0.6 (10)	0.6 (5)
Carp	1.8 (9)	0.2 (1)	0.7 (12)	0.8 (6)
Channel Catfish	1.6 (8)	1.0 (6)	10.2 (183)	10.5 (84)
Flathead	2.2 (11)	1.3 (8)	2.4 (43)	3.6 (29)
Spotted Bass	0.4 (2)	0.5 (3)	0.3 (6)	0.1 (1)
Green Sunfish	0.2 (1)	0.2 (1)	0.2 (3)	0.1 (1)
Long-eared Sunfish	0	0	0.1 (2)	0.4 (3)
Orange-spotted Sunfish	0.2 (1)	0	0	0
White Crappie	0.2 (1)	0.2 (1)	0.2 (5)	0.4 (3)
Freshwater Drum	1.0 (5)	0.8 (5)	5.6 (101)	5.3 (42)
Number captured per hour	13.4	9.3	29.5	33.8

[Pg 403]

Table 10. Numbers of Fish Seen or Captured per Hour by Use of the Shocker. Excludes Fish Taken by Shocking into a Seine on Riffles; Young-of-the-year Channel Catfish and Flathead Catfish Predominated in Samples Taken by that Method.

Species	Marais des Cygnes River							
	Upper			Middle			Lower	
	1957	1958	1959	1957	1958	1959	1957	1958

Gar	.7	1.3	1.2	.6	2.7	...	2.2	9.4
Gizzard Shad	.9	.2	...	9.9	2.5	...	...	.5
Buffalo	2.0	3.7	.6	.8	2.0	...	5.7	6.4
River Carpsucker	4.0	4.9	.6	6.5	2.2	2.0	1.8	3.9
Shortheaded Redhorse	3.3	.9	.6	.8	.2	...	...	...
Carp	10.6	6.4	2.4	8.6	5.0	3.5	6.0	10.4
Black Bullhead	...	...	...	3.9	17.2	...	...	...
Channel Catfish	.5	.9	...	4.7	2.5	...	1.8	.7
Flathead	.2	...	2.4	.5	...	...	1.8	.5
Largemouth	1.0	...	...	.3	.2	...	...	...
White Crappie	1.7	5.1	.6	1.3	.7	...	...	.2
Freshwater Drum	.9	1.6	.6	24.5	2.2	...	.7	.2
Hours shocked	**4½**	**4½**	**1⅔**	**4**	**4**	**2**	**2⅚**	**4½**

	Neosho River					
	Middle			**Lower**		
	1957	**1958**	**1959**	**1957**	**1958**	**1959**
Gar	3.2	4.2	3.8	5.3	4.9	8.4
Gizzard Shad	.5	.2	.4	1.9	1.0	.4
Buffalo	2.9	1.8	1.2	6.2	.9	1.5
River Carpsucker	5.5	7.4	2.9	7.5	13.3	6.3
Shortheaded Redhorse	1.9	.6	1.6	.7	...	1.6
Carp	2.1	2.1	1.4	3.4	1.2	1.1
Channel Catfish	2.6	8.8	.9	107.0	.5	.7
Flathead	7.6	3.7	2.7	10.8	.2	1.2
Bass	1.6	.4	.1	.2	.2	.1
White Crappie	...	.9	.2	1.8	.7	.1
Freshwater Drum	3.9	3.3	.8	15.9	2.8	.7
Hours shocked	**5⅔**	**55⅚**	**48½**	**4⅙**	**4**	**16⅚**

Table 11. Number of Occurrences (Roman type) and Number Counted (*Italic type*) per Seining Unit. One Seining Unit Equals 30 Seine-Hauls (ten each with the 4-foot, 12-foot and 25-foot seine) of Which Six Randomly-chosen Hauls Were Counted. Dashes Signify That the Species Occurred in Uncounted Collections Only.

[Pg 404]

Species	**Marais des Cygnes stations**						**Neosho**	
	Upper		**Middle**		**Lower**		**Lower station**	
	1957	**1959**	**1957**	**1959**	**1957**	**1959**	**1957**	**1959**
Golden Shiner	...	...	—	...	...	...	...	...
Creek Chub	...	—	...	...	...	...	...	...
Silver Chub	...	...	...	...	—	...	...	...
Gravel Chub	...	...	...	...	...	...	...	3.0 *2.3*
Sucker-mouthed Minnow	—	6	...	3 *1*	...	1	2	10.0 *43.0*
Red-finned Shiner	...	...	...	1	2.5 *5.0*	2	...	4.7 *2.3*
Blunt-faced Shiner	...	...	—	...	...	...	...	...
Red Shiner	21 *6*	15	8 *4*	19 *22*	16.0 *69.0*	15 *22*	27 *1119*	20.0 *102.0*
Mimic Shiner	...	...	...	...	...	...	—	...
Ghost Shiner	7.5	1	...	1	9.5 *96.5*	2	17 *54*	11.7 *76*
Sand Shiner	—	7	...	8 *2*	1.5	3	...	1 *.3*
Mountain Minnow	...	...	...	...	...	...	12 *25*	9.3 *13.6*
Blunt-nosed Minnow	—	2	...	8	1.0 *.5*	1	6 *4*	14.0 *7.6*
Parrot Minnow	...	...	...	...	...	...	12 *6*	19.0 *28.6*
Fat-headed Minnow	10.5 *1.5*	4	5 *2*	7 *1*	...	...	...	8.3 *3.0*
Stoneroller	—	6	—	...	...	...	—	2.3 *1.0*
Black Bullhead	...	...	...	...	.5	...	...	...

Channel Catfish	4.5 *1.5*	2	1 *1*	13 *7*	5.0 *1.0*	10 *6*	12 *5*	6.3 *41.6*
Flathead	—	1	—	—	1.0	...	—	.3
Stonecat	...	...	—	...	6.0 *.5*	...	—	1.0
Neosho Madtom	...	...	...	...	...	...	...	3.3 *2.0*
Brook Silversides	...	...	...	...	.5 *1.0*	...	...	1.7
Black-striped Topminnow	...	...	...	...	1.0 *1.0*	2	...	1.0 *.7*
Spotted Bass	...	...	...	...	...	...	2	3.7 *.3*
Largemouth	...	...	1 *1*	3 *1*	...	...	1 *2*	...
Green Sunfish	9 *7.5*	8	9 *3*	17 *3*	11.0 *12.0*	3 *1*	7 *2*	10.0 *3.6*
Long-eared Sunfish	...	...	...	...	.5	...	6	4.3 *.7*
Orange-spotted Sunfish	4.5 *6*	—	2 *4*	3	2.5	...	12 *5*	12.0 *5.0*
Bluegill	1.5	1	...	6 *1*	3.5	1	1	.3 *.3*
White Crappie	...	...	4 *7*	4	...	...	...	...
Logperch	...	...	...	...	...	...	1	.3 *.7*
Slender-headed Darter	—	13	...	2	6.5 *15.0*	3 *1*	1	8.3 *3.0*
Orange-throated Darter	—	7	...	...	...	...	1	—
Seining units	⅔	1	1	1	2	1	1	3

[Pg 405]

FISH-FAUNA OF THE UPPER NEOSHO RIVER

Collections at the upper Neosho station were more intensive than at any other station, especially in 1959. Rotenone was used in the summers of 1957, 1958 and 1959, to obtain large samples of the population in one section of the stream. In September, 1959, the shocker was used in other sections in order to estimate populations in particular pools and riffles, to measure variability in the fauna between areas having slightly different habitat, and to record movement of marked individuals in a short section of the stream.

Description of Study-areas

Two sections of the stream, each about one-half mile long (See p. 366), were studied. Additional description of particular areas is presented below. Area 1 and the pools in which rotenone was used are on the Bosch Farm approximately two miles upstream from the White Farm where Areas 2, 3, 4, 5, 6 and 7 are situated.

Area 1 has a length of 210 feet, an average width of four feet, and a maximum depth of two feet. The upper half is a swift, rubble riffle four inches in average depth; the lower half is one and one-half feet in average depth and has a slow current (Pl. 29, Fig. 1). [Pg 406]

Area 3 has a length of 186 feet, an average width of 34 feet, and a maximum depth of two and one-half feet. This area includes a shallow riffle at both upstream and downstream ends of a pool 73 feet long and approximately one foot in average depth (Pl. 29, Fig. 2).

Area 5 has a length of 250 feet, an average width of 50 feet, and a maximum depth of two and one-half feet. This is a shallow, quiet pool over rubble and bedrock bottom except for a small area of mud bottom (backwater) above the point where a short riffle drains into this pool from Area 6 (Pl. 30, Fig. 1).

Area 6 has a length of 200 feet, an average width of 50 feet, and a maximum depth of one and one-half feet. This is a shallow, quiet pool over bedrock bottom, except for a small area of mud bottom at one side of the upper end of the pool. A short, steep, rubble-riffle is included in this area at the upstream end (Pl. 30, Fig. 2).

Areas 2, 4, and 7 resemble at least one of the areas described above but were sampled less intensively. Data from areas 2, 4, and 7 are included in discussion of the total fauna of the upper Neosho river but are excluded from the discussion of representative parts of that fauna.

Methods

Rotenone

Rotenone was applied to an intermittent pool in 1957. In 1958 and 1959 rotenone was applied to the upper end of a pool and mixed by agitating the water. The concentration in the pool was maintained by slowly introducing part of the rotenone into the riffle at the head of the pool. This was the most effective means of obtaining a large sample of fish from the deeper, slowly flowing water of the upper Neosho. Pools in which rotenone was used had areas of as much as one-half acre and depths in excess of six feet.

Shocker

In 1959 the shocker was used extensively in several areas of the upper Neosho. Because of the small size of the stream, "tennis-racket" electrodes were used effectively by two men—one carrying the electrodes and one picking up fish and placing them in a live-box. In fast water, many fish floated into a seine placed across the lower end of the area. A large segment of the population was collected in this manner. Areas in which fish were collected by means of the shocker included riffles, and pools having flowing water no more than three feet in maximum depth. The bottom-type was usually gravel, rubble or bedrock, but a small amount of mud bottom was present in many pools.

Because of the necessity of wading, we could not use the shocker effectively in water more than three feet deep. In addition, turbidity of the water prevented effective collection of stunned fish in the deeper pools. Therefore, rotenone was more effective in deep water than was the shocker. In shallow, swift riffles and pools, the shocker yielded more reliable samples than did rotenone, because of difficulty in maintaining adequate concentrations of rotenone where flow was swift.

The relative abundance of each species in the upper Neosho was calculated from cumulative results obtained by use of the shocker in seven areas in 1959. Population estimates were made by collecting fish with the shocker, marking them by clipping fins or staining them in Bismark Brown Y at a concentration of 1:20,000 (Deacon, 1961), returning them to the stream, and making a second collection three hours (Areas 1 and 3) or 24 hours (Area 6) later. The same area was shocked again within two to eight days. Collections throughout the one-half-mile section yielded information on movement. [Pg 407]

Changes in the Fauna at the Upper Neosho Station, 1957 Through 1959.

The following discussion is based principally on collections made with rotenone in 1957, 1958 and 1959 (Table 12). Other supplementary data aid in understanding the changes that occurred after the resumption of normal flow at the upper Neosho station.

The population in 1957 was strongly dominated by black bullhead and young-of-the-year channel catfish. Other common species were long-eared sunfish, red shiner, yellow bullhead, orange-spotted sunfish and green sunfish. This fauna, with the exception of young-of-the-year individuals, was a fauna produced during the years of drought. Deacon and Metcalf (1961:318-321) found a similar fauna in streams of the Wakarusa River Basin that had been seriously affected by drought.

The black bullheads taken in 1957 were predominately yearlings. It is likely that by 1956 the total fish population in the upper Neosho had been decimated by drought. The ponded conditions prevalent in that year were conducive to production and survival of young black bullheads. Fig. 3 shows that this dominant 1956 year-class reached an average length of approximately 6.5 inches by August, 1959.

Reproduction by black bullheads was limited in 1957, 1958, and 1959, and slight reduction in relative abundance occurred from 1957 to 1958. The relative abundance in 1959 remained nearly stable. If stream-flow remains essentially continuous for the next few years, the number of black bullheads probably will decline as individuals of the 1956 year-class reach the end of their life-span.

Reference has been made to the large hatch of channel catfish in 1957, in a discussion of that species. Conditions for survival of young channel catfish at the upper Neosho station in 1957 were good because there was continuous flow over many gravel-rubble riffles, which were largely unoccupied by other fish, in the spring and summer of 1957. [Pg 408]

Table 12. Percentage-composition of the Fish-fauna at the Upper Neosho Station in 1957, 1958 and 1959, as Computed from Collections Obtained by Using Rotenone.

Species	1957	1958	1959
Big-mouthed Buffalo.....	.....	T[D]	T
Small-mouthed Buffalo.....	.....	.....	T

River Carpsucker.....	T	0.8	1.8
Golden Redhorse.....	T	3.0	5.7
Creek Chub.....	.....	T	0.8
Red-finned Shiner.....	1.3	3.0	0.8
Red Shiner.....	6.5	13.1	12.1
Ghost Shiner.....	T	T	.....
Blunt-nosed Minnow.....	T	T	T
Fat-headed Minnow.....	T	T	1.4
Stoneroller.....	0.8	1.5	3.5
Black Bullhead.....	40.8	30.5	32.0
Yellow Bullhead.....	5.3	8.8	2.5
Channel Catfish.....	28.4	15.5	18.5
Flathead.....	T	T	T
Stonecat.....	T	T	1.4
Spotted Bass.....	T	T	0.8
Largemouth.....	T	T	T
Green Sunfish.....	3.1	6.8	6.4
Long-eared Sunfish.....	8.8	3.7	1.9
Orange-spotted Sunfish.....	3.1	8.9	2.5
Bluegill.....	T	T	T
White Crappie.....	T	.....	T
Logperch.....	T	2.1	0.8
Slender-headed Darter.....	0.6	0.6	3.1
Orange-throated Darter.....	.....	T	2.5
Total number of fish.....	786	965	513
Size of sample-area in acre-feet..	.002	.33	.33

Channel catfish also showed a slight decline in relative abundance after 1957, resulting from mortality in the 1957 year-class. With continuous flow, channel catfish will probably remain abundant, although annual reproductive success probably will be less than in 1957.

The big-mouthed buffalo, small-mouthed buffalo, creek chub and orange-throated darter were not taken in 1957, but appeared in collections in 1958. The river carpsucker, golden redhorse, red shiner, fat-headed minnow, stoneroller, stonecat, and slender-headed darter also increased in abundance between 1957 and 1959. The increased abundance of all these species in 1958 and 1959 resulted in a more diversified fauna, with lesser predominance by any single species, than in 1957 (Table 12); this change is related to the increased, permanent flow in 1958 and 1959. [Pg 409]

Local Variability of the Fauna in Different Areas at the Upper Neosho Station, 1959

The shallow areas in which the shocker was used in 1959 are the prevalent habitat in the upper Neosho River. The relative abundance of fishes found in these areas is presented in Table 13. The red shiner was most abundant and was followed (in decreasing order) by long-eared sunfish, minnows of the genus *Pimephales*, green sunfish, red-finned shiner, channel catfish, and stoneroller. Other species combined comprise less than ten per cent of the population.

Table 13 also shows the variability in relative abundance of different species among areas that have the same general kind of habitat. The species composition is similar in all areas. The sample obtained with rotenone in 1959 is included in Table 13 to show differences in the fauna of deep, slowly flowing areas and shallower areas with stronger current. The differences in relative abundance indicate the kind of habitat that each species is able to utilize most fully.

Golden redhorse and black bullhead were most abundant in large, deep, quiet pools (5.7 per cent and 32 per cent of the total population) and were more abundant in Area 5 (3.2 per cent and 7.3 per cent respectively) than in any of the other shallow areas. Area 5 has greater average depth, more mud bottom, and less riffle area than areas 1, 3 and 6.

The golden redhorse and black bullhead have specific habitat preferences that are not evident in the above discussion. My collections indicate that the golden redhorse prefers deep water having some current, whereas the black bullhead prefers little or no current.

Species that prevailed in or near riffles were: creek chub, sucker-mouthed minnow, stoneroller, channel catfish (young-of-the-year only), flathead (young-of-the-year only), stonecat, slender-headed darter, and orange-throated darter. Of these species, the sucker-mouthed minnow, slender-headed darter and orange-throated darter reached their greatest abundance at Area 3, where the riffle is shallow, slow, and has a bottom composed of flat limestone rubble.

The riffle at Area 1 is, for the most part, deeper and faster than at Area 3 and has a bottom composed of gravel and small rocks. The creek chub, stoneroller, channel catfish (young-of-the-year), flathead (young-of-the-year), and stonecat reached their greatest abundance in Area 1. All [Pg 410] species that showed a preference for riffles were rare or absent in Area 5 where no riffle-habitat was sampled. The riffle-dwelling species that were present in collections made with rotenone in

the deeper pools were taken from the riffle into which rotenone was introduced.

Table 13. Relative Abundance of Fish (Per Cent of Total Population Made Up by Each Species), in the First Collection Made in Each of Four Different Shallow Areas by Means of the Shocker, is Shown in Vertical Columns 1-4. Results of the Use of Rotenone in a Fifth, Deeper Area are Shown in Column 5. Column 6 Combines Data from All Collections Made by Using the Shocker in Seven Shallow Areas (Including Columns 1-4).

	Area 1	Area 3	Area 5	Area 6	Rotenone	All areas
Big-mouthed Buffalo	....	....	T[E]	....	T	T
Small-mouthed Buffalo	....	....	.6	....	T	T
River Carpsucker	....	T	10.6	T	1.8	.8
River Carpsucker (yy)[F]	....	.8	T	3.7	....	1.0
Short-headed Redhorse	....	....	.6	....	....	T
Golden Redhorse	.8	1.0	3.2	....	5.7	T
Carp	....	....	....	....	....	T
Golden Shiner	....	....	....	....	....	T
Creek Chub	1.6	T	T	T	.8	T
Sucker-mouthed Minnow	....	11.2	T	3.4	....	1.4
Red-finned Shiner	....	....	....	4.0	.8	8.1
Red Shiner	18.2	24.0	7.8	20.1	12.1	35.9
Sand Shiner	....	5.2	....	1.1	....	T
Pimephales (yy)	....	....	....	....	....	6.7
Mountain Minnow	....	....	....	T	....	T
Blunt-nosed Minnow	....	.8	4.1	11.7	T	3.4
Parrot Minnow	....	....	....	....	....	T
Fat-headed Minnow	T	T	3.4	12.1	1.4	2.6
Stoneroller	27.7	17.4	.6	5.8	3.5	5.1
Black Bullhead	2.1	T	7.3	T	32.0	.6
Yellow Bullhead	T	T	....	T	2.5	T
Channel Catfish (j)[G]	5.8	7.6	41.3	T	14.6	4.2
Channel Catfish (yy)	9.5	7.0	T	4.3	3.9	2.5
Flathead (j)	....	.8	2.1	T	T	T
Flathead (yy)	1.6	T	....	....	....	T
Stonecat	10.3	1.4	....	....	1.4	.7
Spotted Bass	....	T	.6	T	.8	T
Largemouth	....	....	T	....	T	T
Green Sunfish	11.2	3.5	5.9	12.2	6.4	10.1
Long-eared Sunfish	5.4	6.0	5.1	14.6	1.9	12.8
Orange-spotted Sunfish	T	T	1.4	1.8	2.5	.5
Bluegill	....	....	1.0	....	T	T
White Crappie	....	....	....	....	T	T
Logperch	T	T	T	T	.8	T
Slender-headed Darter	T	11.4	1.1	1.6	3.1	1.3
Orange-throated Darter	.8	1.8	T	.5	2.5	T
Freshwater Drum	....	....	T	....	....	T
Total number of fish	242	484	727	924	513	17,796
Area in square feet	840	6324	12500	10000	....	....
Volume	....	....	....	....	⅓ acre-foot	

The river carpsucker, blunt-nosed minnow, fat-headed minnow, channel catfish (yearlings and two-year-olds), flathead (yearlings and two-year-olds), green sunfish and long-eared sunfish showed a preference for shallow, quiet water. All of these species were more common in collections from Areas 5 and 6 than in collections from other areas. [Pg 411]

Temporal Variability of Fauna in the Same Areas

The variability of the population in successive collections from the same area is presented in Table 14. Supplementary data obtained in Areas 2, 4 and 7 support conclusions discussed below for Areas 1, 3 and 6. The abundance of some species maintained a constant level, whereas that of others varied.

Table 14. Numbers of Individuals Collected by Means of

THE SHOCKER AT VARYING INTERVALS IN SEPTEMBER, 1959.
THE NUMBER AT THE TOP OF EACH COLUMN IS THE DATE WHEN
THE COLLECTION WAS MADE.

SPECIES	Area 1			Area 3			Area 6		
	3	4	8	9	10	15	16	18	20
Golden Redhorse	2	2	...	5	5	2	...	...	3
Creek Chub	4	3	7	1	...	...	1	2	...
Sucker-mouthed Minnow	...	...	...	54	42	25	31	7	6
Red-finned Shiner	...	...	1	...	...	4	31	13	4
Red Shiner	44	7	211	117	170	438	186	209	62
Blunt-nosed Minnow	...	...	...	4	10	19	108	91	13
Fat-headed Minnow	1	...	...	1	2	3	112	156	48
Stoneroller	67	39	49	84	107	55	54	67	22
Black Bullhead	5	...	1	2	1	...	...	3	7
Yellow Bullhead	1	1	...	2	1	...	1	...	3
Channel Catfish	14	7	...	36	16	...	3	1	23
Channel Catfish(yy)[H]	23	16	17	34	34	22	40	23	28
Flathead	...	...	...	4	8	1	2	...	1
Flathead(yy)	4	1	1	2	1	1	...	...	...
Stonecat	25	8	12	7	7	5	...	...	...
Green Sunfish	27	17	12	13	16	17	62	62	74
Long-eared Sunfish	13	12	1	6	3	3	10	22	31
Logperch	1	...	...	2	...	...	...	...	...
Slender-headed Darter	...	1	2	55	45	23	15	1	1
Orange-throated Darter	2	1	2	9	11	8	5	...	1
Total	**233**	**115**	**316**	**438**	**480**	**626**	**661**	**657**	**347**

Stoneroller, channel catfish (young-of-the-year), green sunfish, and long-eared sunfish formed the most stable element of the population, in that the numbers of these species varied less in successive collections than did numbers of other species. [Pg 412]

The number of orange-throated darters remained constant at Areas 1 and 3, and the number of stonecats changed little in successive collections from Area 3. I suspect that an apparent decline in stonecats at Area 1 on September 4 was due to a slow rate of dispersal from the point of release (see pages 413, 414).

Some species (sucker-mouthed minnow, red-finned shiner, slender-headed darter, and fat-headed minnow) decreased significantly in successive samples from the same area because of mortality in handling or movement out of the area of initial capture.

The decrease in abundance of the sucker-mouthed minnow may have been due to some mobility of the species. Evidence for mortality caused by handling was obtained for the red-finned shiner and probably accounts for the reduction of this species in Area 6. The red-finned shiner is also probably a mobile species. The reduction in abundance of the slender-headed darter seems unexplainable because no evidence was obtained for either movement or mortality.

Fat-headed minnows also declined markedly in successive collections from Area 6, the only area in which the species was common. No marked fat-headed minnows were taken outside the area of release, indicating low mobility of the species. I cannot certainly account for their decline; possibly there was latent mortality due to shocking.

The numbers of red shiners, blunt-nosed minnows, and juvenile channel catfish varied erratically in successive collections, probably as a result of movement. This problem is discussed for all species in a later section.

Population-Estimation

The direct-proportion method was used to estimate fish populations in Areas 1, 3 and 6. Reliable results could not be obtained for all species because of scarcity, mortality in handling, mobility, or other factors.

A high rate of mortality due to handling was observed in Area 1 for the red shiner and in Area 6 for river carpsucker (young-of-the-year), sucker-mouthed minnows, red-finned shiner, red shiner, blunt-nosed minnow, and stoneroller. In Area 3, in contrast, there was little mortality in the same species during the twelve-hour interval that fish were held in traps prior to release as marked individuals. [Pg 413]

The following species were common in at least one area, but probably are sufficiently mobile (see page 416) to invalidate estimates of static populations in small areas: red shiner, red-finned shiner, and channel catfish (yearlings and older). Other species were rare and are indicated as "T" in Table 13.

Those species for which population-estimates seem warranted include: golden redhorse, sucker-mouthed minnow, red shiner, sand shiner, fat-headed minnow, stoneroller, stonecat, channel catfish (young-of-the-year), green sunfish, long-eared sunfish, slender-headed darter, and orange-throated darter. I consider the estimate valid if a high percentage of the marked fish is recaptured. Results are presented in Table 15, and ordinarily will not be referred to in the following discussion of the population in each of the three areas.

Area 1

The order of abundance at Area 1, in terms of the estimated population per 500 square feet, was as follows: stoneroller (47.6), stonecat (29.4), channel catfish (young-of-the-year) (20.6), green sunfish (19.4), red shiner (18.2), long-eared sunfish (9.4), channel catfish (yearlings and older) (6.5), golden redhorse (1.2). Insufficient data make inclusion of other species unreliable.

A comparison of the order of abundance between the estimated total population and the percentage composition in the first collection from each area shows significant correlations. The percentage-composition of the fish fauna at Area 1 was calculated as follows: stoneroller (27.7%), red shiner (18.2%), green sunfish (11.2%), stonecat (10.3%), channel catfish (young-of-the-year) (9.5%), channel catfish (yearlings and older) (5.8%), long-eared sunfish (5.4%), golden redhorse (0.8%). It can be seen that the stoneroller, green sunfish, long-eared sunfish and golden redhorse follow each other in the same order in both calculations. The stonecat is shown to be more common than channel catfish (young-of-the-year) in both calculations, but both species appear to be more abundant than green sunfish and red shiner in calculations of the total population and less abundant in the percentage-composition in the first collection. I think that the order of abundance as shown by percentage-composition is the more accurate figure for Area 1. The abundance of the red shiner is known to have been affected by mortality in collecting. Furthermore, as will be shown later, the species is so mobile that its abundance often changes markedly in a short time. Therefore, it is not surprising to find the red shiner in widely varying positions of relative and absolute abundance. However, the green sunfish maintains stable populations and should remain in about the same position of abundance in relation to other species (such as the stonecat and channel catfish young-of-the-year) that also maintain stable populations. The differences in order of abundance obtained by the two methods for green sunfish and channel catfish young-of-the-year are not great. However, in the estimation of total population the abundance of the stonecat seems significantly greater, in relation to other species, than in the calculation of percentage-composition. I believe that this difference can be attributed to the relatively low number of marked fish recaptured, which is probably due to a slow rate of dispersal from the point of release. Stonecats were released in relatively quiet water, and if they remained there they might be missed in subsequent collections, because they lack air-bladders and tend to remain on the bottom when shocked. Therefore, the calculated total population of the stonecat in Area 1 may be too high. [Pg 414]

Table 15. Data Used in Estimating Total Populations, by Direct Proportions, in Areas 1, 3, and 6 at the Upper Neosho Stations.

Species	Number captured first collection			Number marked and released			Number captured second collection			Number of marked fish recaptured			Estimated total population			Percent of marked fish recovered			Number per 500 square feet		
	1	3	6	1	3	6	1	3	6	1	3	6	1	3	6	1	3	6	1	3	6
Golden Redhorse	2	5	0	2	5	0	2	5	0	2	5	0	2	5	0	100	100	—	1.2	.4	0
Sucker-mouthed Minnow	0	54	31	0	51	15	0	42	12	0	17	0	0	126	—	—	33	0	0	10.0	—
Red Shiner	44	116	186	22	106	86	7	165	202	5	18	14	31	972	1284	23	17	11	18.2	77.1	64
Sand Shiner	0	25	10	0	25	7	0	35	10	—	12	1	0	73	—	—	48	—	0	5.8	—
Blunt-nosed Minnow	0	4	108	0	3	28	0	10	91	0	1	8	0	—	319	—	33	28	0	—	16
Fat-headed Minnow	1	1	112	1	1	101	0	2	156	0	0	19	—	—	830	0	0	19	—	—	41.5
Stoneroller	67	84	54	58	79	33	39	107	67	28	35	8	81	242	276	48	44	24	47.6	19.2	13.8
Channel Catfish (j)	14	37	3	9	32	3	7	16	1	6	13	0	11	39	—	67	41	0	6.5	3.1	—

[I]																					
Channel Catfish (yy)[J]	3	34	40	22	33	39	16	34	23	10	11	1	35	102	—	45	33	3	20.6	8.1	—
Stonecat	25	7	0	25	7	0	8	7	0	4	1	—	50	—	0	16	14	—	29.4	—	0
Green Sunfish	27	[K]—	62	27	—	62	17	—	62	14	—	22	33	—	175	52	—	35	19.4	—	8.8
Long-eared Sunfish	13	6	10	13	6	10	12	3	22	10	3	6	16	6	37	76	50	60	9.4	.5	1.9

Area 3

The order of abundance of the species at Area 3, in terms of the estimated population per 500 square feet, was as follows: red shiner (77.1), stoneroller (19.2), sucker-mouthed minnow (10.0), channel catfish (young-of-the-year) (8.1), sand shiner (5.8), channel catfish (yearlings and older) (3.1), long-eared sunfish (0.5), golden redhorse (0.4). Insufficient data make inclusion of other species unreliable.

For comparison with the estimates of total population, the percentage-composition in the first collection gives the following results: red shiner (24.0%), stoneroller (17.4%), sucker-mouthed minnow (11.2%), channel catfish (yearlings and older) (7.6%), channel catfish (young-of-the-year) (7.0%), long-eared sunfish (6.0%), sand shiner (5.2%), and golden redhorse (1.0%). [Pg 415]

For the most part, the species have the same order of abundance in both methods of analysis. Those that are apparently out of order are channel catfish (yearlings and older) and long-eared sunfish. The first species is mobile (excepting young-of-the-year) and commonly fluctuates widely in numbers in the same area; the second species was treated differently in that only adults were considered in the population-estimation whereas both young and adults were considered in calculating percentage-composition. (I found that I could not confidently distinguish between young-of-the-year of green sunfish, long-eared sunfish and orange-spotted sunfish after staining.)

Area 6

The order of abundance of the species at Area 6, in terms of the estimated population per 500 square feet, was as follows: red shiner (64.0), fat-headed minnow (41.5), blunt-nosed minnow (16.0), stoneroller (13.8), green sunfish (8.8), long-eared sunfish (1.9). Insufficient data make inclusion of other species unreliable.

Calculations of percentage-composition give the following results: red shiner (20.1%), long-eared sunfish (14.6%), green sunfish (12.2%), fat-headed minnow (12.1%), blunt-nosed minnow (11.7%), stoneroller (5.8%). The two species of sunfish form a more significant part of the population in the latter analysis because young are included. Only adults were considered in the estimation of total population. [Pg 416]

The fact that estimates of the total population and the percentage-composition agree in most respects lends support to the validity of both methods of analysis. It should be re-emphasized that differences in the order of abundance in the various areas reflect the ability of each species to utilize each particular kind of habitat.

Movement of Marked Fish

Table 16. Data on Movement of Marked Fish at the Upper Neosho Station, September, 1959.

Species	Number marked	Number recaptured	Number moved upstream	Number moved downstream
Golden Redhorse	24	16	0	2
Sucker-mouthed Minnow	68	27	7	0
Red-finned Shiner	74	0	0	0
Red Shiner	1326	152	48	25
Blunt-nosed Minnow	136	32	1	10
Fat-headed Minnow	151	40	0	0
Stoneroller	177	90	1	0
Black Bullhead	25	6	2	0
Channel Catfish (j) [L]	294	36	4	7

Channel Catfish (yy)[M]	145	34	2	0
Stonecat	33	6	0	0
Green Sunfish	124	68	1	0
Long-eared Sunfish	33	21	0	0
Slender-headed Darter	70	1	0	0
Orange-throated Darter	13	0	0	0

Some measure was gained of the amount of movement exhibited by several species of fish. Results are biased in favor of a conclusion that a species is sedentary because a large percentage of the recaptures were made in collections taken in the same immediate area three hours after release of marked fish, the total area checked was not large (one mile), and collecting was limited to an eleven-day period. Nevertheless, some species were shown to be definitely mobile and others exhibited pronounced sedentary tendencies. The results of experiments on movement are presented in Table 16. Marked fish (dyed and fin-clipped) were taken as long as seven days after being marked. Only those species in which more than ten individuals were marked are included. [Pg 417]

Blunt-nosed minnow, red shiner, and channel catfish (yearlings and older) are more mobile than other species.

The mobility of channel catfish has been discussed by Muncy (1958) and Funk (1957). My records show that of 36 marked channel catfish that were recaptured, 11 were taken in areas other than the one into which they had been returned. A pronounced mobile tendency on the part of the red shiner and blunt-nosed minnow is shown by the fact that of 152 marked red shiners recaptured, 73 had moved from the area of release; and of 32 marked blunt-nosed minnows recaptured, 11 had moved from the area of release. The fact that the habitat occupied by these species is not precise (ranging from swift riffles to quiet pools) supports a conclusion that the species are mobile.

The fat-headed minnow, stoneroller, channel catfish (young-of-the-year), green sunfish and long-eared sunfish form a sedentary element of the population. With the exception of the fat-headed minnow, the sedentary group also maintained relatively stable numbers in Areas 1, 3 and 6 throughout the study (Table 14). It is interesting to note that, in contrast to the mobile group, the species forming the sedentary group have rather well-defined habitat preferences.

A third group of species, represented by the red-finned shiner, stonecat, slender-headed darter and orange-throated darter, was characterized by having a low rate of recapture. I suspect that mortality is a factor contributing to the failure to recapture red-finned shiners, because in one collection only four of 31 red-finned shiners captured were successfully marked and released, in another case 70 of 818. The red-finned shiner occurs most often in pools but is also taken in other areas, is pelagic, and probably is a mobile species.

The stonecat, slender-headed darter and orange-throated darter are generally restricted to riffle-habitats, and are probably sedentary. The low number of recaptures for these three species probably is due either to a slow rate of dispersal from the point of release or to latent mortality resulting from shock. Table 14 shows that these three species maintain comparatively stable populations, but there seems to be a tendency for a reduction in numbers with continued collecting, even though all fish captured were returned to the stream.

Golden redhorse showed a high rate of recapture. All individuals marked were recaptured three hours after release in Areas 1 (two fish) and 3 (five fish). Nine individuals were taken from Area 4 [Pg 418] on 11 September; seven of these were marked and released in the next pool downstream (Area 3). On 15 September, two fish were retaken in Area 3 and two were retaken in Area 2, the next pool downstream. The species was common in Area 5 also where five of eight marked individuals were recaptured two days after release. It seems that the golden redhorse is somewhat restricted in movement, at least for short periods.

The sucker-mouthed minnow and black bullhead showed some movement—less than such mobile species as red shiners and channel catfish, but more than the sedentary group. Seven of 27 marked sucker-mouthed minnows were taken in areas adjacent to the one to which they had been returned. Two of six black bullheads that were recaptured had moved. The black bullhead moved the greater distance. The extent of short-term movement by several of the species in the Upper Neosho correlates well with redistribution subsequent to drought in the Wakarusa River, discussed by Deacon and Metcalf (1961).

Similarity of the Fauna at the Upper Neosho Station to the Faunas of Nearby Streams

The fauna that I found to be characteristic at the upper Neosho station has affinity with the upland tributary-fauna described by Metcalf (1959) for Chautauqua, Cowley and Elk Counties, Kansas. The primary difference is a nearly complete absence at my station of the Ozarkian element of the population. Some species (red-finned shiner, long-eared sunfish, and spotted bass)

listed by Metcalf as characteristic of the mainstream of smaller rivers occur at the upper Neosho station in greater abundance then elsewhere in the Neosho. This difference is probably due to the fact that the upper Neosho station is somewhat larger and slightly more turbid than Metcalf's "upland tributaries."

Hall (1952) reported on the distribution of fishes in the vicinity of Fort Gibson Reservoir, an impoundment on the Grand (Neosho) River in Oklahoma. He separated the fishes into three groups according to habitat-preference: species restricted to upland tributaries on the east side of Grand (Neosho) River, species restricted to lowland tributaries on the west side of Grand (Neosho) River, and species occurring in the Grand River proper and/or tributaries on one or both sides.

Several species found in the upper Neosho River also occur in the area studied by Hall. Of these, only the creek chub was restricted to upland tributaries on the east side of Grand (Neosho) River. [Pg 419] The sucker-mouthed minnow and red-finned shiner were restricted to the lowland tributaries on the west side of Grand (Neosho) River in the Fort Gibson Reservoir Area. Golden redhorse, stoneroller, yellow bullhead, spotted bass, green sunfish, long-eared sunfish, and orange-throated darter were present in collections from the Grand River proper and/or tributaries on both sides of the river, most commonly in tributaries.

Hall's data show that black bullhead, large-mouthed bass, white crappie, and logperch occurred most frequently in or near the quiet water of the reservoir. In my study these fish were most common in the larger, quiet pools at the upper Neosho station.

COMPARISON OF THE FISH FAUNAS OF THE NEOSHO AND MARAIS DES CYGNES RIVERS

The Marais des Cygnes River has less gradient (especially in the upstream portions), fewer and shorter riffles, and more mud bottom than does the Neosho River. Stream-flow during drought was reduced to a proportionately greater degree in the Neosho River than it was in the Marais des Cygnes River. Average flow of the Neosho River near Parsons (drainage area: 4905 square miles), Kansas, was less than average flow of the Marais des Cygnes River at Trading Post (drainage area: 2880 square miles), Kansas, in 1953, 1955 and 1956. In normal times the Neosho River carries a larger volume of water than the Marais des Cygnes. The Neosho River has a greater variety of habitat-conditions and a more diversified fish-fauna than the Marais des Cygnes.

The following species were taken in the Neosho River but not in the Marais des Cygnes River: blue sucker, high-finned carpsucker, golden redhorse, gravel chub, mimic shiner, mountain minnow, parrot minnow, Neosho madtom (the only endemic in either river), mosquitofish, spotted bass, smallmouth, black crappie, logperch and fan-tailed darter. Most of the above species are usually found in association with gravel-bottom, which is prevalent in Neosho River. The blue sucker, high-finned carpsucker, gravel chub, mountain minnow, and parrot minnow normally occur in the larger streams in Kansas. The last three species became more abundant in the Neosho River following resumption of flow. The golden redhorse also increased in abundance from 1957 to 1959, but was most numerous at the upper Neosho station, whereas the other species occurred mainly at the lower stations.

The mimic shiner, spotted bass, smallmouth, and fan-tailed darter are characteristic of upstream habitats with clear water (tributaries, rather than the mainstream), and were taken in the Neosho River only in 1957 or became less abundant from 1957 to 1959. [Pg 420]

The silver chub, slender madtom and tadpole madtom were taken in the Marais des Cygnes River only in 1957 and were not taken in the Neosho River.

The following species, common to both rivers, were more abundant in the Neosho: long-nosed gar, short-nosed gar, river carpsucker, creek chub, sucker-mouthed minnow, red-finned shiner, red shiner, ghost shiner, blunt-nosed minnow, fat-headed minnow, stoneroller, yellow bullhead, channel catfish, flathead, stonecat, largemouth, long-eared sunfish, slender-headed darter, and freshwater drum. These species, collectively, reflect the more diversified habitats (more gravel-bottom, more riffle-areas, more gradient, greater range of stream-size sampled) in the Neosho River.

The following species, common to both rivers, were more abundant in the Marais des Cygnes: gizzard shad, carp, sand shiner, black bullhead and white crappie. These species (with the exception of sand shiner) emphasize the fact that the Marais des Cygnes is a sluggish stream with large areas of mud bottom. Differences in the abundance of the sand shiner in the two rivers are part of taxonomic and distributional studies being conducted by Mr. Bernard C. Nelson.

The following species were not consistently more abundant in one river than the other: big-mouthed buffalo, black buffalo, small-mouthed buffalo, short-headed redhorse, green sunfish,

orange-spotted sunfish and orange-throated darter. These species, excepting the orange-throated darter and short-headed redhorse, occurred in a wide variety of habitats.

FAUNAL CHANGES, 1957 THROUGH 1959

The following species increased in abundance from 1957 to 1959 (Tables 10 and 11): long-nosed gar, short-nosed gar, river carpsucker, creek chub, gravel chub, sucker-mouthed minnow, mountain minnow, blunt-nosed minnow, parrot minnow, stoneroller, stonecat, Neosho madtom, green sunfish, slender-headed darter, and orange-throated darter.

These species can be separated into three groups, characteristic of different habitats but having in common a preference for permanent flow. One group, composed of long-nosed gar, short-nosed gar, river carpsucker, gravel chub, mountain minnow, parrot minnow, and Neosho madtom, prefers streams of moderate to large size. [Pg 421]

A second group composed of creek chub, sucker-mouthed minnow, stoneroller, and orange-throated darter occurs most abundantly in small, permanent streams. The green sunfish may be included here on the basis of its abundance at the upper Neosho station; however, this is a pioneer species and does not require permanent flow.

The third group is characteristic of continuously flowing water, but in both upstream and downstream situations. The species in this group (blunt-nosed minnow, stonecat, and slender-headed darter), increased in response to a resumption of permanent flow, but did not respond as quickly as did channel catfish, flatheads and freshwater drum, which are discussed subsequently.

The fact that riffle-insects were abundant throughout my study convinces me that food was not a limiting factor in the re-establishment of the fish-fauna on riffles of the Neosho River.

The following species decreased in abundance during my study (Tables 10 and 11): gizzard shad, carp, rosy-faced shiner, blunt-faced shiner, red shiner, mimic shiner, black bullhead, yellow bullhead, channel catfish, flathead, slender madtom, tadpole madtom, freckled madtom, spotted bass, largemouth, black crappie, fan-tailed darter, and freshwater drum.

Among the species that decreased, three groups, characteristic of different habitats, can be distinguished. The first group occurs most commonly in ponded conditions or in slowly flowing streams. Species in this group are: shad, carp, black bullhead, tadpole madtom, largemouth, black crappie, and white crappie. Bullhead, bass and crappie commonly occur in farm ponds and lakes in Kansas and seem less well adapted to streams. It is therefore not surprising to find that these species decreased in abundance when flow was resumed.

A second group, composed of rosy-faced shiner, blunt-faced shiner, mimic shiner, slender madtom, freckled madtom, spotted bass, and fan-tailed darter, normally is characteristic of clear tributaries rather than the mainstream of rivers. These species probably used the mainstream as a refugium during drought; with the resumption of flow, conditions became unsuitable for these populations in the mainstream. At the same time, conditions probably became favorable to the re-establishment of these species in tributaries. Metcalf (1959:396) listed the rosy-faced shiner, blunt-faced shiner and mimic shiner as species that were characteristic of upland tributaries in [Pg 422] the Flint Hills and Chautauqua Hills of Chautauqua, Cowley and Elk counties in Kansas. The slender madtom and fan-tailed darter are more common in clear streams of southeast Kansas than in other areas of the state (Cross, personal communication and data of the State Biological Survey of Kansas). Both species are recorded by Hall (1952:57-58) only in upland tributaries on the east side of Grand (Neosho) River in the Fort Gibson Reservoir area of Oklahoma. Neither species was taken in faunal studies of the Verdigris River in Oklahoma (Wallen, 1958), in the Verdigris and Fall rivers in Kansas (Schelske, 1957), or by Metcalf (1959).

The spotted bass is not so restricted in its distribution and its habitat-requirements as are other species in this group; but, in Kansas, spotted bass are most abundant in clear creeks in the southeast part of the state.

The freckled madtom was taken in most of the studies cited above and is most common in the smaller streams of the southeast one-fourth of Kansas and the northeast one-fourth of Oklahoma. Schelske (1957:47) reports that the freckled madtom was taken only in March, April, October and November in the Verdigris River, Kansas. My only record of this species was obtained in the Neosho River in April, 1958.

The third group is composed of channel catfish, flathead, and freshwater drum. This group represents that element of the population that responded most quickly to the resumption of continuous flow. The fact that adult channel catfish and flatheads live in pools and do not require flowing water to spawn gives these species a survival advantage as well as a reproductive advantage over obligatory riffle fishes (such as most darters) in the highly variable conditions found in Kansas streams. These factors resulted in unusually high reproductive success in 1957. Subsequent survival of fry was excellent; however, some mortality in the highly-dominant 1957 year-class became apparent in the 1958 and 1959 collections, accounting for a numerical decline in these species. The ability to respond immediately to increased flow is an adaptive feature that

allows these species to maintain high levels of abundance in the highly fluctuating streams of Kansas.

The continuous flow that occurred in 1957 in the Neosho and Marais des Cygnes rivers, for the first time in four years, provided the necessary habitat for survival of young catfish hatched in that year. The nearly complete absence of other species on the riffles, and the abundant [Pg 423] populations of riffle-insects that I observed in the summer of 1957, were undoubtedly factors contributing to the survival of young.

The decrease in abundance of the red shiner may be partially due to an increase in the numbers of other species that are well adapted to conditions of permanent flow. At the completion of my study, the red shiner was still the most abundant minnow in both rivers. In 1957 this species was common in many habitats, including swift riffles, that were later occupied by madtoms, darters, the gravel chub, mountain minnow and sucker-mouthed minnow.

The basic pattern of change was clearly an increase in the species that are characteristic of permanently flowing waters, and a decrease in the species that are characteristic of ponds or small, clear streams.

CONCLUSIONS

The fauna of the Neosho and Marais des Cygnes rivers is capable of a wide range of adjustment in response to marked environmental changes. As these rivers become low and clear they take on many of the faunal characteristics of smaller tributaries and ponds. Species such as black bullhead, spotted bass, largemouth, white crappie, red shiner, rosy-faced shiner, blunt-faced minnow, mimic shiner, and slender madtom assume a more prominent position in the total population. Other species such as channel catfish, flathead, freshwater drum, blue sucker, and such riffle-dwelling species as the gravel chub, Neosho madtom, and slender-headed darter hold a less prominent position in the total population.

When permanent flow is re-established the more mobile and the more generalized species (with respect to habitat) are able to utilize the available space immediately. As a result, these species increase rapidly in numbers. This increase occurs both by movement from more permanent waters and by reproduction. Channel catfish, flathead, freshwater drum, and river carpsucker are mobile species (Funk, 1957; Trautman, 1957) and long-nosed gar probably are mobile. Individuals that move supplement those that survive in residual pools, and provide brood stock adequate to produce a large year-class in the first year of permanent flow.

The five species last mentioned are found in diverse kinds of streams, indicating that they are adaptable to varying habitats. A sixth species, the red shiner, although probably less mobile, is able to utilize opportunistically nearly any kind of habitat in Plains streams. Although this species [Pg 424] seldom is abundant in riffles, it was, in 1957, abundant in both pool and riffle situations at all my stations. These riffles were almost unoccupied by other species in 1957 until mid-summer, when hatches of channel catfish and flatheads occurred. Although adult channel catfish and flatheads live well in pools, the young occupy mainly riffles. This age- and size-segregation, in different habitats, was an advantage to the rapid re-establishment of these species in the Neosho and Marais des Cygnes rivers in 1957.

Species that occupy restricted habitats, especially riffle-dwellers such as the Neosho madtom, gravel chub, and slender-headed darter, were slowest to increase following drought. These species seem less capable of adapting to the variable conditions prevalent in the Neosho and Marais des Cygnes rivers than species that have more generalized habitat-requirements.

In the Neosho and Marais des Cygnes rivers nearly all species that were found in years just prior to the drought of 1952-1956 were again found in the last year of my survey; however, some species that live in a restricted habitat may eventually be extirpated in these two rivers. The high-finned carpsucker *Carpiodes velifer*, common shiner *Notropis cornutus*, horny-headed chub *Hybopsis biguttata*, and johnny darter *Etheostoma nigrum* all have specific habitat requirements and have disappeared or become restricted to one tributary in the Wakarusa River System (Deacon and Metcalf, 1961). The disappearance or reduction of these species implies long-term changes in the environment.

Suckers, minnows and catfishes constitute the main fauna of the Neosho and Marais des Cygnes rivers, because these families contain many species that have generalized habitat-requirements. Many of these fish are able to live successfully in either ponds or flowing waters and others are capable of long migrations. Because these fish predominate in the streams of Kansas, attempts should be made to utilize them more effectively.

In years such as 1957, large numbers of young channel catfish could be collected and used to stock new ponds and lakes. So doing would not affect the numbers of *adults* produced in the stream, and, if enough young could be removed, those remaining in the streams might grow faster.

Suckers and carp are abundant in the two rivers and mostly are unused at present, because current regulations preclude the use of methods effective for the capture of these species.

ACKNOWLEDGMENTS

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Assistant Professor Kenneth B. Armitage and Associate Professor Ronald L. McGregor read the manuscript and gave helpful advice. Mrs. Maxine Deacon typed the manuscript and assisted in other ways.

FOOTNOTES

[A] (Oct. 1-Sept. 30, inclusive)

[B] (Oct. 1-Sept. 30, inclusive)

[C] The gaging station was moved a short distance downstream to the Kansas-Missouri state line.

[D] T denotes less than one-half of one per cent of the population.

[E] "T" designates species that comprised less than 0.5 per cent of the population.

[F] (yy) signifies young-of-the-year.

[G] (j) signifies yearlings or two-year-olds.

[H] (yy) means young-of-the-year only.

[I] (j) Denotes juveniles only.

[J] (yy) Denotes young-of-year only.

[K] A dash denotes incomplete or insufficient data.

[L] (j) denotes juveniles only.

[M] (yy) denotes young-of-year only.

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PLATE 26

PLATE 26

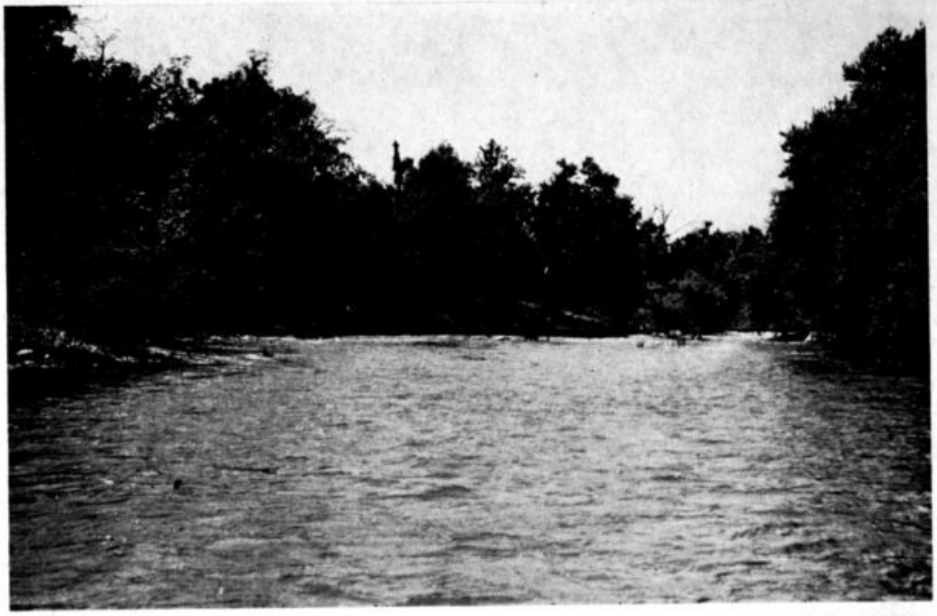

FIG. 1. Neosho River, Middle Station, Sec. 3 and 4, T. 24 S., R. 17 E., looking upstream, July, 1958.

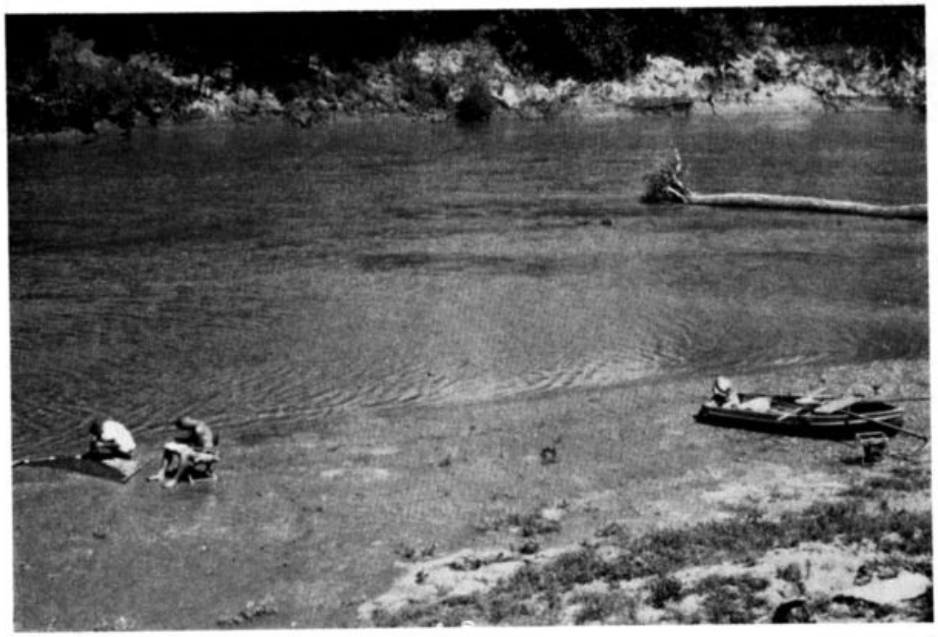

FIG. 2. Neosho River, Lower Station, Sec. 16, T. 29 S., R. 20 E., along gravel bar, July, 1959.

FIG. 1. Neosho River, Middle Station, Sec. 3 and 4, T. 24 S., R. 17 E., looking upstream, July, 1958.

FIG. 2. Neosho River, Lower Station, Sec. 16, T. 29 S., R. 20 E., along gravel bar, July, 1959.

PLATE 27

PLATE 27

FIG. 1. Marais des Cygnes River, Upper Station, Sec. 12, T. 17 S., R. 17 E., looking downstream, June, 1960.

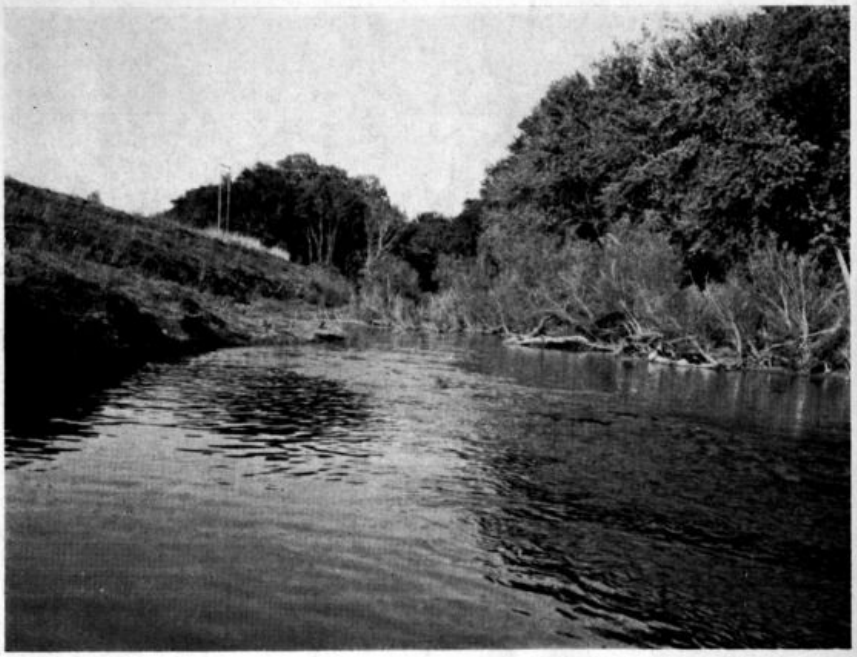

FIG. 2. Marais des Cygnes River, Middle Station, Sec. 6, T. 17 S., R. 20 E., looking downstream, June, 1960.

FIG. 1. Marais des Cygnes River, Upper Station, Sec. 12, T. 17 S., R. 17 E., looking downstream, June, 1960.

FIG. 2. Marais des Cygnes River, Middle Station, Sec. 6, T. 17 S., R. 20 E., looking downstream, June, 1960.

PLATE 28

PLATE 28

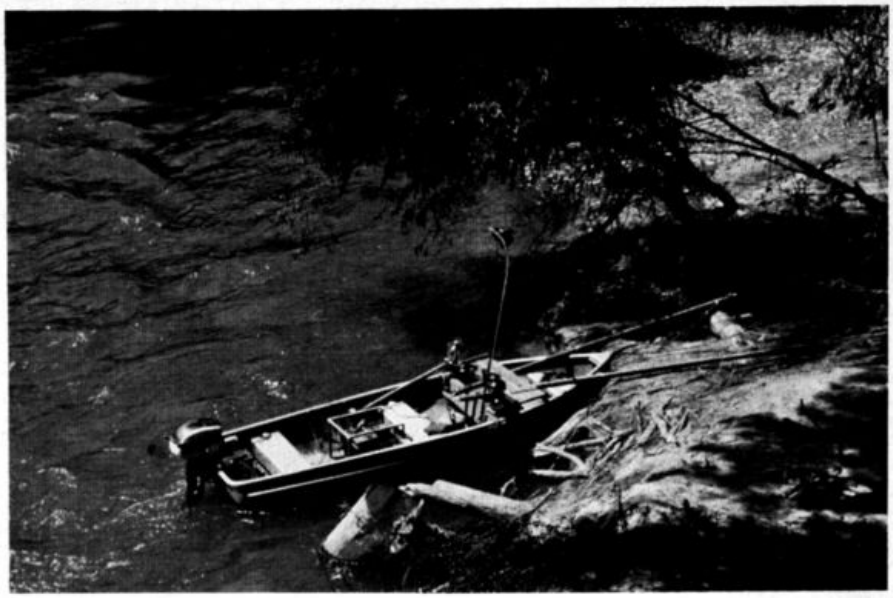

FIG. 1. Electrical fishing gear used at night.

FIG. 2. Pool at the upper Neosho station in which rotenone was used, Sec. 33, T. 15 S., R. 8 E., looking downstream, June, 1960.

FIG. 1. Electrical fishing gear used at night.

FIG. 2. Pool at the upper Neosho station in which rotenone was used, Sec. 33, T. 15 S., R. 8 E., looking downstream, June, 1960.

PLATE 29

PLATE 29

FIG. 1. Area 1, upper Neosho station, Sec. 33, T. 15 S., R. 8 E., looking upstream, June, 1960.

FIG. 2. Area 3, upper Neosho station, Sec. 10, T. 16 S., R. 8 E., looking downstream, June, 1960.

FIG. 1. Area 1, upper Neosho station, Sec. 33, T. 15 S., R. 8 E., looking upstream, June, 1960.

FIG. 2. Area 3, upper Neosho station, Sec. 10, T. 16 S., R. 8 E., looking downstream, June, 1960.

PLATE 30

PLATE 30

FIG. 1. Area 5, upper Neosho station, Sec. 3, T. 16 S., R. 8 E., looking upstream, June, 1960.

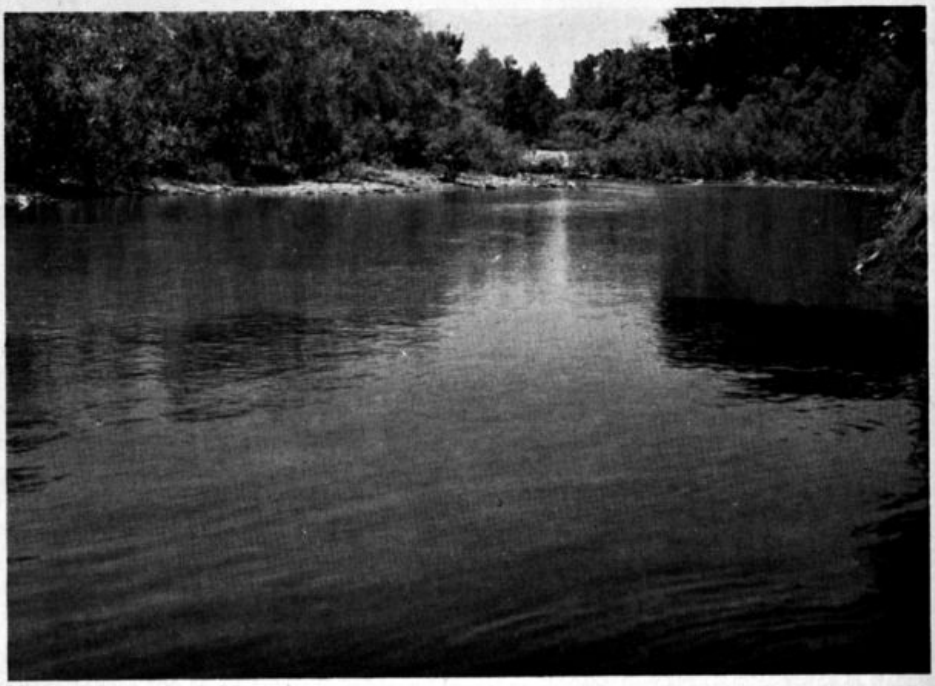

FIG. 2. Area 6, upper Neosho station, Sec. 3, T. 16 S., R. 8 E., looking upstream, June, 1960.

FIG. 1. Area 5, upper Neosho station, Sec. 3, T. 16 S., R. 8 E., looking upstream, June, 1960.

FIG. 2. Area 6, upper Neosho station, Sec. 3, T. 16 S., R. 8 E., looking upstream, June, 1960.

□

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13. A new cottontail (Sylvilagus floridanus) from northeastern Mexico. By Rollin H. Baker. Pp. 609-612. April 8, 1955.

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