THE SOUTHWESTERN NATURALIST 14(2):231–248 OCTOBER 10, 1969

BENTHIC MACROINVERTEBRATES OF THE OTTER CREEK DRAINAGE BASIN, NORTHCENTRAL, OKLAHOMA

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ABSTRACT. Distribution, seasonal abundance, and ecological notes on 122 taxa of benthic macroinvertebrates collected in the Otter Creek Drainage system are discussed. The freshwater nemertean, *Prostoma rubrum* (Leidy), and the oligochaetes, *Tubifex templetoni* Southern, *Dero digitata* (Muller), *Nais variabilis* Piguet, *Pristina breviseta* Bourne, *P. longiseta Leidyi* Smith, *P. longidentata* Harman, and two species of *Pristina* new to science are reported from Oklahoma for the first time.

Benthic macroinvertebrate studies have recently become of increased importance to aquatic biologists because of their use in evaluating effects of pollutional effluents, and recognition of their central position in aquatic food chains. Benthic macroinvertebrates of southwestern lotic waters are poorly known. The only major contributions in this area are by Hornuff (1957) and Wilhm and Dorris (1966). This situation is further complicated by the draeth of taxonomic studies on immature stages of many aquatic invertebrates. These points can be emphasized by pointing out that eight of the 11 species of oligochaetes collected during this study represent new state records, two of these are new to science. Furthermore, only 65 of the 122 taxa collected could be identified to species.

This report consists of information concerning distribution, seasonal abundance, and ecological notes on species collected during a one year study of the Otter Creek Drainage system. Distribution is discussed in terms of Horton's (1945) stream order classification, as modified by Strahler (1954; 1957) and redescribed by Kuehne (1962) and Leopold (1962). Kuehne (1962), Harrel et al., (1967) and Harrel and Dorris (1968) showed the usefulness of stream order classification in successional studies.

Detailed evaluations of drainage basin geomorphology, physicochemical conditions, and species diversity of benthic macroinvertebrates and fishes have been published elsewhere (Harrel et al., 1967;

Harrel and Dorris, 1968). Thus the description of the basin and physico-chemical conditions that follows is presented in summary form.

DESCRIPTION OF BASIN. Otter Creek drainage basin is a 6th order, intermittent system occupying 302.1 km^2 in Logan and Garfield Counties, Oklahoma. The main channel flows 41.8 km southward and empties into Skeleton Creek, a tributary of the Cimarron River. The stream has formed eroding valleys ranging in depth from about one meter along some of the upland, low order streams to 22.8 m along the 6th order stream. Rocks exposed in the basin consist mostly of sandstone and shale, with some gypsum (USGS, 1945). Soils along the stream channels are sandy or clayey silts and loams (Fitzpatrick et al., 1939; Galloway, 1960).

The basin is in a mixed-grass prairie association. The climate is long-summer continental, and severe droughts are common (Fitzpatrick et al., 1939; Galloway, 1960).

METHODS and PROCEDURES. Twenty-one stations were selected in nine separate streams in the Otter Creek drainage basin (Fig. 1). Six stations were selected in each of 3rd, 4th, and 5th order streams. Three stations were selected in the 6th order stream. Stations were designated by numbers corresponding to the order of sampling. Numbers in parenthesis following station numbers indicate stream order.

Physico-chemical measurements and benthic macroinvertebrates were collected monthly from June 1964 to May 1965. Physico-chemical measurements were taken according to STANDARD METHODS . . . (APHA, 1960). Benthic organisms were collected with an Ekman dredge or Surber sampler. Four Ekman dredge hauls were taken monthly from pools at each station. Two riffle samples were collected monthly from 6th order stations with a Surber sampler. Bottom samples were preserved in the field with 10% formalin. In the laboratory samples were washed in a #40 U.S. standard soil seive, organisms were removed, and preserved in 80% isopropyl alcohol. When large numbers of organisms were present they were removed by sugar solution flotation (Anderson, 1959).

RESULTS. I. *Physico-Chemical Conditions.* During July and August drought conditions existed and the only flow observed was a trickle at station 1(6). In August all 3rd and 4th order stations except 3(3), 11(3), 18(4) and 9(4) were dry. Station 7(5) was also dry during August. During spring and fall the streams flowed below stations 9(4) and 21(5), and pools existed above these stations. During winter flow was continuous at all stations except 11(3), 12(3) and 13(3).

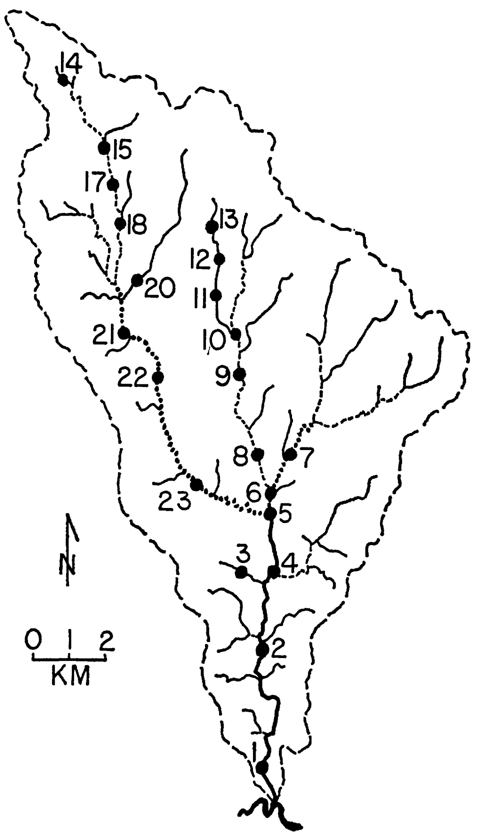

Fig. 1. Otter Creek drainage basin and collecting stations, 1st and 2nd order streams omitted, 3rd order = (—), 4th order = (— — —), 5th order = (. . . .), 6th order = (———).

Generally, physico-chemical fluctuations, water temperature, turbidity, and steepness of gradient decreased as stream order increased. Conversely, permanence of water, alkalinity, specific conductance, and discharge increased as stream order increased (Table 1). Generally, turbidities were low and conductivities were high during winter, the reverse being true during fall. Intermediate conductivities and turbidities occurred during spring and summer.

Exceptions to the above summary occurred at stations 9(4) and 22(5) that received oil field brines by seepage through the soil from oil wells located approximately 180 m from the streams above these stations. These stations had higher discharges, conductivities and alkalinities, and lower turbidities than other stations of the same order (Table 1). Conductivity was higher at station 22(5) than at station 9(4), denoting the presence of more concentrated brines at station 22(5).

II. *Benthic Macroinvertebrates.* One hundred and twenty-two taxa of benthic macroinvertebrates were collected (Table 2).

Oligochaetes and chironomid larvae formed over 90% of the total number of pool organisms throughout the year. *Simulium vittatum* formed over 85% of the total number of riffle organisms. Mean monthly density ranged from 565/M^2 in September, following a flood which occurred after a prolonged drought, to 6715/M^2 in May after eight months of continuous stream flow (Fig. 2). During July and August all species were isolated in small pools and the number of stagnant-water, predatory forms increased, while numbers of running-water species decreased. After the flood the number of most running-water species increased throughout the remainder of the study. Most species that were common before the flood were unsuited for repopulation of flowing water and were absent or reduced in numbers until spring when stream flow decreased.

Distinct longitudinal segregation of benthic invertebrates was not as evident in this nearly natural stream as in Skeleton Creek reported by Wilhm and Dorris (1966). Skeleton Creek is a polluted stream that receives domestic and oil refinery effluents, and of which Otter Creek is a tributary. Wilm and Dorris (1966) found a total of 42 taxa, six from an up-stream, 4th order station just below the outfalls, and 30 species at their downstream, 7th order station. In Otter Creek the

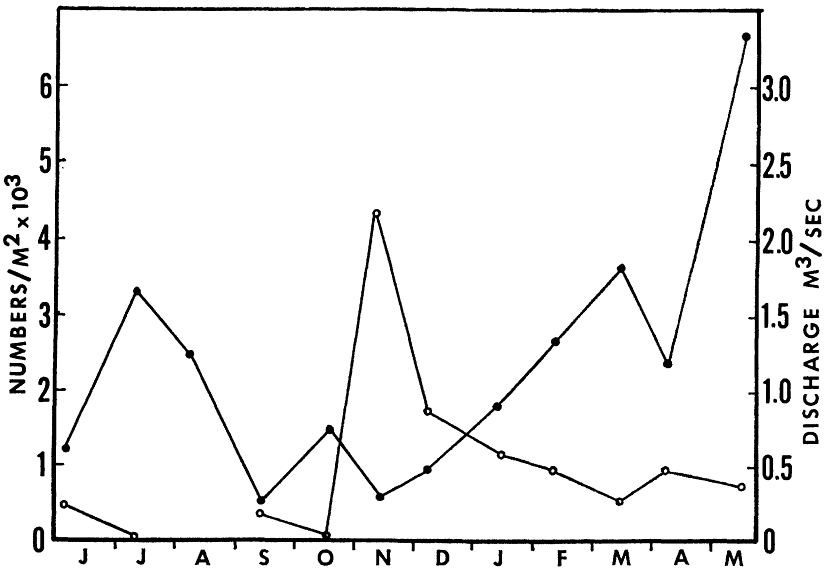

Fig. 2. Mean monthly density of benthic macroinvertebrates in all stream order pools (●) and discharge at station 1(6) (○).

TABLE 1

Mean annual physico-chemical conditions and extremes for stream orders and stations that received oil field brines

Order or station		3	4	9(4)	5	22(5)	6
Temperature	Mean	16.6	16.2	15.7	16.4	17.4	15.0
C	Extremes	2–39	1–34	2–25	1–33	2–33	1–26
pH	Mean	8.08	8.24	8.20	7.99	8.09	8.06
	Extremes	6.8–9.8	7.4–9.4	7.4–8.6	7.2–8.5	7.3–8.3	7.4–8.4
Alkalinity	Mean	173	167	235	168	199	210
ppm	Extremes	39–459	65–456	118–387	74–316	85–281	85–280
Turbidity	Mean	138	133	50	117	34	116
ppm	Extremes	8–>310	11–>310	12–102	10–>310	14–62	11–>310
Conductivity	Mean	533	608	607	616	2462	640
micromohs/cm	Extremes	120–1640	178–1412	350–831	184–2104	875–4235	210–1163
Dissolved O_2	Mean	8.86	10.32	13.16	9.51	9.56	9.52
ppm	Extremes	0.6–17.5	2.4–17.3	2.7–23.0	1.0–13.1	2.7–12.45	5.3–12.3
Discharge	Mean	Trace	0.03	0.04	0.04	0.06	0.08
m^3/sec.	Extremes	0–.006	0–.08	0–.09	0–.17	0–.20	0–.32

number of species increased from 75 in 3rd order pools to 86 in 5th order pools. Only 68 species were collected in the 6th order pools. This decrease is attributed to heavy siltation which reduced the number of available microhabitats. Many species were more abundant in pools of a particular stream order, 6th order riffles, or at stations that received oil field brines (Table 2). Factors that affected distribution and seasonal abundance of common species, and collecting data for new state records are discussed below.

Nemertea

Prostoma rubrum (Leidy) was collected on eight occasions from six stations in 4th, 5th and 6th order streams (Tables 2 and 3). Seasonal occurrence, October through April, corresponded with the period of continuous stream flow. Maximum density and frequency occurred at station 22(5) that received concentrated oil field brines and had an abundant growth of *Vaucheria* sp. (Table 3). Child (1901) stated that *P. rubrum* feeds primarily on *Nais* sp., a small oligochaete. In Otter Creek the seasonal occurrence of *P. rubrum* and *Nais variabilis* corresponded closely, but *N. variabilis* was never collected at station 22(5) where *P. rubrum* was most abundant. Specimens collected during winter were covered in a cyst-like covering of sand and slime. Coe (1959) gives the range of *P. rubrum* as ". . . from New England to Florida and westward to Washington and California." These are the first records of *P. rubrum* in Oklahoma.

Nematoda

Nematodes in the family Mermithidae were collected throughout the year and from all stream orders (Table 2). Maximum numbers occurred during late winter and early spring in 4th and 5th order pools, and 6th order riffles when their host, *Orthocladius* larvae, were most abundant. Several specimens were collected during March and April while emerging from the hemocoel of *Orthocladius* larvae.

Ectoprocta

Fredericella sultana (Blumenbach) was observed in all stream orders and during all monthly collections except August. Generally, *F. sultana* was restricted to the surface of larger rocks in riffle areas, and did not occur up-basin above stations 9(4) and 20(3). However, during March and April colonies were abundant in pools and riffles on all possible sites of attachment. At this time they extended their distribution up-basin to station 17(4). Maximum estimated numbers occurred at stations 9(4) and 2(6) during April.

Annelida

Oligochaeta: *Limnodrilus* sp. was taken in all collections at every station. Maximum numbers were collected from station 22(5) and 4th order stations (Table 2). *Limnodrilus* sp. was the most abundant pool organisms during all months except August when the predatory chironomid *Pelopia* sp. B became dominant. During August all organisms were concentrated in small, stagnant pools and oligochaetes were greatly reduced by predation. Minimum average density ($334/m^2$) occurred during September following a flood. Maximum average density ($3539/m^2$) occurred in May following the longest period of continuous stream flow (Table 4). Several specimens were identified as *L. udekemianus* Clap. Wilhm and Dorris (1967)

TABLE 2

Annual density of benthic macroinvertebrates for stream orders and stations that received oil field brines (Nos./m²)

	3-Pools	4-Pools	9(4)	5-Pools	22(5)	6-Pools	6-Riffle
Dugesia tigrina	1	1	. .	1	. .	. .	. .
Prostoma rubrum	. .	1	2	1	7	1	1
Mermithidae	1	3	8	4	4	1	4
Fredericella sultana	P	P	P	P	P	P	P
Limnodrilus sp.	960	2159	2147	977	5620	447	41
Tubifex sp.	25	17	154	17	32	4	1
Branchiura sowerbyi	1	. .	. .	2	. .	221	30
Dero digitata	65	47	1005	61	37	15	2
Nais variabilis	1	14	300	15	. .	10	21
Pristina breviseta	. .	. .	. .	1	. .	. .	. .
P. longiseta	. .	. .	2	. .	. .	. .	. .
P. longidentata	. .	. .	. .	1	. .	. .	. .
P. sp. 1	1	1	193	. .	. .	1	1
P. sp. 2	1	1	4	1	. .	. .	. .
Enchytraeidae	. .	. .	1	. .	. .	. .	. .
Helobdella nepheloidea	22	39	19	14	5	17	1
H. fusca	. .	1	. .	1	. .	. .	. .
Dina microstoma	8	11	1	1	2	. .	. .
Placobdella sp.	. .	. .	. .	. .	. .	. .	1
Caenestheriella belfragei	3	1	. .	. .	. .	. .	. .
Hyalella azteca	2	1	25	13	4	1	1
Procambarus simulans	P	P	. .	P	. .	P	. .
Orconectes nais	P	P	P	P	P	P	P
Hexagenia sp.	4	2	4	11	13	5	. .
Callibaetis sp.	3	2	4	4	2	1	1
Caenis sp.	4	24	136	44	76	22	12
Baetis sp.	. .	1	. .	1	. .	1	8
Stenonema sp.	1	1	. .	1	. .	2	12
Nehalennia sp.	2	1	2	2	2	1	. .
Lestes sp.	1	1	1	. .	. .	. .	. .
Telleallagma sp.	. .	1	. .	. .	. .	. .	. .
Argia sp.	. .	. .	. .	1	1	2	2
Orthemis sp.	1	. .	. .	. .	. .	. .	. .
Gomphus sp.	1	. .	. .	1	4	2	. .
Macrothemis sp.	1	1	. .	1	. .	. .	. .
Tetragoneuria sp.	1	. .	. .	. .	. .	. .	. .
Libellula sp.	. .	. .	. .	1	. .	. .	. .
Cordulia sp.	. .	. .	. .	1	. .	. .	. .
Aeschna sp.	. .	. .	. .	1	. .	. .	. .
Didymops sp.	. .	. .	. .	1	. .	. .	. .
Hetaerina sp.	. .	. .	. .	. .	. .	. .	1
Ophigomphus sp.	. .	. .	. .	. .	. .	. .	1
Trichocorixa calva	3	6	1	9	1	5	1
Belostoma flumineum	. .	. .	. .	1	. .	. .	. .

TABLE 2—Continued

	3-Pools	4-Pools	9(4)	5-Pools	22(5)	6-Pools	6-Riffle
Sialis sp.	1	1	5	12	3	1	..
Corydalus cornutus	.	..	..	..	..	..	1
Cheumatopsyche sp.	1	1	..	1	..	2	97
Oecetis inconspicua	..	1	2	2	..	1	..
Enochrus nebulosus			..	1	..	1	2
Berosus peregrinus	1	1	..	7	21	4	1
Tropisternus lateralis	1	1	5	1	..	..	1
Copelatus chevrolatis	..	.	..	1	.	.	..
Agabus semivittatus	.	1	..	1	1	1	1
Laccophilius fasciatus	2	2	.	1	..	1	1
Hydroporus sp.	26	1	6	5	..	5	1
Cyphon sp.	1	.	.	1	..	..	..
Peltodytes littoralis	..	1	1	3	..	2	..
Dineutus assimilis	.	1	..	.	..	1	1
Dubiraphia vittata	2	1	8	22	10	16	5
Stenelmis sp.	..	..	..	1	..	1	24
Helichus lithophilus	..	..	..	..	..	..	8
Paracymus subcupress	..	..	..	..	..	..	2
Cymbiodyta fimbriata	..	..	..	..	..	..	1
Helophorus sp.	..	..	..	..	..	..	1
Tipula furca	1	1	..	..	..	1	..
Limnophila sp.	..	..	.	1	1	1	..
Limonia sp.	..	..	1	..	..	..	1
Gonomyia sp.	1	1	1	1	1	..	..
Erioptera sp.	1	1	1	1	1	1	1
Megistocera sp.	..	..	..	..	1	..	..
Anopheles punctipennis	1	1	1	1	..	..	..
Culiseta inornata	1	..	..	..	..	..	..
Psorophora signipennis	1	..	..	..	..	..	..
Aedes vevans	1	..	..	..	..	..	..
Chaoborus sp.	13	44	2	18	8	10	1
Odontomyia sp.	.	..	1	..	.	1	..
Tabanus sp.	2	4	8	5	5	2	..
Chrysops sp.	..	..	..	..	..	..	1
Ephydra sp.	..	..	5	1	..	1	..
Notiphila sp.	..	..	1	..	..	..	..
Limnophora sp.	.	1	..	.	1	1	2
Cecidomyiidae	2	4	..	1	2	2	1
Asilidae	1	..	..	..	..	..	..
Mycetophilidae	1	1	..	1	1	..	..
Hemerodromia sp.	..	.	..	..	..	..	4
Simulium vittatum	4	8	1	7	..	11	7444
Stilobezzia sp.	8	12	90	37	50	19	1
Bezzia sp.	1	1	..	1	..	1	1
Culicoides sp.	1	2	2	3	13	2	1
Palpomyia sp.	1	1	4	3	6	1	1
Atrichopogon sp.	..	..	2	..	..	..	..

Procladius bellus	44	116	161	85	64	13	..
Pelopia sp. B	15	32	27	95	20	31	..
Ablabesmyia mallochi	4	4	12	8	14	10	74
Orthocladius sp.	4	22	70	57	286	76	226
O. nr. *nivoriundus*	6	25	12	43	250	49	20
Metricnemus sp.	2	19	53	17	117	40	274
Cricotopus sp.	1	6	1	..	..	..	1
Psectrocladius sp.	1	..	..	1	2	1	4
Smittia nr. *atterrima*	..	1	2	1	..	..	1
Pseudosmittia sp.	1	14	16	10	27	19	1
Tendipes attenuatus	45	74	31	10	105	2	..
Glyptotendipes sp.	..	2	6	2	4	..	..
G. nr. *senilis*	53	7	90	12	89	33	51
Cryptochironomus nr. *fulvus*	13	25	45	24	32	14	1
Stictochironomus devinctus	9	43	17	16	7	5	..
Calopsectra nr. *guerla*	27	12	216	11	28	37	58
Polypedilum illinoense	3	4	25	10	31	16	138
P. halterale	13	4	22	12	19	15	1
P. parascalaenum	..	1	..	..	..	1	1
Dicrotendipes sp.	8	4	7	9	12	17	50
Harnischia nr. *pseudotener*	11	1	..	3	2	2	..
Tanytarsus flavipes	1	2	2	1	..	1	1
Pseudochironomus Fulviventris	..	..	14	1	..	..	1
Paratendipes albimanus	20	..	..	..	..	..	..
Stenochironomus sp.	..	..	..	..	..	..	1
Ferrissia shimekii	2	..	1	..	..	..	1
Physa anatina	8	21	36	19	23	5	6
Lymnaea humilus	2	1	1	1	..	..	..
Helisoma anceps	1	5	..	1	..	..	..
Sphaerium transversum	2	11	68	43	3	30	5
Uniomerus tetralasmus	..	1	..	1	1	1	..

* Rounded to nearest number except when less than $1/m^2$, these are shown as $1/m^2$.
P = present

reported four species of *Limnodrilus* from Skeleton Creek, of which Otter Creek is a tributary.

Tubifex sp. was collected during all months except August (Table 4) and from all stations except 13(3) and 17(4). Maximum average density ($71/m^2$) occurred during March. Average density decreased as stream order increased, when stations that received oil field brines are excluded. However, highest density always occurred at station 9(4) that received oil field brines (Table 2). Several specimens were identified as *T. templetoni* Southern. This represents a new state record.

Branchiura sowerbyi Beddard was taken in every collection at stations 1(6) and 2(6), and during summer and fall it was collected at stations 3(3), 6(5), 7(5) and 4(6) (Table 2). Larger numbers were taken from station 2(6) during fall, winter, and spring. During summer larger numbers were found at station 1(6). Seasonally, maximum density occurred during July and August correlating with increased water temperature (Table 4). Brinkhurst (1965) states that *B. sowerbyi* is thermophilic. The marked decrease between July and August can be explained by increased predation in the small pools present at that time. *B. sowerbyi* was first reported in Oklahoma by Evans (1959) from a single specimen collected in a stock tank in Marshall County. However, Schaefer et al., (1965) found it to be common in ponds, lakes, and streams in northcentral Oklahoma.

Seven species in the family Naididae were collected, all representing new state records.

Dero digitata (Muller) was collected throughout the year, and at all stations (Tables 2 and 4). Minimum average density (3/m^2) occurred in September following a flood, and maximum density (156/m^2) occurred in May following the longest period of continuous stream flow. A density of 10,408/m^2 was estimated for station 9(4) during May. Budding individuals were collected the year-round, but were more common during later winter and early spring. They were most abundant on a substrate of fine sand and silt from which they construct their tubes.

Nais variabilis Piguet, the only eyed oligochaete collected, was taken from November through May, and in all stream orders (Tables 2 and 4). This was during the longest period of continuous stream flow and lowest turbidity. Average density increased from 1/m^2 in November to 75/m^2 in April, then decreased to 5/m^2 in May when stream flow decreased. Highest stream order density occurred in 6th order riffles, but highest station frequency and density occurred at station 9(4) that received oil field brines.

Pristina breviseta Bourne was was collected at station 21(5) during September.

Pristina longiseta Leidyi Southern was collected at station 9(4) during Octover.

Pristina longidentata Harman was collected at station 7(5) in June, September, November, and February.

Pristina sp. 1 and *Pristina* sp. 2 are new to science and are presently being studied by Dr. Walter J. Harman, Louisiana State University. Both species had scattered distributions seasonally and in the drainage basin, but were most abundant at station 9(4) (Table 2).

Hirudinea. *Helobdella nepheloidea* (Graf.) was collected during summer, fall, and spring, and from all stream orders (Tables 2 and 4). Maximum numbers occurred

TABLE 3

Distribution of Prostoma rubrum *and limnological conditions at collecting stations*

Date	Station and stream	Density (No./m^2)	Temp. (C)	Oxygen (ppm)	pH	Alkalinity (ppm)	Turbidity (ppm)	Conductivity (micromohs/cm)
10 Oct. 64	23(5)	11	13	...	8.0	110	250	380
22 Nov. 64	4(6)	11	16	7.7	7.8	85	>310	274
22 Dec. 64	22(5)	54	8	10.3	7.6	197	32	1966
22 Dec. 64	7(5)	11	6	11.1	8.2	285	14	580
23 Jan. 65	22(5)	22	2	12.5	8.0	281	29	2612
18 Feb. 65	22(5)	11	11	11.3	7.8	275	29	3530
13 Apr. 65	9(4)	22	17	10.5	8.3	303	66	701
13 Apr. 65	2(6)*	11	14	7.6	8.3	247	102	861

* Collected in a riffle.

TABLE 4

Average monthly abundance of common annelids in pools (Nos./m^2)

Species	Month											
	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Oligochaeta												
Limnodrilus sp.	820	1182	358	334	909	416	645	1052	1424	1707	1450	3539
Tubifex sp.	3	4	...	5	13	16	10	6	31	71	12	28
*Branchiura sowerbyi**	43	947	524	115	312	25	89	154	97	151	79	111
Dero digitata	62	100	34	3	18	16	10	7	78	59	67	156
Nais variabilis	...	...	...	...	...	1	1	11	11	12	74	5
Hirudinea												
Helobdella nepheloidae	12	232	51	...	1	1	...	...	...	1	1	7
Dina microstoma	3	12	28	1	3	1	...	...	4	1	2	18

* Density based only on 6th order stations, all others based on all stream orders.

in stagnant, 3rd and 4th order pools rich in organic material during July and August. During these months several specimens were collected carrying from 5 to 41 young.

Dina microstoma Moore was common in 3rd and 4th order streams and was occassionally taken at stations 21(5) and 22(5) (Table 2). Habitat preference and seasonal occurrence was about the same as *H. nepheloidae* (Tables 2 and 4). During July and August several specimens were observed with oligochaetes (*Limnodrilus* sp. and *Tubifex* sp.) in their mouths. One specimen had a larval fish, probably *Pimephales promelas*, in its mouth.

Arthropoda

Crustacea. *Caenestheriella belfragei* (Packard) was collected from isloated pools at stations 15(4) during July and 13(3) during October. During both collections the pools were very turbid (>310 ppm) and the pH was 8.6 and 8.7, respectively.

Hyalella azteca (Saussure) was collected from all 5th order stations and at stations 3(3), 9(4), 8(4), and 2(6) throughout the year (Table 2). Larger numbers occurred during spring. Larger densities and frequencies occurred at stations 23(5) and 9(4), characterized by relatively clear water and an abundance of *Spirogyra* sp.

Crayfishes were not quantitatively sampled, but were observed in all stream orders during spring, summer, and fall.

Procambarus simulans (Faxon), a burrowing form, occurred throughout the basin, but was more abundant in 3rd and 4th order pools.

Orconectes nais (Faxon) was collected from all stations but 9(4) and 18(4). This species was most abundant in 5th and 6th order streams. *O. nais* will construct burrows during drought, but is typically an open-water form (Williams and Leonard, 1952). This species has a tendency to migrate upstream, and this is the principal means of resettling an area following drought or flood (Momot, 1966).

Insecta. Ephemeroptera. *Hexagenia* sp., a burrowing form, was collected in all stream orders, but was most abundant in 5th order pools (Table 2). Larger numbers were taken at stations where mud and organic debris was abundant. Seasonally they were most abundant during July and August.

Caenis sp., a bottom sprawler, was collected at all stations except 10(4). Average density increased from $4/m^2$ in 3rd order pools to $44/m^2$ in 5th order pools, then decreased to $22/m^2$ in 6th order pools where siltation was heavier (Table 2). Seasonally, larger numbers occurred during July, October, and April when many very small nymphs were collected.

Callibaetis sp., a climbing form, was taken in all stream orders and during all months except June (Table 2). Maximum monthly density occurred during August when all organisms were concentrated into small pools.

Baetis sp., a free-swimming riffle form, was collected sporadically in all but 3rd order streams (Table 2).

Stenonema sp., a clinging riffle form, occurred sporadically in all stream orders (Table 2). The largest density occurred during April when many small nymphs were collected from crevices on the underside of stones.

Odonata. Fourteen genera were collected (Table 2). However, occurrence of all but the three listed below was so sporadic no inferences could be made concerning their distribution.

Nehalennia sp. was collected throughout the year and from all stream orders. Greater frequency occurred in 5th order streams where they were taken from every station several times during the year.

Gomphus sp. and *Argia* sp. were common in 5th and 6th order streams during all seasons, but were most abundant during February and March.

Hemiptera. *Trichocorixa calva* (Say) was common in all stream orders during spring, summer and fall (Table 2). It was most common in 5th order streams, but highest density (225/m^2) occurred at station 15(4) during July.

Megaloptera. *Sialis* sp. was collected from all 5th order station and stations 3(3), 18(4), 10(4), 9(4), 8(4) and 4(6) during spring, summer and fall. Average density increased steadily during spring and summer months to 21/m^2 during August. A density of 172/m^2 was estimated at station 21(5) during August.

Trichoptera. *Cheumatopsyche* sp. was abundant in riffles and was occasionally taken from pools during summer and spring (Table 2). The highest monthly density (2306/m^2) occurred during October. During July and August, when all riffles were dry, except for a small trickle at station 1(6), specimens were collected only at stations 3(3) and 1(6), indicating a high mortality during drought. Newly hatched individuals were abundant in 6th order riffles (639/m^2) during September after the drought had ended. Apparently the eggs had survived and were the principal means of repopulating the stream.

Oecetis inconspicura (Walker) was collected from 4th, 5th and 6th order streams during summer (Table 2). Maximum density of 75/m^2 occurred at station 23(5) during August.

Coleoptera. Sixteen species representing seven families were collected (Table 2).

Dytiscidae: *Hydroporus* sp. larvae and adults were common in 5th and 6th order pools, but occurred in all stream orders (Table 2). The higher annual density at 3rd order stations was due to large concentrations of adults in small, drying pools at stations 14(3) and 3(3) during July and August. One hundred and two specimens of *Hydroporus vittatipennis* (G. and H.) were collected from a small pool at station 14(3) in July where they were actively feeding on dead *Ictalurus melas*. At the time of this collection the water temperature was 39°C.

Laccophilus fasciatus Aube was collected in all stream orders, and during all seasons. Larger annual densities occurred in 3rd and 4th order streams (Table 2). The highest monthly density (5/m^2) occurred during May.

Agabus semivittatus Le Conte was collected in 4th, 5th, and 6th order streams during September and spring months (Table 2).

Hydrophilidae: *Berosus peregrinus* Herbst was collected from 4th, 5th and 6th order streams during all seasons and from station 3(3) during spring and winter (Table 2). They were most common in 5th order streams and highest annual density (21/m^2) occurred at station 22(5) that received concentrated oil field brines and characterized by the algae *Vaucheria* sp. *Berosus* is the only hydrophilid that feeds entirely on algae (Usinger, 1963).

Tropisternus lateralis (Say) was collected from all stream orders during October, and one specimen was collected from station 17(4) during April.

Elmidae: *Dubiraphia vittata* Melshiemer was collected from 5th and 6th order streams throughout the year, and from 3rd and 4th order streams during winter and spring (Table 2). Highest monthly density of 19/m^2 occurred during October.

Stenelmis sp. was common in 6th order riffles and was occasionally collected in 5th and 6th order pools (Table 2). Highest monthly density of 34/m^2 occurred during May following the longest period of continuous stream flow. A density of 20/m^2 (mostly adults) occurred during September immediately following the end of the drought. They had apparently survived in the small remaining pools or by burrowing into the sandy stream bottom. Larimore et al., (1959) reported that many aquatic forms, including some beetles, survive dry spells by burrowing into sand and gravel following moisture as the stream bed dries up.

Dryopidae: *Helichus lithophilus* (German) was taken only from 6th order riffles during July, April and the fall months. Maximum density of 40/m^2 occurred during September.

Haliplidae: *Peltodytes littoralis* (Matheson) was collected during August and fall months from silty pools in 4th, 5th and 6th order streams (Table 2).

Diptera Tipulidae: *Erioptera* sp. was collected sporadically from all stream orders throughout the year and was most numerous durring winter in 4th order streams (Table 2).

Culicidae: *Psorphora signipennis* (Coquillett), *Culiseta inornata* (Williston), and *Aedes vevans* (Meigen) were collected only from 3rd order pools. The former was collected during July, the latter two during August.

Anopheles punctipennis (Say) was collected in 3rd, 4th, and 5th order pools during September and October, but was common only in 4th order pools.

Chaoborus punctipennis (Say) was collected throughout the year, and in all stream orders (Table 2). They were most common in stagnant 4th order pools during July and August, and a density of 1151/m^2 occurred at station 18(4) during August.

Simuliidae: *Simulium vittatum* Zett. formed 85% of the total number of riffle organisms, and occurred in pools in all stream orders (Table 2). New generations occurred seasonally and population peaks were reached during July, October, February and April. Females were observed depositing eggs at the lower end of pools during most collections. During April, all riffle areas and pool margins were black with larvae and a density of 74,512/m^2 was estimated for the riffle at station 2(6).

Tabanidae: *Tabanus* sp. was collected throughout the year and at all stations except 12(3) and 21(5). Density increased in 3rd through 5th order streams and decreased in the 6th order stream (Table 2). Larger numbers occurred during winter.

Ceratopogonidae: *Stilobezzia* sp. was common in all stream orders and most numerous in 5th order streams (Table 2). Highest monthly density (88/m^2) occurred during May, and a density of 786/m^2 was found at station 9(4) at this time.

Culicoides sp. and *Palpomyia* sp. were collected sparsely from all stream orders throughout the year, and were most abundant in 5th order streams (Table 2).

Bezzia sp. occurred sparsely throughout the year in all stream orders.

Atrichopogon sp. was collected at station 9(4) during October and occasionally in 6th order riffles.

Cecidomyiidae: Gall gnat larvae, representing at least two species, were collected sporadically throughout the year from all stream orders. Larger numbers occurred during spring, and a density of 172/m^2 was found at station 18(4) during April.

Chironomidae: Twenty-five species in the subfamilies Pelopiinae (3 species), Orthocladiinae (7 species), and Chironominae (15 species) were collected. Many species demonstrated a preference for conditions in one or two stream orders, or in 6th order riffles (Table 2). Relative numbers increased as stream order increased, from 19% of the total number in 3rd order pools to 31% in 6th order pools. In 6th order riffles chironomids formed 66% of the total number when *Simulium vittatum* was excluded, but only 1% when it was included.

Seasonal distribution patterns were evident (Table 5). The pelopiinaes and *Crytochironomus* nr. *fulvus*, all predaceous on other midges and oligochaetes, were abundant during July and August, the period of drought. During August ***Pelopia*** sp. B replaced *Limnodrilus* sp. as the most abundant organism.

TABLE 5

*Seasonal abundance of chironomid larvae (NO./m²)**

Species	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Pelopiinae												
Pelopia sp. B (Joh.)	3	125	603	...	3	...	...	...	...	...	...	...
Procladius bellus (Loew)	25	448	214	8	14	3	2	3	18	14	7	70
Ablabesmyia mallochi (Wall.)	4	20	3	4	4	1	1	1	3	9	3	18
Orthocladiinae												
Orthocladius sp.	1	...	...	...	...	6	29	116	103	126	20	1
O nr. *nivoriundus* (Joh.)	..	...	...	...	...	3	29	97	67	107	7	...
Metriocnemus sp.	1	...	...	...	3	5	31	13	29	92	18	7
Cricotopus sp.	1	8	...	...	...	...	...	...	...	1	8	1
Psectrocladius sp.	..	...	...	...	...	...	...	1	1	1	...	...
Smittia nr. *atterrima* (Meig.)	..	...	...	1	...	...	1	1	1	3	1	...
Pseudosmittia sp.	..	...	...	...	3	...	3	33	74	2	...	...
Chironominae												
Tendipes attenuatus (Walk.)	83	16	7	1	8	13	24	11	18	10	16	216
Glyptotendipes sp.	2	1	...	...	...	...	...	1	...	...	1	...
G. nr. *senilis* (Joh.)	5	142	1	2	3	8	1	6	15	54	27	57
Cryptochironomus nr. *fulvus* (Joh.)	19	43	32	16	14	10	3	7	12	15	19	53
Stictochironomus devinctus (Say)	2	48	11	3	7	3	2	3	7	7	39	108
Calopsectra nr. *guerla* Roback	1	62	111	5	10	1	1	4	20	36	28	16
Polypedilum illinoense (Mall.)	2	1	2	2	29	1	1	1	1	2	8	36
P. halterale (Coq.)	6	8	21	3	8	5	2	6	6	14	18	18
P. parascalaenum Beck	..	...	5	...	...	1	...	1	...	1	1	...
Dicrotendipes sp.	1	2	...	1	3	3	12	12	13	41	5	7
Harnischia nr. *pseudotener* (Goetg.)	2	51	6	1	...	1	...	...	...	1	1	5
Tanytarsus flavipes (Meig.)	..	...	...	...	...	...	1	1	2	1	3	6
Pseudochironomus fiulviventris (Joh.)	..	...	...	...	...	...	1	...	...	...	...	1
Paratendipes albimanus (Meig.)	..	...	...	...	...	...	...	...	...	...	133	...
Stenochironomus sp.†	1	...	...	...	...	...	...	...	...	...	...	...

* Rounded off to the nearest whole number.
† Collected only in riffles.

The Orthocladiinae were most abundant during winter or early spring, and were absent or sparsely collected during summer and fall.

Chironominae were most numerous during spring and/or summer, but most species were collected during all seasons.

Mollusca

Gastropoda: *Physa anatina* Lea was collected from all stations and during all months except September following a flood. Highest annual density occurred in 4th order streams (Table 2), and highest monthly density (44/m^2) occurred during October when many young specimens were present.

Lymnaea humilis (Say) was collected in 3rd, 4th and 5th order streams during winter and fall months. It was collected from more 4th order stations, but highest annual density occurred in 3rd order stations (Table 2). Hoff (1937) reported that distribution of *L. humilis* exhibited a temperature controlled amphibious cycle in Illinois. He reported the species to be truly aquatic during the winter months, amphibious during early spring, and terrestrial from late spring until rains occur. The amphibious part of the cycle occurred when the air temperature rose above 4 or 5°C and returned when it fell below that figure. This could explain the absence of these snails from Otter Creek during the spring and summer months.

Helisoma anceps (Menke) was collected from stations 14(3), 15(4), 17(4), 10(4) and 21(5) indicating a preference for conditions in 4th order streams (Table 2). Seasonally it occurred during fall, winter and spring. The shells were always covered with a species of *Cladophora* as previously reported by Branson (1961).

Ferrissia shimekii (Pilsbry) was collected at station 3(3) during winter and spring and at station 9(4) during June. A single specimen was taken from a riffle at station 4(6) during April.

Pelecypoda: *Sphaerium transversum* (Say) was collected at all stations except 14(3), 13(3), 12(3), 11(3), and 10(4). Annual density increased from 2/m^2 in 3rd order stations to 43/m^2 in 5th order streams, then decreased to 30/m^2 in the 6th order stream where siltation increased (Table 2). Numbers were low during winter and high during summer. A density of 570/m^2 occurred at station 21(5) during May.

Uniomerus tetralasmus (Say) was collected at stations 15(4), 21(5), 22(5), 2(6) and 1(6) during spring and summer. Although no live specimens were taken from stations on the east fork of the basin, several valves were found in the channels.

Verifications of invertebrate determinations were made by William F. Hahnert, Hirudinea; Walter J. Harman, Naididae; Carl F. Prophet, Conchostraca; Jay R. Traver, Ephemeroptera; Edward J. Kormondy, Odonata; Kurt F. Schaefer, Hemiptera; Paul J. Spangler, Dytiscidae, Halipidae, Helodidae, Hydrophilidae, and Gyrinidae; Ralph M. Sinclair, Elmidae; C. Dennis Hynes, Tipulidae; Selwyn S. Roback, Chironomidae; Willis W. Wirth, Ceratopogonidae; Alan Stone, Culicidae; Harold D. Murray, Gastropoda and Unionidae; and H. B. Herrington, Sphaeriidae. The study was supported by Public Health Service Research Fellowship 5-F1-WP-23, 074. Preparation of the manuscript was financed by the Research Council of Lamar State College of Technology.

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