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SPECIES COMPOSITION AND DIVERSITY OF BENTHIC MACROINVERTEBRATE POPULATIONS OF THE PECOS RIVER, TEXAS[1]

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ABSTRACT. A 2 year study (1976–1977) of benthic macroinvertebrates of the Pecos River in western Texas was conducted. Diversity was influenced by season and year, station, and various environmental parameters. Diversity was depressed in the upper reach by high salinity and extreme physiochemical fluctuations, but increased in the lower reach due to freshwater inflow and overall improvement in water quality. Coastal saltwater organisms occurred in the upper reach.

Studies on benthic macroinvertebrate organisms in Texas are inadequate (Hendricks et al. 1969). An acute paucity of such work exists in western Texas, particularly on the Pecos River where previous studies of benthic macroinvertebrates are lacking. The present study was conducted to relate seasonal and annual variation in species composition and diversity of benthic macroinvertebrates in the Pecos River to physicochemical and other ecological factors.

STUDY AREA AND COLLECTION STATIONS. The study area was located on the Pecos River in western Texas (Fig. 1), an arid region in which the average annual rainfall increases downstream from 30 cm at Orla to 41 cm at the mouth (Mendieta 1974). Elevation above mean sea level decreases from 832 m near Orla to 345 m near the mouth about 602 km downstream.

The Pecos River Valley in Texas is physiographically diverse and is recognized as a transitional zone between three biotic provinces, the Chihuahuan to the west, the Kansan to the northeast, and the Balconian to the southeast (Blair 1950). The upper Pecos flows through the Toyah Basin from Red Bluff Reservoir to a point about 35 km south of Girvin, the sediments of which are alluvial deposits of Quaternary age, including unconsolidated to partially consolidated sand, silt, caliche, gypsum, clay, gravel, and boulders (Grozier et al. 1966, 1968). The meandering river channel has long pools formed by gravel bars, rock outcrops,

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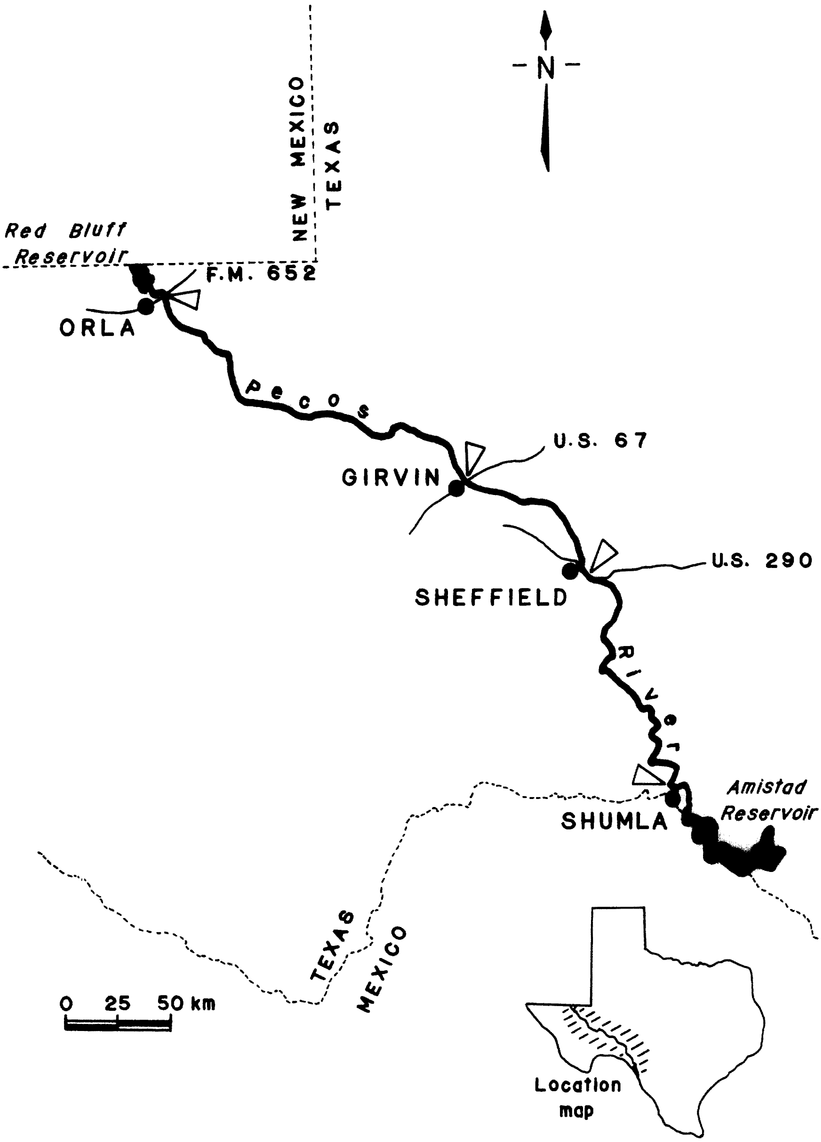

Fig. 1. Pecos River, Texas. Arrows indicate collection stations, which are designated in the text by the name of the nearest town (i.e., Pecos River at Orla, Girvin, Sheffield, and Shumla).

and low diversion dams, and the river banks support dense growths of saltcedar (*Tamarix* spp.).

Two stations were located in the upper reach. One was at Farm Road 652 east of Orla (31° 51′ 21″ N, 103° 49′ 52″ W), 23 river km below Red Bluff Reservoir, in a riffle-run on a hard substratum of gravel, silt, and organic detritus. Widgeon grass (*Ruppia maritima*), the green alga *Cladophora*, and periphytic diatoms, mainly *Synedra*, were usually prevalent on the substratum in the collecting area. The other station was at U.S. Hwy 67 east of Girvin (31° 04′ 46″ N, 102° 21′ 37″ W) at river km 311 in a run on a mucky substratum of thin silt and organic detritus underlain by black clay. Dense growths of filamentous green algae (*Cladophora*, *Vaucheria*, and *Ulothrix*), widgeon grass, and periphyton (*Synedra*) occurred periodically, while at other times the streambed was virtually devoid of vegetation.

The river below the Toyah Basin is deeply incised in Comanchean Cretaceous limestones of the Stockton Plateau, the Trans-Pecos extension of the Edwards Plateau (Spiers and Hejl 1970). Steep limestone bluffs occur on one or both banks in this reach. Saltcedar is common along the banks and extensive growths of cane grass (*Phragmites*) occur near the mouth. The streambed is gravel, cobblestones, and boulders, with gravel bars creating pools which are separated by riffles and runs.

Two stations were located in the lower reach. One was at U.S. Hwy 290 southeast of Sheffield (30° 39′ 34″ N, 101° 46′ 11″ W) at river km 417 in a riffle-run on a streambed of caliche and coarse gravel. Periphyton, mainly diatoms, usually covered the substratum, but the immediate area was devoid of rooted aquatic macrophytes. The other station was at Shumla (29° 48′ 10″ N, 101° 26′ 45″ W) at river km 595 in a riffle-run area on a gravel and sand substratum. Sparse growths of a green filamentous alga (*Zygnema*) and attached diatoms (*Cymbella*) were usually present on the substratum. Shoreline vegetation and aquatic macrophytes were absent at the beginning of the study at Shumla due to scouring by a severe flood in September 1974 (peak discharge, 577,000 cfs; gage height, 22.9 m). By the end of the study, dense stands of cane grass and small numbers of saltcedar saplings were present on the banks, and dense beds of *Chara* and *Potamogeton* were growing in shallow pools and backwaters where recently deposited, finer sediments had accumulated.

A power plant located 1.6 km above the Girvin station is the only wastewater discharger into the Pecos River in Texas, and the small volume of cooling water discharged has no appreciable effect on the river.

METHODS AND MATERIALS. Quarterly benthic macroinvertebrate and water samples were collected at each station from January 1976 through November 1977.

Physicochemical methods. Field physicochemical analyses included dissolved oxygen (modified Winkler method), pH (Sargent Welch Model PB-X pH meter), specific conductance (Hydrolab Model TC-2 conductivity meter), temperature (0–100° C mercury thermometer), and turbidity (Hach DR-EL Field Test Kit). The additional analyses were performed according to standard methods by the Texas Department of Health and San Antonio River Authority laboratories.

Biological methods. All benthic macroinvertebrate samples were taken in riffles and runs in areas as devoid of vegetation as possible using a Surber square foot sampler. Adequate sample size was determined at each station by combining samples until diversity ($\bar{d}$) approached an asymptote, which occurred by the first two accumulated samples at each station. Thereafter, an excessive number of samples (generally four or five) was collected.

Collections were preserved in 5% formalin in the field and rose bengal stain was added to facilitate sorting. Samples were washed in the lab in a U.S. Standard No. 30 sieve and sorted under a 10X dissecting microscope.

Taxonomic treatment of each group was uniform throughout the study. Each level of identification was considered as one taxon for $\bar{d}$ calculations and for determining the total number of taxa in the samples. Chironomid pupae and Nematoda were not identified and were not used in any calculations, nor were colonial coelenterates. Oligochaetes and ostracods were lumped in all samples to maintain uniformity since most samples contained immature individuals which could not be identified.

Diversity was calculated using the equation for $\bar{d}$ described by Wilhm (1967), and redundancy using the equations derived for $\bar{r}$ by Young et al. (1976). The latter equations are useful when the total number of individuals in a sample is small (< 100), as was the case in numerous samples in this study.

PHYSICOCHEMICAL CHARACTERISTICS. High dissolved solids exist in the Pecos River near Orla (Fig. 2). Flow is derived mainly from seepage and seasonal releases from naturally saline Red Bluff Reservoir and highly saline inflow from Screwbean Draw, the only flowing tributary above Sheffield. Water quality was poorer near Girvin due to lack of fresh inflow, concentration of dissolved solids by high evaporation, seepage of saline groundwaters, irrigation return flows, and possible inflow of brine from oilfield activities. Seepage of moderately fresh groundwater below Girvin resulted in some reduction of dissolved solids through dilution. Numerous spring-fed creeks and seepages from Cretaceous aquifers contributed fresh inflow below Sheffield and cumulatively resulted in extensive dilution of dissolved solids in the lower reach (Fig. 2).

Pecos River water was moderately productive (mesotrophic) as indicated by concentrations of chlorophyll *a*, total organic carbon, nitrate nitrogen, and total phosphorus (Fig. 2). Average total organic carbon concentrations were higher at Girvin, probably due mainly to periodic decay of large amounts of aquatic vegetation, and at Orla due mainly to excessive introduction of terrestial plant material. A major source of nitrate nitrogen at Orla and Girvin may be decay of allocthonous organic detritus as indicated by winter peaks during maximal introduction of saltcedar leaves and concurrent elevations in ammonia nitrogen. Ammonia nitrogen was negligible at the two lower stations since most of the discharge originated from springflow. Nitrate nitrogen increased in the lower reach due mainly to inputs by ground-

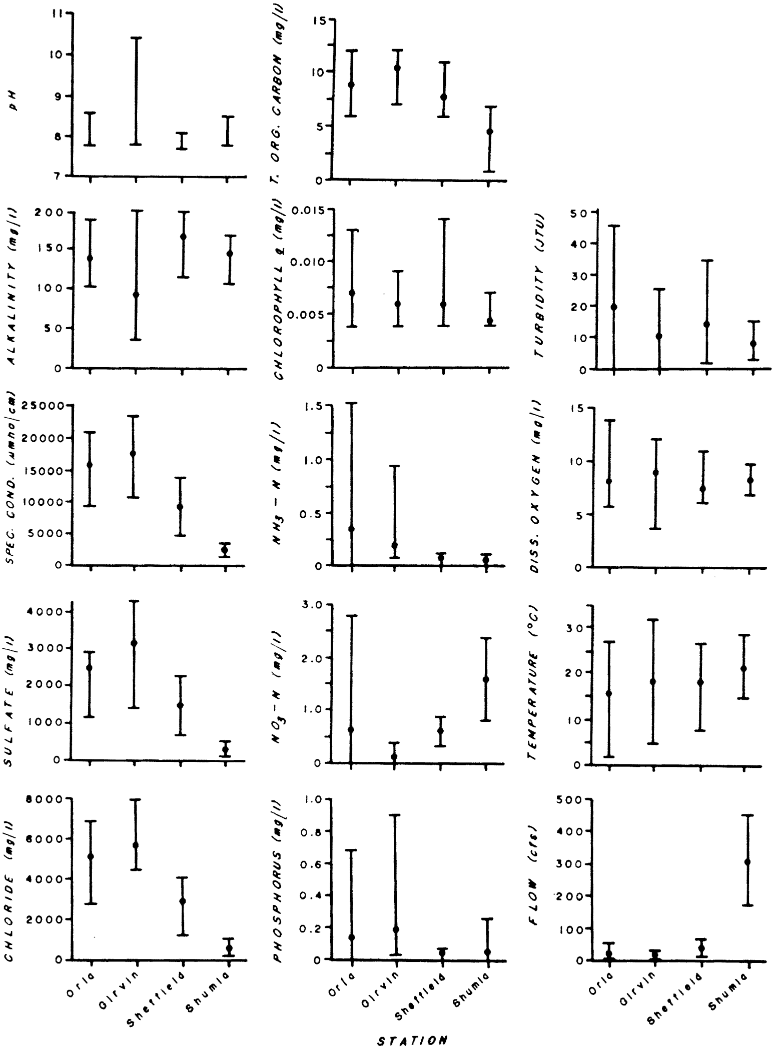

Fig. 2. Means and ranges of physicochemical parameters from four collection stations on the Pecos River, Texas, 1976–1977.

water inflow, a common phenomenon in limestone regions (Wetzel 1975). Nitrate nitrogen in samples from a number of spring-fed tributaries in the lower reach ranged from 1.0–2.6 mg/l in this study and from 0.27–2.93 mg/l in a study by Spiers and Hejl (1970).

Total phosphorus at Orla and Girvin exhibited winter peaks, which implies that decaying allocthonous organic material is a major contributor. Total phosphorus was poor in groundwaters of the lower Pecos River basin ($\leq$0.04 mg/l), which contributed to low phosphorus levels at Sheffield and Shumla since most of the water there is springflow.

A ranking of the stations in decreasing order of trophic condition based on chlorophyll *a*, total organic carbon, and standing crops of aquatic vegetation and benthic macroinvertebrates (Figs. 2 and 3) is Girvin > Orla $\approx$ Sheffield > Shumla. Phosphorus appeared to be the main factor limiting productivity in the river as the density of aquatic vegetation among the stations varied directly with the total phosphorus concentration and independently of the nitrate nitrogen concentration.

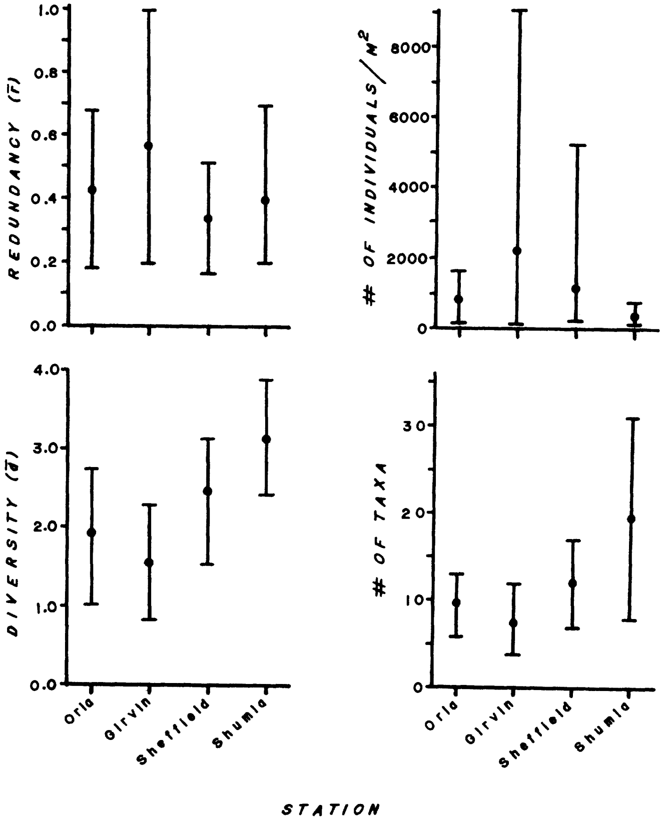

Fig. 3. Means and ranges of benthic macroinvertebrate diversity, redundancy, standing crop, and number of taxa at four collection stations on the Pecos River, Texas, 1976–1977.

Turbidity was highest at Orla due to a preponderance of clay sediments, a brownish staining of the water probably imparted by decaying saltcedar leaves, and moderate density of phytoplankton (Fig. 2). Lower turbidity at Girvin is attributable to decreased velocity and increased salinity which facilitates precipitation of suspended solids (Keeton 1959). Turbidity was higher at Sheffield due to lessened salinity and increased stirring of bottom sediments by greater velocity. Turbidity was low at Shumla due to the limestone substratum and the resultant paucity of finer sediments.

Total alkalinity (as $CaCO_3$) and pH were high and relatively stable at Orla, Sheffield, and Shumla but fluctuated widely at Girvin (Fig. 2). The alkalinity was occasionally low at Girvin, always during heavy aquatic plant growth, with corresponding high pH values (>10). Apparently excessive photosynthesis periodically depleted carbon dioxide which raised the pH, causing precipitation of carbonates and a decrease in alkalinity.

Dissolved oxygen was generally >5.0 mg/l at all stations, although considerable fluctuation occurred at Orla and Girvin during heavy aquatic vegetation growth (Fig. 2). The dissolved oxygen concentration was 3.7 mg/l (42% saturation) at Girvin at 1000 h on 19 April 1977. Dense aquatic vegetation apparently caused this oxygen deficit through nocturnal respiration, and the sag continued into the morning hours due to an overcast sky.

Surface water temperatures progressively increased downstream (Fig. 2) due to climatic warming in a southerly direction.

BIOLOGICAL CHARACTERISTICS. *Diversity.* Mean diversities ($\bar{d}$) at Orla and Girvin (Fig. 3) were depressed due to high salinity and extreme physicochemical fluctuations. Environmental stress limited the number of taxa to 17 at Orla and 21 at Girvin. Typical freshwater organisms such as ephemeropteran nymphs and dryopoid beetles were excluded from the upper reach. Species occurring at Orla and Girvin must withstand extreme salinity changes. The adaptable species often occurred in dominant numbers, depressing diversity and increasing redundancy ($\bar{r}$). Mean diversities at Orla (1.95) and Girvin (1.56) were considerably below the range generally associated with "clean" water streams (2.6–4.0, Wilhm 1970), but were higher than the values usually associated with severe pollution (<1.0).

Mean diversity and the number of taxa (24) increased downstream at Sheffield (Fig. 3), which is indicative of the improvement in water quality (Fig. 2). A few taxa generally associated with freshwater occurred at Sheffield (e.g., *Choroterpes mexicanus, Stenelmis*). The more favorable environment at Sheffield resulted in lower dominance patterns and redundancy (Fig. 3). Greatly improved water quality at Shumla resulted in high mean diversity, a large number of taxa (50), and the presence of many typical freshwater forms (e.g., Ephemeroptera, 8 spp.; dryopoid beetles, 6 spp.; Trichoptera, 9 spp.). Redundancy was relatively low. Mean diversity at Shumla (3.14) fell within the observed range for "clean" water streams, while mean $\bar{d}$ at Sheffield (2.50) approximated the minimum of that criterion.

Seasonally, diversities at Orla, Girvin, and Sheffield generally varied inversely with the macrobenthic standing crop, the number of taxa, and redundancy. This indicates that seasonal changes in $\bar{d}$ at those stations were due more to one or more taxa establishing or losing dominance than to loss or gain in the number of taxa. Conversely, seasonal changes in $\bar{d}$ at Shumla were induced to a greater degree by changes in the number of taxa than by changes in dominance, as $\bar{d}$ varied directly with the number of taxa and $\bar{d}$ and $\bar{r}$ varied more independently.

Annual and seasonal diversity at all stations varied irregularly and exhibited no direct correlation to seasonal physicochemical changes. Diversity at Orla generally varied directly with the duration of constant-volume release from Red Bluff Reservoir prior to sampling. Diversity was usually low at Orla during the irrigation season when reservoir releases were irregular (e.g., July 1976; April 1977), probably due to sudden salinity fluctuations and scouring of the substratum. Such conditions apparently favored a few osmotically adaptable taxa which became dominant. Winter peaks in diversity were preceded by long periods ($\approx$ 70 days) of non-release and stable, low-flow conditions, even though salinity was high during those periods, which suggests that physicochemical fluctuations exerted more influence on diversity at Orla than did absolute chemical concentrations.

Diversities at Girvin were similar in the two winter samples and in the two autumn samples, but varied widely in the spring and summer samples. Diversity seemed to be largely determined by the size of the standing crop and condition (i.e., living or decomposing) of aquatic vegetation. Plant growth was periodically dense, but at other times was sparse or absent. The growth cycle exhibited a vague relationship to the seasons of the year. Moderate aquatic plant density in the autumn supported few taxa and individuals, and $\bar{d}$ and $\bar{r}$ were moderate. Vegetation density peaked in winter, resulting in a large macrobenthic standing crop and a higher number of taxa. Winter diversity was low and redundancy high due to dominance by herbivores, mainly *Tanytarsus* (Jan. 1976, 7284/m^2, 79% of macrobenthos; Jan. 1977, 3391/m^2, 79%). Vegetation was more sparse in the spring due in part to heavy exploitation by herbivores and nutrient depletion, the remaining vegetation being in a state of decomposition. Diversity increased and redundancy decreased in the spring due to increased numbers of detritivores (mainly Oligochaeta) and decreased numbers of herbivores (mainly *Tanytarsus*). By summer, virtually all remaining vegetation had been reduced to organic detritus. Diversity was variable and dependent on the amount of food remaining. The macrobenthic standing crop was meager in July 1976 (23/m^2) due to depletion of organic food material. In July 1977 much organic debris remained which supported high numbers of macrobenthic individuals (2646/m^2). Low diversity and high redundancy resulted from dominance by decaying vegetation feeders (*Berosus* adults, 319/m^2, 12% of macrobenthos) and detrital omnivores (Ostracoda, 2224/m^2, 84%).

Temporal variations in diversity at Sheffield and Shumla were erratic, with greatest year-to-year variations in autumn at Sheffield and in the summer at Shumla. Diversity exceeded 3.0 twice at Sheffield and once in each season (four times) at Shumla.

Macrobenthic standing crop. The density of aquatic vegetation appeared to largely determine the size of the macrobenthic standing crop at all stations. Moderately dense aquatic vegetation year around at Orla supported a moderate macrobenthic standing crop which varied little in size seasonally (Fig. 3). Periodic dense plant growth at Girvin supported a large mean macrobenthic standing crop, with wide seasonal fluctuations in the number of individuals. At Sheffield, primary production, mostly of periphyton, was moderate as was the mean macrobenthic standing crop. Low primary productivity at Shumla led to a small mean macrobenthic standing crop. Narrow seasonal variations in aquatic vegetation density and in the physicochemical environment minimized seasonal fluctuations in the number of individuals at Shumla.

Dominancy and seasonal succession of taxa. Seasonal succession of taxa was low at Orla as the dominant taxa exhibited a high frequency of occurrence, with 12 of the 17 taxa (71%) occurring in over half of the samples (Table 1). Herbivores (*Ithytrichia*, *Tanytarsus*), omnivores (*Cheumatopsyche*, *Dicrotendipes neomodestus*, *Pseudochironomus*), and organic sediment feeders (Oligochaeta) were dominant and comprised 87% of the macrobenthos. Salt-tolerant herbivores

TABLE 1. *Percent of total number of individuals in each locality (numerator) and number of samples occurring in (denominator) for species of benthic macroinvertebrates from the Pecos River. P = Present.*

Taxon	Orla	Girvin	Sheffield	Shumla
	Locality			
COLEOPTERA				
Elmidae				
Elsianus texanus Schaeffer				4.7/8
Hexacylloepus ferrugineus (Horn)				1.7/3
Microcylloepus pusillus (LeConte)				2.0/4
Stenelmis bicarinata LeConte				3.7/6
Stenelmis sp.			< 0.1/1	
Hydrophilidae				
Berosus infuscatus LeConte			P	
Berosus subsignatus LeConte			P	
Berosus spp.	0.9/4	10.9/8	0.4/4	
Limnichidae				
Lutrochus luteus LeConte				2.2/3
Psephenidae				
Psephenus texanus Brown and Arrington				0.2/2
DIPTERA				
Anthomyiidae (family)	0.1/1			
Ceratopogonidae				
Dasyhelea sp.				0.1/1
Palpomyia tibialis (Meigen)	1.5/4	0.1/3	0.1/1	
unid. sp.				1.0/4
Chironomidae				
Ablabesmyia sp.	4.3/4			
Chironomus attenuatus Walker			< 0.1/1	
Chironomus sp.		< 0.1/1		
Cladotanytarsus sp.	0.1/2			
Cricotopus bicinctus (Meigen)	1.9/4	< 0.1/1	18.3/7	1.5/3
Cricotopus sp. II				0.1/1
Dicrotendipes neomodestus Malloch	6.8/6	0.2/1	3.7/6	
Goeldichironomus holoprasinus (Goeldi)			0.1/1	
Microtendipes sp.	0.1/1	3.1/5		

Nilotanypus sp.				0.1/1
Polypedilum digitifer Townes		P		
Polypedilum sp.	0.3/3	0.5/5	0.2/3	0.2/2
Psectrotanypus sp.				0.1/1
Pseudochironomus sp.	9.2/4		27.0/8	0.1/1
Rheotanytarsus sp.				3.4/5
Tanytarsus spp.	21.5/5	55.6/4	1.6/4	1.2/2
Telopelopia okoboji (Walley)			0.4/4	
unid. pupae	P	P	P	P
Dolichopodidae (family)		0/1/2		
Empididae (family)				0.2/1
Simuliidae				
Simulium venustum Say				1.0/2
Tabanidae				
Tabanus sp.			0.2/3	1.6/6
EPHEMEROPTERA				
Baetidae				
Baetis sp.				0.3/3
Baetodes sp.				0.1/1
Caenidae				
Caenis sp.				0.1/1
Leptophlebiidae				
Choroterpes mexicanus Allen			7.6/7	4.6/4
Thraulodes sp.				19.7/7
Traverella sp.				6.4/2
Siphlonuridae				
Isonychia sp.				0.1/1
Tricorythidae				
Tricorythodes sp.				14.8/7
HEMIPTERA				
Corixidae (family)		< 0.1/1		
Naucoridae				
Ambrysus sp.				0.3/2
Cryphocricos sp.		< 0.1/1		6.1/8
Limnocoris sp.				0.8/3
LEPIDOPTERA				
Pyralididae				
Cataclysta sp.			0.1/1	0.4/3
MEGALOPTERA				
Corydalidae				
Corydalus cornutus (Linnaeus)			< 0.1/1	0.5/4
NEUROPTERA				
Sisyridae				
Climacia areolaris (Hagen)				0.1/1
ODONATA				

Coenagrionidae				
Argia translata Hagen			P	
Argia sp.	2.1/5	0.1/1	4.4/8	0.2/1
Enallagma sp.		0.5/3		
Gomphidae				
Erpetogomphus sp.	0.8/3			0.2/2
Gomphus externus Hagen			< 0.1/1	
Libellulidae				
Brechmorhoga mendax (Hagen)				0.9/6
unid. sp. (immature)		< 0.1/1		
TRICHOPTERA				
Hydropsychidae				
Cheumatopsyche spp.	26.2/4	0.2/3	19.8/6	6.7/7
Hydropsyche sp.				0.4/2
Smicridea sp.				0.2/1
Hydroptilidae				
Hydroptila sp.	0.8/5		0.6/5	5.4/4
Ithytrichia sp.	6.5/7	<0.1/1	8.0/8	
unid. sp. (undescribed)			0.1/1	0.1/1
Leptoceridae				
Oecetis avara (Banks)				0.2/2
Philopotamidae				
Chimarra spp.				3.5/7
Psychomyiidae				
(*Cernotina*?) Genus C (Flint)				0.5/3
Rhyacophilidae				
Protoptila sp.				0.2/2
AMPHIPODA				
Talitridae				
Hyallela azteca (Saussure)		2.5/4	< 0.1/1	
OSTRACODA		20.9/6		0.1/1
Cytheridae				
Limnocythere sp.		P		
Cyprideis sp.		P		
HYDRACARINA				
Arrenuridae				
Arrenurus sp.		< 0/1/1		
PORIFERA				
Spongillidae (family)				P
COELENTERATA				
Clavidae				
Cordylophora lacustris Allman	P		P	
NEMATODA				
unid. spp.	P	P	P	P

TURBELLARIA				
Planariidae				
Dugesia tigrina (Girard)				1.1/5
OLIGOCHAETA	16.6/6	5.1/8	5.9/5	0.6/4
Lumbriculidae (family) (immature)				P
Naididae				
Paranais litoralis (Müller)		P		
Tubificidae				
Limnodrilus hoffmeisteri Claparède			P	
L. udekemianus Claparède			P	
Monopylephorus sp. (undescribed)	P	P	P	
GASTROPODA				
Physidae				
Physa virgata Gould		0.1/1	1.5/7	
PELECYPODA				
Corbiculidae				
Corbicula manilensis (Philippi)				0.1/1
Sphaeriidae				
Sphaerium striatinum (Lamarck)				0.6/2

(*Berosus* larvae, *Microtendipes, Tanytarsus, Hyallela azteca*) occurred in high numbers at Girvin, with omnivorous scavengers (Ostracoda, Oligochaeta, and *Berosus* adults) dominant during decay of aquatic vegetation. Those taxa comprised 98% of the macrobenthos. Seasonal succession of taxa was high at Girvin as only seven of the 21 taxa (33%) occurred in half the samples. At Sheffield, 13 of the 24 taxa (52%) occurred in half the samples. Six taxa comprised 87% of the macrobenthos (*Pseudochironomus, Cricotopus bicinctus, Cheumatopsyche, Ithytrichia, Choroterpes mexicanus,* Oligochaeta). More carnivorous taxa were present at Sheffield than upstream (e.g., *Argia, Gomphus, Corydalus cornutus, Telopelopia okoboji, Tabanus*). Seasonal succession of taxa at Shumla was high as only 17 of the 50 taxa (34%) occurred in half the samples, and the number of taxa exhibited extreme seasonal variations. High succession was a function of the variety of life cycles represented and the resultant high rate of appearance/disappearance of species. The six most common taxa (*Thraulodes, Tricorythodes, Cheumatopsyche, Traverella, Cryphocricos, Hy-*

droptila) cumulatively comprised only 59% of the macrobenthos. The remaining 41% included 44 taxa. The presence of many species represented by small numbers of individuals reflects the healthy environment at Shumla.

Distribution of taxa. Few taxa were unique to Orla or Girvin (Table 1). Species in inland saline waters must be almost completely independent of the concentration and ionic composition of the media to be successful under conditions of highly fluctuating salinity (Beadle 1943). Therefore, most of the species at the upper stations were widely distributed in the river except where excluded by other ecological factors (e.g., high competition for limited food, high predation, etc.). Conversely, many species were restricted to the lower reach, their upstream distribution probably limited by salinity.

Salinity tolerance. Almost all Ephemeroptera require freshwater for development (Berner 1975), but one species collected in this study (*Choroterpes mexicanus*) is obviously euryhalinous (tolerating a broad range in salinity) as indicated by its presence at Sheffield and Shumla. Several chironomids collected have been considered oligohalobous (freshwater forms occurring in salinities of <500 mg/l) (Beck 1977). However, their presence in the Pecos River in much higher salinity establishes them as euryhalinous. This group included *Chironomus attenuatus*, *Cricotopus bicinctus*, *Dicrotendipes neomodestus*, *Goeldichironomus holoprasinus*, and *Polypedilum digitifer*. Other chironomid genera whose species have exclusively been classified as oligohalobous were represented in the Pecos River fauna by species which are either mesohalobous (occurring in salinities of 500–30,000 mg/l) or euryhalinous. These Pecos River forms may include differentiated, undescribed species which have evolved to exist under saline conditions. This group included *Ablabesmyia*, *Cladotanytarsus*, *Microtendipes*, *Pseudochironomus*, and *Tanytarsus*. Many of the species at Shumla have been considered freshwater forms, but since salinity there frequently exceeds 500 mg/l, they cannot be considered strictly oligohalobous.

Locality records. The oligochaete, *Paranais litoralis*, is well known from Europe and North America, but in most previous collections has been coastal or under the influence of coastal saltwater intrusion. Its occurrence in the Pecos River at Girvin is only the third inland record in the world (Harman et al. 1979). A rare oligochaete, *Monopylephorus* sp., was collected at Orla, Girvin, and Sheffield, being previously known from swamps in southeastern Louisiana (Harman et al. 1979). *Monopylephorus* sp. occurs among the roots of aquatic plants and its presence appeared to be associated with a coastal macrophyte found extensively in the upper Pecos River, widgeon grass (*Ruppia maritima*). This macrophyte is uncommon inland, and previous Texas records are from the coast (Gould 1975).

Two ostracods from Girvin included *Cyprideis* sp., a non-swimming genus characteristic of brackish water, and *Limnocythere* sp., a minute, mud-crawling form morphologically similar to a species from Long Island, New York (I. G. Sohn, pers. comm.). The naucorid hemipterans *Cryphocricos* and *Limnocoris* were common in the lower river, each having been reported previously from single localities in the U.S. (J. T. Polhemus, pers. comm.). Pecos River naucorids are currently being studied in detail by the author. The rare trichopteran *Ithytrichia* was common in the upper reach, and specimens contributed to the National Museum of Natural History were the first larvae to be deposited there (O. S. Flint, Jr., pers. comm.).

The colonial coelenterate *Cordylophora lacustris* was collected at Orla and Sheffield and these are among the first Texas records (McClung et al. 1978). The Asiatic clam, *Corbicula manilensis*, was collected at Shumla, the first record of this widely distributed exotic from the Pecos River. This pelecypod is common below Shumla in Amistad Reservoir and the adjacent Rio Grande (pers. obs.). Freshwater sponges (Spongillidae) were common at Shumla and supported the parasitic neuropteran, *Climacia areolaris*.

Two undescribed species were collected. A larval hydroptilid trichopteran from Sheffield and Shumla is unique in its case construction, the case being translucent, purselike, and remotely similar to that of *Ithytrichia* pupae. It belongs to the Hydroptilidae group containing *Neotrichia* and *Mayatrichia*, but at present cannot be placed more closely (O. S. Flint, Jr., pers. comm.). The oligochaete *Monopylephorus* sp. from the upper Pecos River is currently being described by M. S. Loden (Harman et al. 1979).

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LITERATURE CITED

BEADLE, L. C. 1943. Osmotic regulation and the faunas of inland waters. Biol. Rev. 18:172–183.

BECK, Jr., W. M. 1977. Environmental requirements and pollution tolerance of common freshwater Chironomidae. U.S. Environ. Prot. Agen., Cincinnati, 261 pp.

BERNER, L. 1975. Ephemeroptera. Pp. 123–132, *in* Keys to the water quality indicative organisms of the southeastern United States. (F. K. Parrish ed.) U.S. Environ. Prot. Agen., Cincinnati.

BLAIR, W. 1950. The biotic provinces of Texas. Texas J. Sci. 2:93–117.

GOULD, F. W. 1975. Texas Plants: A Checklist and Ecological Summary. Texas Agr. Exp. Stat., College Station, Texas, 121 pp.

GROZIER, R. U., H. W. ALBERT, J. F. BLAKEY, AND C. H. HEMBREE. 1966. Water-delivery and low-flow studies, Pecos River, Texas, quantity and quality, 1964 and 1965. Rep. 22, Texas Water Develop. Bd., Austin.

GROZIER, R. U., H. R. HEJL, Jr., AND C. H. HEMBREE. 1968. Water-delivery study, Pecos River, Texas, quantity and quality, 1967. Rep. 76, Texas Water Develop. Bd., Austin.

HARMAN, W. J., M. S. LODEN, AND J. R. DAVIS, 1979. Aquatic Oligochaeta new to North America with some further records of species from Texas. Southwest. Nat. 24:509–525.

HENDRICKS, A., W. M. PARSONS, D. FRANCISCO, K. DICKSON, D. HENLEY, AND J. K. G. SILVEY. 1969. Bottom fauna studies of the lower Sabine River. Texas J. Sci. 21:175–187.

KEETON, D. 1959. Limnological effects of introducing oil field brines into farm ponds to reduce the turbidity. Rep. 72, Oklahoma Fish. Res. Lab.

McCLUNG, G. D., J. R. DAVIS, D. COMMANDER, J. PETTITT, AND E. C. COVER. 1978. First records of *Cordylophora lacustris* Allman, 1871 (Hydroida: Clavidae) in Texas with morphological and ecological notes. Southwest. Nat. 23: 363–370.

MENDIETA, H. B. 1974. Reconnaissance of the chemical quality of surface waters of the Rio Grande Basin, Texas. Rep. 180, Texas Water Develop. Bd., Austin.

SPIERS, V. L., AND H. R. HEJL, Jr. 1970. Quantity and quality of low flow in the Pecos River below Girvin, Texas, February 6–9, 1968. Rep. 107, Texas Water Develop. Bd., Austin.

WETZEL, R. G. 1975. Limnology. W. B. Saunders Co., Philadelphia, 743 pp.

WILHM, J. L. 1967. Comparison of some diversity indices applied to populations of benthic macroinvertebrates in a stream receiving organic wastes. J. Water Poll. Contr. Fed. 39:1673–1683.

WILHM, J. L. 1970. Range of diversity index in benthic macroinvertebrate populations. J. Water Poll. Contr. Fed. 42:221–224.

YOUNG, W. C., D. H. KENT, AND B. G. WHITESIDE. 1976. The influence of a deep storage reservoir on the species diversity of benthic macroinvertebrate communities of the Guadalupe River, Texas. Texas J. Sci. 27:213–224.