THE MAYFLY NYMPHS (INSECTA: EPHEMEROPTERA)

OF THE GUADALUPE RIVER BASIN, TEXAS

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INTRODUCTION

The Ephemeroptera, commonly called mayflies, are widely distributed insects that spend a majority of their life cycle as aquatic nymphs, emerging as a winged immature, the sub-imago, which molts to form the winged adult. Recently, pollution studies have focused attention on the use of mayflies in assessing stress on aquatic habitats. Therefore, organisms must be identified as completely as possible. Dispersion of these organisms has been influenced by many factors, especially latitude, intensifying the value of regional population studies.

A review of the literature concerning aquatic insects in the Guadalupe, San Antonio, and Nueces river basins of Texas (Longley, 1973) revealed a scarcity of published works on mayflies and other aquatic insects. The available literature comes mainly from industrial monitoring programs and academic regional distribution studies. A 25-year monitoring program by the E.I. du Pont de Nemours Company, performed by the Academy of Natural Sciences of Philadelphia (ANSP) utilized four sample stations; one near Seguin, Texas, and the remaining three in the area of a du Pont plant outfall near Victoria, Texas (ANSP, 1949; ANSP, 1963). Moore (1950) reported nymphs of several mayfly species found on a field trip into Central Texas. A species diversity study by Kent (1971) listed nymphs of several mayfly genera in the region of Canyon Reservoir. Intensive work on the Leptophlebiidae by Allen, 1973; Brusca and Allen, 1973; Cohen and Allen, 1972; and Traver and Edmunds, 1967, has shown new species and new distributions of

mayflies. In almost all cases, the available literature related findings in the major streams, with little published data concerning the mayfly fauna of the minor creeks and streams and their drainage systems.

The study area is on the boundary of the nearctic and neotropical zoogeographic realms making its geographic location significant in the distribution of mayflies. Allen and Brusca (1973) illustrated the seven major dispersal patterns of the Mexican mayfly genera into North America. Texas is on the migration path of most of their dispersal routes and the Guadalupe River Basin, which extends from the Gulf of Mexico north-westward to beyond the longitudinal mid-line of the State, is well situated for intensive ecological, taxonomic, and distributional investigations into the current status of many of the genera listed by Allen and Brusca (1973). The fauna of streams in Texas had not received any intensive investigation prior to 1973.

This study should provide baseline data on the mayfly fauna of the Guadalupe River Basin of Texas (Figure 1). Descriptions of the Guadalupe River Basin were found in Young et al. (1973), Kuehne (1955), Truett and Gallaway (1975), and Bayer (1975). Biotic and abiotic components of the entire basin were analyzed to provide data for correlation of ecological distributions of organisms with the habitat. Illustrations and a key are provided to facilitate future identification. From this study, priorities may be established for further work on the taxonomy and distributions of mayflies of the region.

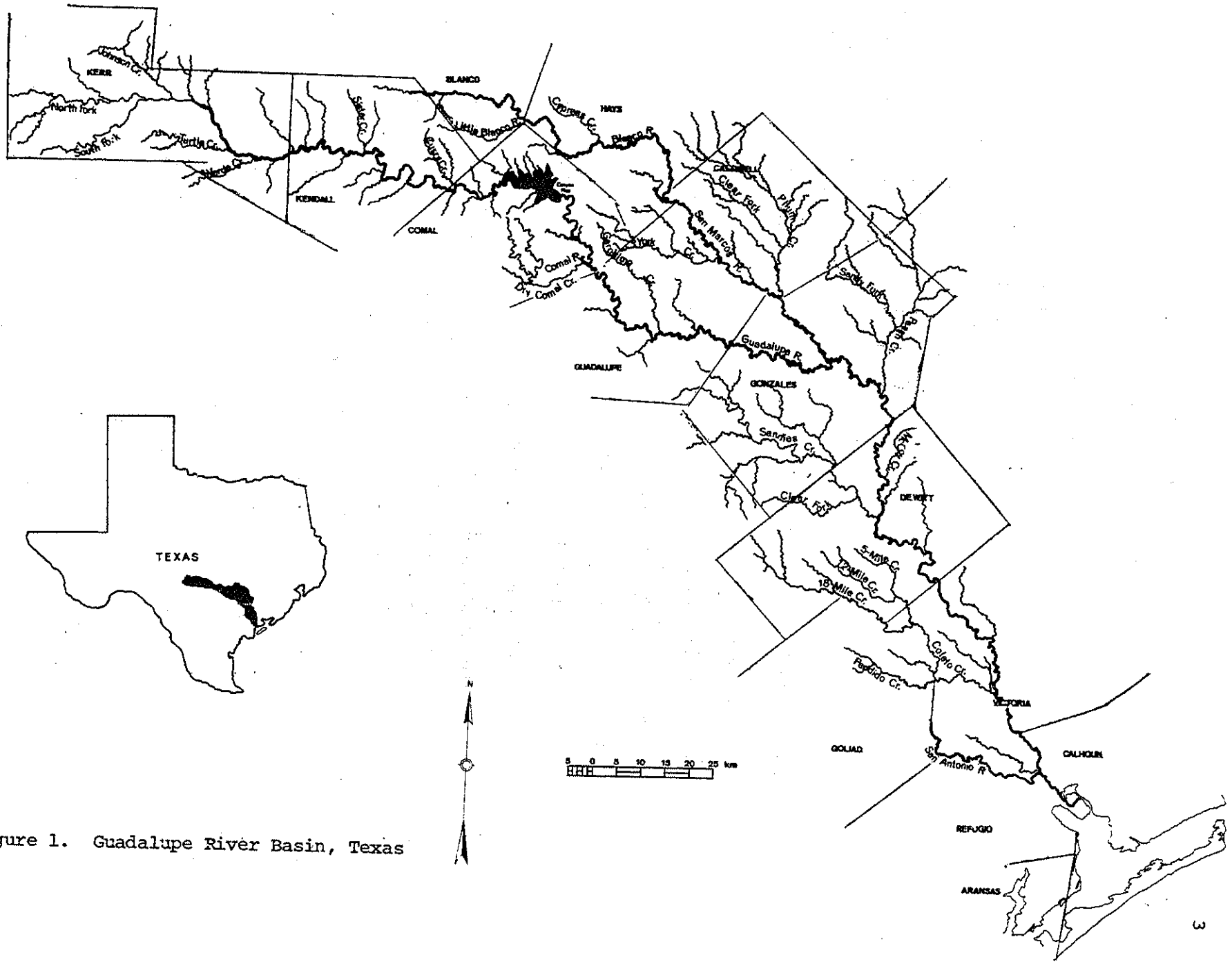


Figure 1. Guadalupe River Basin, Texas

METHODS AND MATERIALS

Sixty-two sample sites were visited from one to four times between January, 1973, and August, 1974 (Figure 2). Table 1 lists the stations and gives the location of each. Most sites were at highway crossings and an attempt was made to adequately sample each stream, from source to mouth. All distances are reported in river kilometers (RK) from the mouth to the source as shown on 1:24,000 scale maps prepared by the U.S. Geological Survey.

Sampling techniques varied with the substrates and habitats found at each sample site. Hand nets, constructed by tacking plastic window screening between two poles, were stretched across a portion of the stream and held at an angle to the substrate by one worker while another kicked upstream rocks, gravel, or other substrate, dislodging organisms into the current, which carried them into the netting. The net was taken to the streambank and the organisms removed. The largest, oldest organisms were selected to aid identifications but smaller organisms were included to obtain the various instars. A similar method of collection was used in streams with a larger percentage gravel substrate. A D-frame net was held with the flat portion on the stream bottom and the gravel upstream from the opening disturbed by kicking, which allowed the current to carry dislodged organisms into the net. The catch was dumped into white porcelain pans and the organisms were separated from the debris and accumulated gravel. These nets were also used to sample exposed roots and vegetation. An Ekman dredge was used to sample deeper streams and lakes.

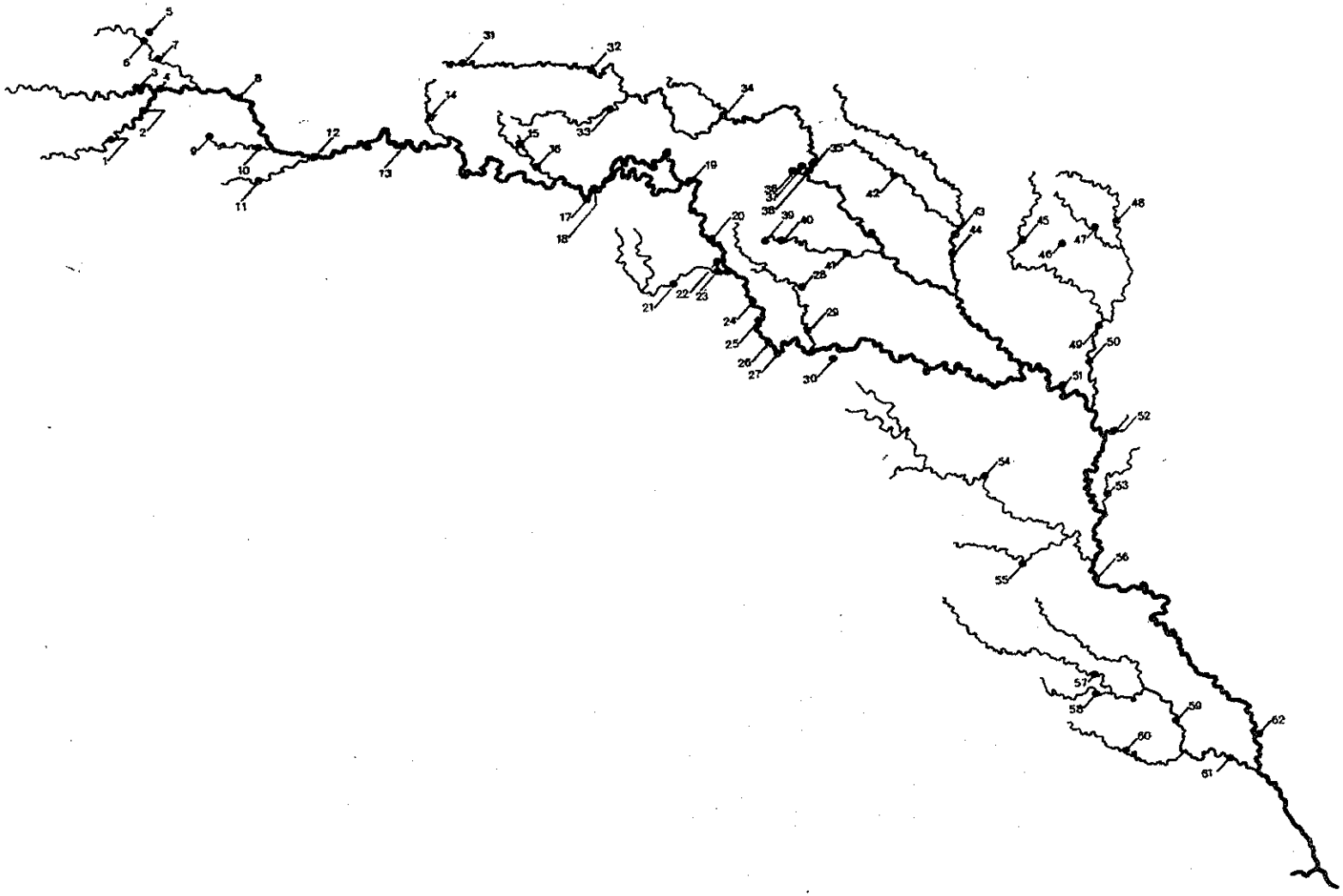


Figure 2. Location of collections

Table 1. Location of collection stations

Station	County	Stream or pond	Road Crossing Location or Coordinates
1	Kerr	South Fork of Guadalupe River	FM 39
2	Kerr	South Fork of Guadalupe River	FM 39
3	Kerr	North Fork of Guadalupe River	FM 1340
4	Kerr	Guadalupe River	FM 39
5	Kerr	Fessenden Creek	State Fish Hatchery
6	Kerr	Johnson Creek	30° 09' 44" N 99° 21' 49" W
7	Kerr	Johnson Creek	30° 07' 06" N 99° 18' 20" W
8	Kerr	Guadalupe River	SH 16
9	Kerr	Turtle Creek	FM 2771
10	Kerr	Turtle Creek	FM 1273
11	Kerr	Verde Creek	SH 173
12	Kerr	Guadalupe River	Center Point

Table 1. Continued

Station	County	Stream or pond	Road Crossing Location or Coordinates
13	Kendall	Guadalupe River	Waring
14	Kendall	Sister Creek	FM 473
15	Kendall	Sheps Creek	FM 473
16	Kendall	Curry Creek	FM 3160
17	Comal	Guadalupe River	US 281
18	Comal	Guadalupe River	FM 311
19	Comal	Guadalupe River	Below Canyon
20	Comal	Guadalupe River	29° 45' 39" N 98° 48' 20" W
21	Comal	Dry Comal Creek	29° 40' 08" N 98° 11' 45" W
22	Comal	Comal River	29° 42' 38" N 98° 07' 44" W
23	Comal	Comal Springs	29° 42' 54" N 98° 07' 52" W
24	Guadalupe	Guadalupe River	29° 39' 05" N 98° 03' 31" W

Table 1. Continued

Station	County	Stream or pond	Road Crossing Location or Coordinates
25	Guadalupe	Lake McQueeney	Guadalupe River near Seguin
26	Guadalupe	Trainer's Pond	29° 33' 41" N 98° oo' 46" W
27	Guadalupe	Meadow Lake	Guadalupe River near Seguin
28	Guadalupe	Moltz's Pond	29° 42' 22" N 97° 58' 34" W
29	Guadalupe	Geronimo Creek	FM 20
30	Guadalupe	Ullrich's Pond	29° 31' N 97° 51' W
31	Kendall	Blanco River	near FM 1886
32	Blanco	Blanco River	FM 165
33	Blanco	Little Blanco River	RR 12
34	Hays	Blanco River	RR 12
35	Hays	Blanco River	IH 35 to SH 80
36	Hays	Aquatic Station Pond	29° 53' 29" N 97° 56' 02" W
37	Hays	San Marcos River	Cheatham Street

Talbe 1. Continued

Station	County	Stream or pond	Road Crossing Location or Coordinates
38	Hays	Blanco River	29° 52' N 97° 55' W
39	Comal	Temporary Pond D-Bar Ranch	29° 48' 01" N 98° 02' 07" W
40	Comal	York Creek	IH 35
41	Guadalupe	York Creek	FM 20
42	Caldwell	Clear Fork of Plum Creek	near FM 20
43	Caldwell	Plum Creek	near SH 86
44	Caldwell	Plum Creek	FM 1322
45	Caldwell	Sandy Fork of Peach Creek	near FM 1386
46	Gonzales	Farm Pond	29° 44' N 97° 23' W
47	Gonzales	Copperas Creek	FM 1115
48	Fayette	Peach Creek	FM 1115
49	Gonzales	Peach Creek	FM 532
50	Gonzales	Peach Creek	US 90A
51	Gonzales	Guadalupe River	US 183
52	Gonzales	Boggy Creek	FM 443
53	DeWitt	McCoy Creek	US 183

Table 1. Continued

Station	County	Stream or pond	Road Crossing Location or Coordinates
54	Gonzales	Sandies Creek	FM 1116
55	DeWitt	Clear Creek	US 87
56	DeWitt	Guadalupe River	FM 766
57	DeWitt-Goliad	15 mi. Coleto Creek	US 183
58	Goliad	18 mi. Coleto Creek	US 183
59	Goliad	Perdido Creek	FM 622
60	Goliad	Perdido Creek	FM 622
61	Victoria	Coleto Creek	US 77
62	Victoria	Guadalupe River	City Park

The organisms were picked from the collecting pans using eye-droppers and forceps and placed in plastic vials containing 95% ethanol. The vials were taken to the lab where they were further sorted and the organisms placed into 70% ethanol for permanent storage. Preservation in the field with 70% ethanol resulted in extremely fragile, soft specimens that would not withstand the rigors of handling during the process of identification. Imagoes and sub-imagoes were preserved immediately in 70% ethanol.

Identification was based on keys found in several sources: Edmunds (1959); Traver (1935); Burks (1953); Day (1956); and Berner (1950). Generic revisions, species descriptions, and distributional studies by various authors were also used. Verification was done by Dr. George F. Edmunds, Jr. (University of Utah) and Dr. R.K. Allen (State University of California at Los Angeles).

Water samples were collected at the same time as benthic samples. Several parameters were measured at each site. Specific conductance (25 C) was determined with a temperature compensated Beckman RB3 Solu-Bridge conductivity meter. A Corning model 175 Portomatic pH meter was used to determine the hydrogen ion concentration. Air and water temperatures were determined by a standard Celsius thermometer. Water velocity was estimated by the floating chip technique. Wind velocity was measured with a Dwyer wind meter. Alkalinity was determined in the laboratory from samples collected in polyethylene bottles and held on ice during transit. Total alkalinity was determined on the field samples by titration to the methyl orange end point (APHA, 1976).

RESULTS AND DISCUSSION

This section consists of a taxonomic discussion of all organisms found during the study period and a key to the species, and, in some cases, subspecies of nymphal Ephemeroptera. The suprageneric classification employed is that of Edmunds and Traver, 1954.

Taxonomic and Distribution Discussion

SUPERFAMILY HEPTAGENIOIDEA

Family Siphlonuridae

Genus *Isonychia* Eaton

Isonychia sicca manca Eaton

Isonychia sicca manca was described by Eaton (1871). The type locality given was "Texas." McDunnough (1931c) reported that the specimen used by Eaton was a female adult collected in Bosque County by Belfrage. McDunnough (1931c) also relegated *I. manca* as a subspecies of *I. sicca*.

Moore (1950) reported finding *Isonychia aurea* Traver at Stations 34 and 36 of this study. At the time of his study, the most used key was that of Traver (1935). This key was not sufficiently selective to differentiate between *I. aurea* and *I. sicca*. *Isonychia sicca manca* was the only form of this genus collected in intensive collecting trips by Dr. Kenneth W. Stewart (personal communication), North Texas State University, at any point in central and south Texas. The genus *Isonychia* was reported in the Canyon Reservoir area by Kent (1971). The specimens collected by Kent have been examined and identified as *Isonychia sicca*

manca. There were no published species records of Isonychia sicca manca in the Guadalupe River Basin.

The organisms collected during this study were most often found in sites of swift (5-10 km/hr) water on a hardpan or rubble substrate. The distribution of this organism is given in Figure 3.

Collection records:

TEXAS: Kerr County; North Fork of the Guadalupe River; 10 km W Hunt; 24 II 73 MP; 12 III 74 MP. TEXAS: Kerr County; Guadalupe River; SH 16 Crossing; 25 II 73 MP; 27 VII 73 MP; 12 IV 74 MP; TEXAS: Kerr County; Turtle Creek; FM 2771 Crossing; 28 VII 73 MP; 1 II 74 MP. TEXAS: Kerr County; Center Point dam; 28 VII 73 MP; 1 II 74 MP. TEXAS: Kerr County; Verde Creek; SH 16 Crossing; 1 II 74 MP. TEXAS: Kerr County; FM 1273 crossing; 2 II 73 MP; 24 VIII 73 MP. TEXAS: Kerr County; Johnson Creek; Mr. Keith Meadows property; 12 VII 73 MP; 12 III 74 MP. TEXAS: Kendall County; Guadalupe River; Waring Crossing; 25 II 73 MP; 19 I 74 MP. TEXAS: Kendall County; Sister Creek; FM 473 crossing; 25 II 73 MP; 19 I 74 MP. TEXAS: Kendall County; Curry Creek; FM 3160 crossing; 19 I 74 MP. TEXAS: Kendall County; Blanco River; 8 km upstream from Blanco Co. line; 15 VIII 73 MP. TEXAS: Blanco County; Blanco River; FM 165 crossing; 5 II 73 MP; 15 VIII 73 MP. TEXAS: Blanco County; Little Blanco River; SH 32 Crossing; 28 VII 73 MP; 19 XI 73 MP. TEXAS: Comal County; Hueco Springs Road crossing 15 VIII 73 MP; 27 XII 73 MP. TEXAS: Comal County; Guadalupe River; FM 311 Crossing; 15 VIII 73 MP; 27 XII 73 MP. TEXAS; Comal County; Guadalupe River; US 281 Crossing; 16 III 73 MP. TEXAS; Comal County; Comal River; Landa Park Railroad Trestle; 16 III 73 MP. TEXAS: Hays County; Cypress Creek-Blanco River Confluence; 5 III 73 MP. TEXAS: Hays County; Blanco River; RR 12 Crossing; 19 XII 73 MP. TEXAS: Hays County; San Marcos River; Cheatham St. bridge; 27 I 73 MP. TEXAS; Hays County; Blanco River; Green Valley Crossing; 8 VI 73 MP. TEXAS: Caldwell County; Clear Fork of Plum Creek; Road crossing north of SH 20 County; Plum Creek; Longitude 97 34' Latitude 29 47'; 16 VIII 73 MP. FM 183; 17 V 73 MP; 18 I 74 MP. TEXAS: Caldwell County; Plum Creek; Road crossing off FM 1386; 17 I 74 MP. TEXAS: Guadalupe County; Geronimo Creek; SH 20 crossing; 18 V 73 MP; 16 VIII 73 MP. TEXAS; Guadalupe County; York Creek; SH 20 Crossing; 16 VIII 73 MP. TEXAS; Gonzales County; Sandies Creek; FM 1115 crossing; 15 III 73 MP; 7 IV 74 MP. TEXAS: Gonzales County; Guadalupe River; US 183 Crossing; 15 III 73 MP; 7 IV 74 MP. TEXAS: Gonzales County; Peach Creek; FM 532 Crossing; 7 IV 74 MP. TEXAS: Gonzales County; Peach Creek; US 90-A Crossing; 7 IV 74 MP. TEXAS; Gonzales County; Boggy Creek; FM 443 Crossing; 16 VII 73 MP. TEXAS: DeWitt County; Clear Creek; US 87 crossing; 24 VIII 73 MP. TEXAS: Victoria County; Guadalupe River; Victoria City Park; 14 III 73 MP. 23 VIII 73 MP. TEXAS: Victoria County; Coleto Creek; US 77 Crossing; 23 VIII 73 MP. TEXAS: Goliad County; Fifteen Mile Coleto Creek; US 87 Crossing; 2 II 74 MP; 24 VIII 73 MP. TEXAS: Goliad County; FM 662 Crossing; 2 II 74 MP.

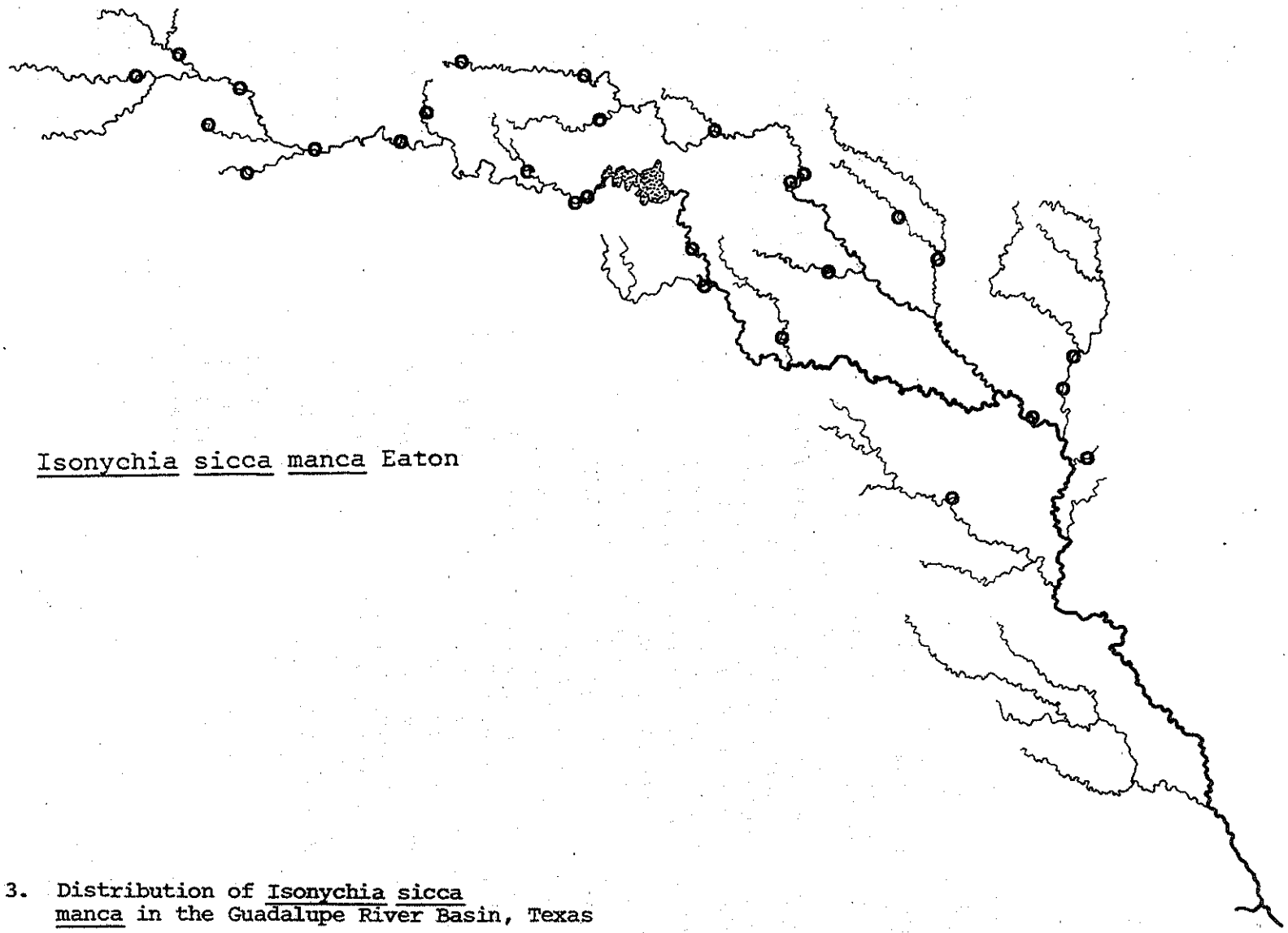


Figure 3. Distribution of Isonychia sicca manca in the Guadalupe River Basin, Texas

Family Oligoneuriidae

Homeoneuria Eaton

Homeoneuria sp.

The genus Homeoneuria Eaton was thought to be strictly south american at the time Traver's work (1935) was published. There was no mention of the genus in the works of Burks (1953) and Berner (1950). The discussion of the genus by Edmunds, et al. (1958) is the most comprehensive work currently available for identification purposes. The nymph of this genus is distinguished from other genera in the subfamily by the absence of a fimbrate portion in the gills on abdominal segments two through seven (Edmunds, 1961).

Existing records for the genus in Texas are limited to the Guadalupe River Basin (Edmunds, et al. 1958). Their paper cites a collection locality on the Guadalupe River downstream from Station 62 of this study. The nymphs were neither identified to species at that time nor described as a new species.

One specimen was found at Station 61 during this study. The sampling site was very near the collecting site of Edmunds, et al. (1958). The collection locality was a broad peneplain of sand, braided with numerous narrow, shallow channels around one main channel approximately 3 m deep. The nymph was found in the sand near concrete bridge pilings. This site was afforded almost constant shade.

Collection records:

TEXAS: Victoria County; Coleto Creek; US 77 Crossing; 23 VIII 73 MP.

Family Heptageniidae

Genus Heptagenia Walsh

Heptagenia flavescens Walsh

The genus Heptagenia Walsh is differentiated from Stenonema Traver by the presence of a gill on the seventh abdominal segment that is very similar to the gills on the preceeding segments. The species Heptagenia flavescens is separated by the absence of denticles on the tarsal claws and by the distinctive markings on the ninth sternite. The only record of this genus is an adult collected by V.A. Little (College Station, Texas) and placed in the Cornell University collection (Traver, 1935).

Heptagenia flavescens was found at station 61, in moderate numbers during one visit. This station has been described previously.

Collection records:

TEXAS: Victoria County; Coleto Creek; US 77 Crossing; 15 III 73 MP.

Genus Stenacron Jensen

Stenacron heterotarsale (McDunnough)

This species originally described by McDunnough as a species of Ecdyonurus (McDunnough, 1933), was transferred to the genus Stenonema by Traver (1935). The latest revision of the genus placed this species in a new genus Stenacron (Jensen, 1974). The descriptions of McDunnough and Traver were based on the imago and there is no record of a nymphal description, although keys have been constructed that identify the nymph of Stenacron heterotarsale.

There are no prior records of Stenacron or the Stenonema interpunctatum group from the Guadalupe River Basin or Texas. Traver (1935)

gave the eastern United States as the group's distribution range.

This study recorded Stenacron heterotarsale throughout the basin at scattered locations. The species was recorded once in the Guadalupe River, at the confluence of the North and South Forks (station 4). All other locations were in tributaries with moderate current (0.5-5 km/hr), gravelly to sandy substrates, and scattered to moderate macrophyte growth. Apparently, the individuals of this species are much more selective for the microhabitat than are the other Stenonema species found in the basin. A distribution map is given in Figure 4.

Collection records:

TEXAS: Kerr County; Confluence of North and South Forks of Guadalupe River; 24 VII 73 MP. TEXAS: Kerr County; Fessenden Creek; State Fish Hatchery Road; 27 VII 73 MP. TEXAS: Hays County; Blanco River; RR 12 Crossing; 7 III 73 MP. TEXAS: Caldwell County; Clear Fork of Plum Creek; Road Crossing from SH 20; 16 VIII 73 MP; 18 I 74 MP. TEXAS: Caldwell County; Plum Creek; Road crossing off of FM 1386; 17 I 74 MP. TEXAS: Gonzales County; Peach Creek; US 90-A Crossing; 7 IV 74 MP. TEXAS: Sandies Creek; FM 1115 Crossing; 17 V 73 MP; 16 III 73 MP; 24 VIII 73 MP. TEXAS: Fayette County; Peach Creek; FM 1115 Crossing; 15 III 73 MP. TEXAS: DeWitt County; Clear Creek; US 87 Crossing; 24 VIII 73 MP. TEXAS: Goliad County; Fifteen Mile Coleto Creek; US 183 Crossing; 2 II 74 MP.

Genus Stenonema Traver

The Stenonema species are very difficult to identify using existing keys. This genus may not be fully differentiated at the present time since intergrades are common (Lewis, 1969). A species-complex may exist since much variation in morphological characters was noted. Two species verified for the Guadalupe River Basin were Stenonema femoratum tripunctatum (Banks) and Stenonema ares Burks. They are differentiated by the shape of the abdominal gills in general and by the gill on abdominal segment 7 in particular.

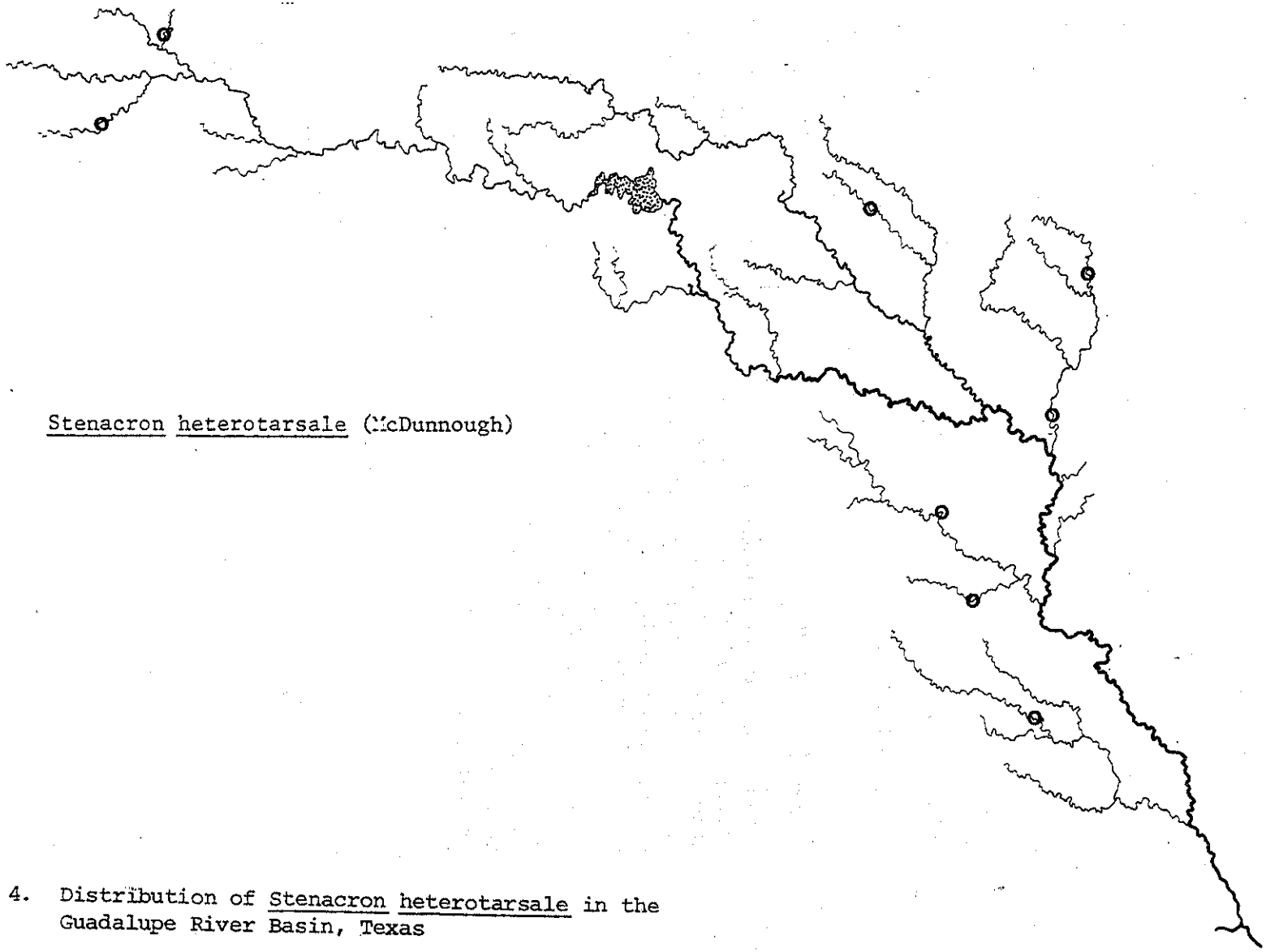


Figure 4. Distribution of Stenacron heterotarsale in the Guadalupe River Basin, Texas

Stenonema femoratum tripunctatum (Banks)

Stenonema f. tripunctatum was listed by Moore (1950) as occurring in the San Marcos River (station 37 of this study) and at Cypress Creek (station 34 of this study). Traver (1935) cited H.B. Parks identification S. f. tripunctatum from north of this study area. Moore (1950) reported a species of the S. tripunctatum group, Stenonema birdi, in a San Antonio River Basin stream.

Stenonema femoratum tripunctatum was found in a wide variety of habitats but seemed to be more common in stream sites with a rubble, gravel substrate and streamside vegetation consisting of brush and trees. A distribution map for this species is given in Figure 5.

Collection records:

TEXAS: Victoria County; Coleto Creek; US 77 Crossing; 2 II 74 MP; 15 III 73 MP. TEXAS: DeWitt County; McCoy Creek; US 183 Crossing; 2 II 74 MP. TEXAS: Hays County; Blanco River; PR 12 Crossing; 7 III 73 MP; 8 III 73 MP. TEXAS: Blanco County; Little Blanco River; SH 32 Crossing; 19 XII 73 MP; TEXAS: Comal County; Canyon Reservoir Tailrace, 16 III 73 MP; TEXAS: Comal County; Guadalupe River; US 281 Crossing; 16 III 73 MP; TEXAS: Comal County; Guadalupe River; FM 311 Crossing; 27 XII 73 MP; TEXAS: Kendall County; Blanco River; 8 km W. of Blanco; 19 XII 73 MP. TEXAS: Blanco River; FM 165 Crossing; 18 II 73 MP; 11 VI 73 MP; TEXAS: Kendall County; Blanco River; 8 km upstream from Blanco County line; 15 VIII 73 MP. TEXAS: Guadalupe River; Center Point; 1 II 74 MP. TEXAS: Kerr County; Verde Creek; SH 173 Crossing; 1 II 74 MP; TEXAS: Kerr County; Johnson Creek; Keith Meadows prop.; 12 VIII 73 MP; TEXAS: Kerr County; Fessenden Creek; State Fish Hatchery Rd.; 27 VIII 73 MP; TEXAS: Guadalupe River; North Fork-South Fork Confluence; 24 II 73 MP; TEXAS: Kerr County; North Fork of Guadalupe River; 8 km W. of Hunt; 27 VII 73 MP; 12 III 74 MP. TEXAS: Kerr County South Fork of Guadalupe River; 9 km SW Hunt; 24 II 73; 12 III 73; 27 VIII 73 MP.

Stenonema ares Burks

This species, and the S. pulchellum group, have not been reported from this region previously. The truncate abdominal gills on segments 2-6

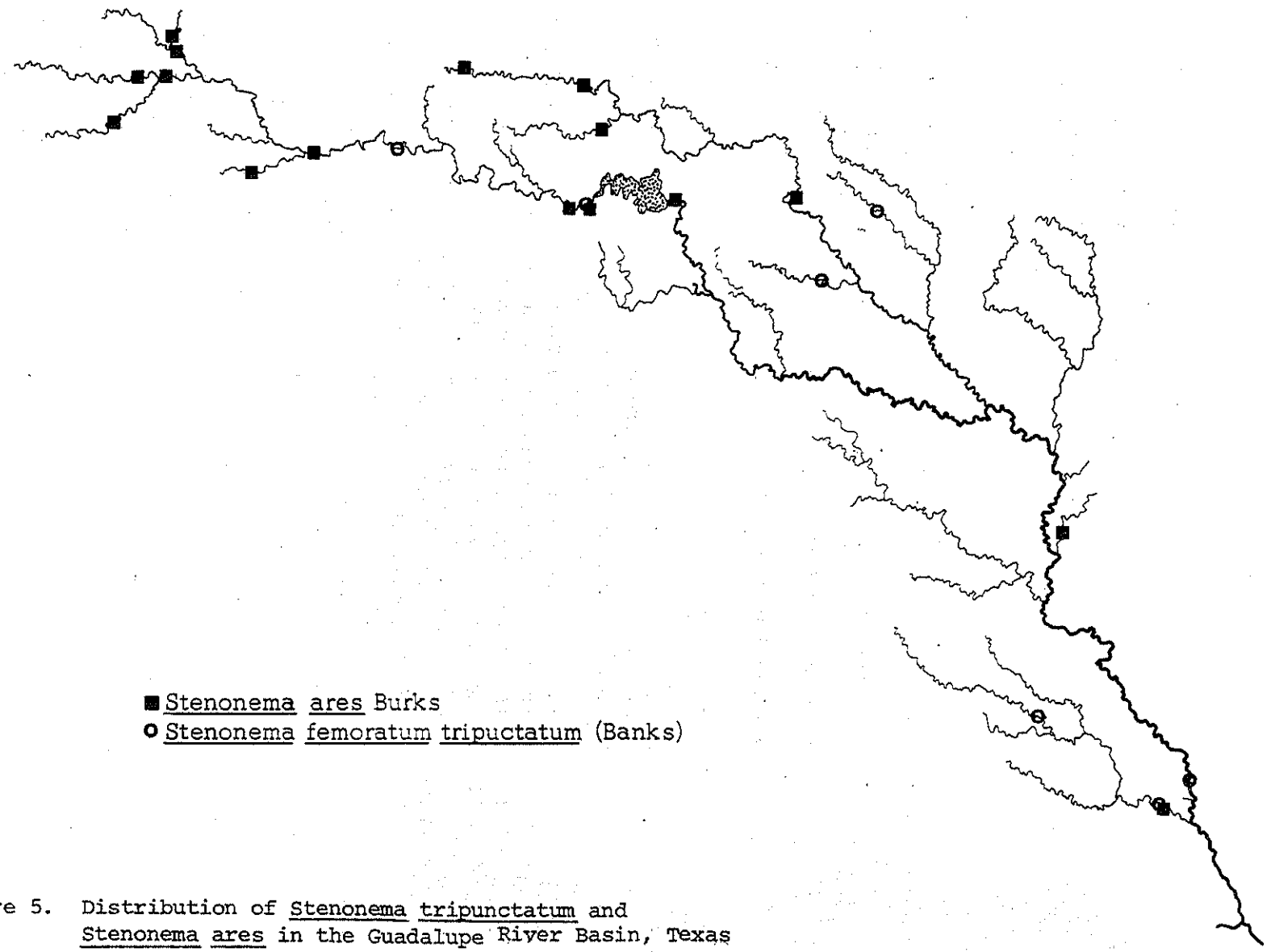


Figure 5. Distribution of Stenonema tripunctatum and Stenonema ares in the Guadalupe River Basin, Texas

and the sternite coloration pattern distinguish this organism. The Guadalupe River Basin distribution for this species is given in Figure 5. Habitats for this species varied.

In addition to the verified species described, unverified identifications were made of two other species, Stenonema pudicum (Hagen) and Stenonema femoratum femoratum (Say).

Stenonema pudicum (Hagen), similar to Stenonema ares in that both possess truncated gills on abdominal segments 2-6, is differentiated from S. ares by the marked spinelike shape of the posterolateral angles of abdominal segments 4-9, with the spine on segment 8 longer than the spine on segment 9 (Burks, 1953; Traver, 1935). The nymph was described by Traver (1935). There are no literature records of this species occurring in the Guadalupe River Basin in Texas. Organisms identified as S. pudicum were found at three stations; 1, 34, and 35. These three stations are three of the northernmost stations in the Guadalupe River Basin. These specimens were found only in late winter to early spring months.

The specimens identified as Stenonema pudicum were very similar to the type description (Traver, 1935), except for the coloration on the abdominal sternites. Traver (1935) stated that S. pudicum has "a wide dark brown longitudinal streak on each side, extending the length of the 9th sternite," a pattern not found in the Guadalupe River Basin specimens. Other coloration patterns were similar to the Traver description. The organism was easily keyed in Traver (1935), but with difficulty with the key of Burks (1953).

Collection records:

TEXAS: Kerr County; South Fork of Guadalupe River; 9 km SW Hunt; 24 II 73 MP. TEXAS: Caldwell County; South Fork of Peach Creek; Road crossing

off of FM 1865; 19 I 74 MP. TEXAS: Hays County; Blanco River-Cypress Creek confluence; 8 IV 73 MP.

Stenonema femoratum femoratum (Say)

A closely related organism to Stenonema femoratum tripunctatum, Stenonema femoratum femoratum, differs in having a slightly flattened rather than evenly rounded head with no white spot on the anterior margin, and the coloration patterns on the abdominal sternites and tergites (Burks, 1953). There are no previous records of this species from the Guadalupe River Basin or from elsewhere in Texas. Organisms identified as Stenonema femoratum femoratum (Say) were found at stations 14, 32, and 45. The stations were three of the northern most stations for the Guadalupe River Basin.

Collection records:

TEXAS: Gonzales County; Sandy Branch of Peach Creek; Road crossing off of FM 1243; 17 V 73 MP. TEXAS: Kendall County; Sister Creek; FM 473 Crossing; 28 VII 73 MP. TEXAS: Blanco County; Blanco River; FM 165 Crossing.

Family Baetidae

Genus Baetis Leach

The most troublesome genus for a distributional study of this type is the genus Baetis. The genus is evidently a recent invader of this region and has not developed genotypes with distinct morphologies. No character or group of characters were consistent enough to allow differentiation in the nymphal stage.

Baetis flavistriga McDunnough and Baetis intercalaris McDunnough were reported from this river basin by the Academy of Natural Sciences

of Philadelphia (1963). Baetis flavistriga was reported by Traver (1935) as occurring in Ontario and as far south as Maryland with no mention of a southwestern range. Burks (1953) stated that B. intercalaris was the most common Baetis species in Illinois and Berner (1940 and 1958) reported B. intercalaris as common in Florida. The species has not been reported elsewhere west of the Mississippi River or south of the Missouri River. Since distribution records do not support these identifications, these two species should be referred to a Baetis near flavistriga and Baetis near intercalaris. Moore (1950) reported Baetis vagans McDunnough, Baetis cingulatus McDunnough, and an unidentified Baetis species of the parvus brunneicolor group. Baetis vagans McDunnough inhabits the New York-Ontario-Quebec area (Traver, 1935) with a range that extends as far south as Illinois (Burks, 1953). B. cingulatus McDunnough was also cited as occurring primarily in Ontario (Traver, 1935). Therefore, based on existing dispersion records, existing species records seem unreliable.

Organisms identified as belonging to the genus Baetis were found at almost every station throughout the basin, in all habitats. Specimens collected for this study were sent to Mr. Paul Carlson and have not been identified further than genus.

Baetodes Needham and Murphy

Originally described from Brazil (Needham and Murphy, 1924), the first report of this genus in North America was by Edmunds (1950). The genus is readily distinguished from other Baetidae by the presence of gills on abdominal segments 1-5 only and possession of only two lateral cerci.

Three species are currently known to occur in the southwest but only one of these has been reported in Texas. Edmunds (1950) reported

this genus in North America based on specimens from the Frio River, not far southwest of the Guadalupe River Basin. Koss (1972) described the species discussed by Edmunds (1950), and named it Baetodes edmundsi. Two other species known to occur in the southest are Baetodes sigallatus Allen and Chao, from Arizona (Allen and Chao, 1972), and Baetodes arizonensis Koss, also known from Arizona.

Specimens collected for this study could not be identified below genus and there may be three new species. Ventral and dorsal patterns of abdominal segments, femoral patterns, tubercles, and pronota of previously reported species were different from those species collected during this study. All organisms identified to this genus were found only on the Edwards Plateau streams, indicating a preference for highly alkaline waters flowing rapidly across limestone rubble substrates.

Collection records:

TEXAS: Kendall County; Curry Creek; FM 3160 Crossing, 19 I 74 MP. TEXAS: Kendall County; Guadalupe River; Waring Crossing; 24 II 73, 28 VII 73, 19 I 74 MP. TEXAS: Kendall County; Blanco River; 8 km upstream from Blanco County Line; 15 VIII 73 MP. TEXAS: Kendall County; Sister Creek; FM 473 Crossing; 28 VII 73 MP. TEXAS: Comal County; Comal River; Landa Park; 16 III 73 MP. TEXAS: Comal Co.; Blanco River; SH 32 Crossing; 19 XII 73 MP. TEXAS: Hays County; San Marcos River; Cheatham Street; 6 VI 73 MP. TEXAS: Hays County, Blanco River; SH 80 Crossing, 26 IV 73 MP. TEXAS: Hays County, Blanco River; RR 12 Crossing; 19 XII 73 MP. TEXAS: Gonzales County; Peach Creek; US Highway 90-A Crossing; 15 III 73 MP. TEXAS: Kerr County; Guadalupe River; North Fork; 8 km West of Hunt; 27 VII 73, 24 II 73 MP. TEXAS: Kerr County; Turtle Creek; FM 2771 Crossing, 1 II 74 MP. TEXAS: Kerr County; Guadalupe River; South Fork; 9 km SW of Hunt; 27 VII 73 MP. TEXAS: Kerr County; Guadalupe River; SH 16 Crossing; 27 VII 73, 25 II 73 MP. TEXAS: Kerr County; Johnson Creek; Keith Meadows Property; 25 II 73 MP. TEXAS: Kerr County; Guadalupe River; North Fork-South Fork Confluence; 24 II 73 MP. TEXAS: Kerr County; Guadalupe River; Center Point; 1 II 74, 28 XII 73 MP.

Callibaetis Eaton

Burks (1953) indicated that nymphs of Callibaetis Eaton commonly occur in still water and permanent ponds. They have long, slender tarsal claws provided with a row of long, ventral denticles. The gills have densely pennate tracheation in sheetlike ventrally recurved lamellae. Identifications beyond the generic level were difficult, partially due to absence of keys for species from this geographic region.

Texas records have been reported only as Callibaetis species (ANSP, 1963). Traver (1935) mentioned collections of male adults from Weslaco and Austin, Texas, by S.W. Clark and H.B. Parks, Jr., respectively, that were similar to Callibaetis montanus Eaton, but he did not positively identify them as C. montanus.

Centroptilum Eaton

The genus Centroptilum is distinguished by the presence of a long, 3-segmented maxillary palp, double lammelate gills and hind wing pad in the nymph. Nymphs of only a few species have been described.

Centroptilum album McDunnough has been reported to occur at station 37 of this study (Moore, 1950). Traver (1935) gave this species a northeast distribution and Berner (1959) reported it from Canada. These references, therefore, cast doubt on the validity of the C. album identification.

For this study, I was unable to identify or separate individual forms with any consistency.

Genus Dactylobaetis Traver and Edmunds

Dactylobaetis mexicanus Traver and Edmunds

This species is the only representative of the spatulate clawed baetids found in the Guadalupe River Basin. The original description gave localities in the mexican state of Nuevo Leon (Traver and Edmunds, 1968). There are no other literature references that report this species as occurring in the southwest. Specimens of Dactylobaetis mexicanus varied slightly from the original description in the number of denticles per claw. Traver and Edmunds (1968) cited 5-6 denticles per claw whereas specimens collected for this study ranged from 4-7 denticles, exclusive of the large denticle.

These organisms were limited almost exclusively to the highly alkaline waters of the Edwards Plateau. Three exceptions were specimens found at stations 51, 58 and 62. The two records from Guadalupe River stations may be explained by downstream drift, and since the specimens from the Coleto Creek Station were very immature, their occurrence likely resulted from upstream migration at mating. The organisms preferred moderately wide (5-20 m) permanent streams with swift (5-10 km/hr) currents and hardpan substrates. They were able to withstand seasonal temperature extremes from a summer temperature between 20-30 C to a winter temperature between 5-10 C. A distribution map is given in Figure 6.

Collection records:

TEXAS: Gonzales County; Guadalupe River; US 183 Crossing, 7 IV 74 MP; 23 VIII 73 MP. TEXAS: Kerr County; Guadalupe River; SH 16 Crossing; 12 III 74 MP; 25 II 73 MP; 27 VII 74 MP. TEXAS: Victoria County; Guadalupe River; Victoria City Park; 14 III 74 MP; 23 VIII 73 MP. TEXAS: Kerr County; South Fork of Guadalupe River; 9 km SW Hunt; 27 VIII 73 MP. TEXAS: Goliad County; 24 km Coleto Creek; US 183 Crossing, 2 II 74 MP; 18 V 73 MP. TEXAS: Caldwell County; Clear Fork of Plum Creek; Road Crossing upstream from SH 20 Crossing; 16 VIII 73 MP; 17 V 73 MP. TEXAS:

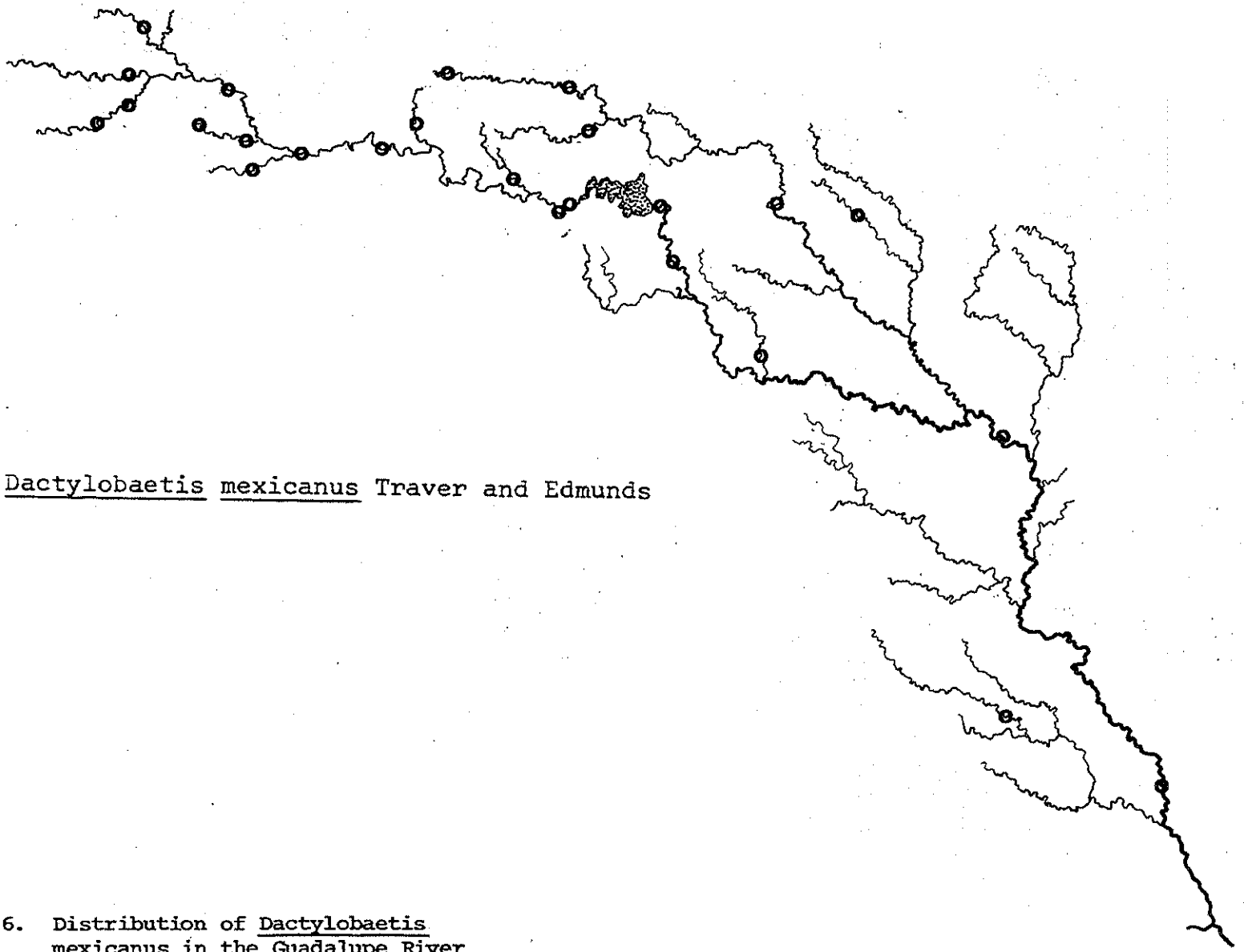


Figure 6. Distribution of Dactylobaetis mexicanus in the Guadalupe River Basin, Texas

Kerr County; North Fork of Guadalupe River; 8 km W Hunt; 27 VIII 73 MP. TEXAS: Kerr County; Turtle Creek; FM 2771 Crossing; 1 II 74 MP. TEXAS: Kerr County; Turtle Creek; FM 1273 Crossing; 28 VII 73 MP. TEXAS: Comal County; Guadalupe River; Hueco Springs Road 1st Crossing; 27 XII 73 MP; 15 VIII 73 MP. TEXAS: Blanco County; Blanco River; FM 165 Crossing; 18 XI 73 MP. TEXAS: Kerr County; South Fork of Guadalupe River; 9 km SW Hunt; 24 II 73 MP. TEXAS: Hays County; Blanco River; Ranch Road 12 Crossing; 7 III 73 MP. TEXAS: Kerr County; Johnson Creek; Roadside park near Mountain Home; 25 II 73 MP. TEXAS: Kendall County; Guadalupe River; Waring Crossing; 28 VII 73 MP; 25 II 73 MP. TEXAS: Kerr County; Verde Creek; SH 16 Crossing; 1 II 74 MP. TEXAS: Comal County; Guadalupe River; US 281 Crossing, 16 III 73 MP. TEXAS: Comal County; Guadalupe River; Canyon Reservoir Tailrace; 16 III 73 MP. TEXAS: Kerr County; Guadalupe River at North Fork-South Fork Confluence; 17 II 73 MP. TEXAS: Kendall County; Curry Creek; FM 3160 Crossing; 19 I 74 MP. TEXAS: Comal County; Guadalupe River; FM 311 Crossing, 15 VIII 73 MP; 27 XII 73 MP. TEXAS: Kerr County; Guadalupe River; Below Center Point Dam; 28 VII 73 MP. TEXAS: Kendall County; Blanco River; 8 km upstream from Blanco County line at road crossing; 15 VIII 73 MP. TEXAS: Kendall County; Blanco River, Road Crossing 8 km W of Blanco; 19 XII 73 MP. TEXAS: Blanco County; Little Blanco River; SH 32 Crossing; 28 VII 73 MP.

Pseudocloeon Klapalek

The organisms in this genus are superficially similar to those of the genus Baetis. The hind wing pad is absent in Pseudocloeon, and the middle cercus is usually vestigial. The genus was described from specimens from Java and was first reported in North America by McDunnough (1931).

Only a few records indicating the presence of this genus in the state or in the Guadalupe River Basin were found. Traver (1935) cited a specimen collected at Austin by H.B. Parks which was termed "similar to Pseudocloeon veteris McDunnough." Kent (1971) reported the genus in the Guadalupe River above and below Canyon Reservoir (stations 18 and 19 of this study).

Seven distinct forms were tentatively discerned in examining specimens collected in this study. Positive species verifications by rearing for nymph-adult correlations were not performed for these seven forms.

SUPERFAMILY CAENOIDEA

Family Caenidae

Genus Brachycercus Curtis

The taxonomy of this genus is poor at the present time. Burks (1953) keyed nymphs of Brachycercus lacustris and Brachycercus prudens but gave no description of the organisms. He also synonymized B. idei Lestage and B. pallidus with B. lacustris. Berner (1950) provided a key to the nymphs of B. nitidus, B. lacustris, B. maculatus, and B. sp. a. He also discussed the adult stage of B. flavus (which occurs at the Louisiana-Texas border region) but did not key the nymph of the species. The ecology and life history of B. maculatus were discussed in detail in Berner (1950). Traver (1935) gives a key to the adults of B. prudens, B. flavus, B. nitidus, and B. idei but only to the nymphs of B. nitidus and B. lacustris.

Literature references to this genus in Texas and the Guadalupe River Basin are limited. A diversity study by Kent (1971), which reported the genus above and below Canyon Reservoir (stations 17 and 18 of this study), was the first report of this genus outside the Mississippi River drainage. No other references could be found for other locations in the state or the basin.

Brachycercus maculatus Berner

The presence of reduced and laterally marginal tubercules and non-banded legs separates Brachycercus maculatus from Brachycercus lacustris, the other species of this genus found in the Guadalupe River Basin. The nymph of B. maculatus was described by Berner (1950).

B. maculatus was found above Canyon Reservoir in collections made for this study. Specimens collecte by Kent (1971) have also been examined and determined to be Brachycercus maculatus. The nymph of this species was found in rapid (greater than 10 km/hr) waters with high alkalinity. The substrate was rubble and boulders, and macrophyte cover was reduced. This species was found at only two stations, with a third locality added with the Kent collection. A distribution map is given in Figure 7.

Collection records:

TEXAS: Comal County; Guadalupe River; FM 311 Crossing; 27 XII 73 MP.
TEXAS: Comal County; Guadalupe River; US 281 Crossing; 16 III 73 MP.

Brachycercus lacustris (Needham)

Needham (1918) described this organism as a species of the genus Caenis, another genus in this family. The distinguishing features of this species are the very prominent protuberances on the head, dark bands around the legs, and the distinct markings on the tergites. There have been no previous literature records for Brachycercus lacustris for any location in Texas or southwest of the Missouri River-Mississippi River basins.

Brachycercus lacustris (Needham) was found at three stations (Figure 7). These had sand substrates with slow to moderate current (0.5-2.5 km/hr). Summer temperatures exceeded 30 C and winter temperatures were moderate (10-20 C). Streamside vegetation was short herbs and grasses. Macrophytes were absent. Needham (cited in Berner, 1950) reported that this species inhabited lakes, making the habitat of the Guadalupe River Basin specimens exceptions to the rule.

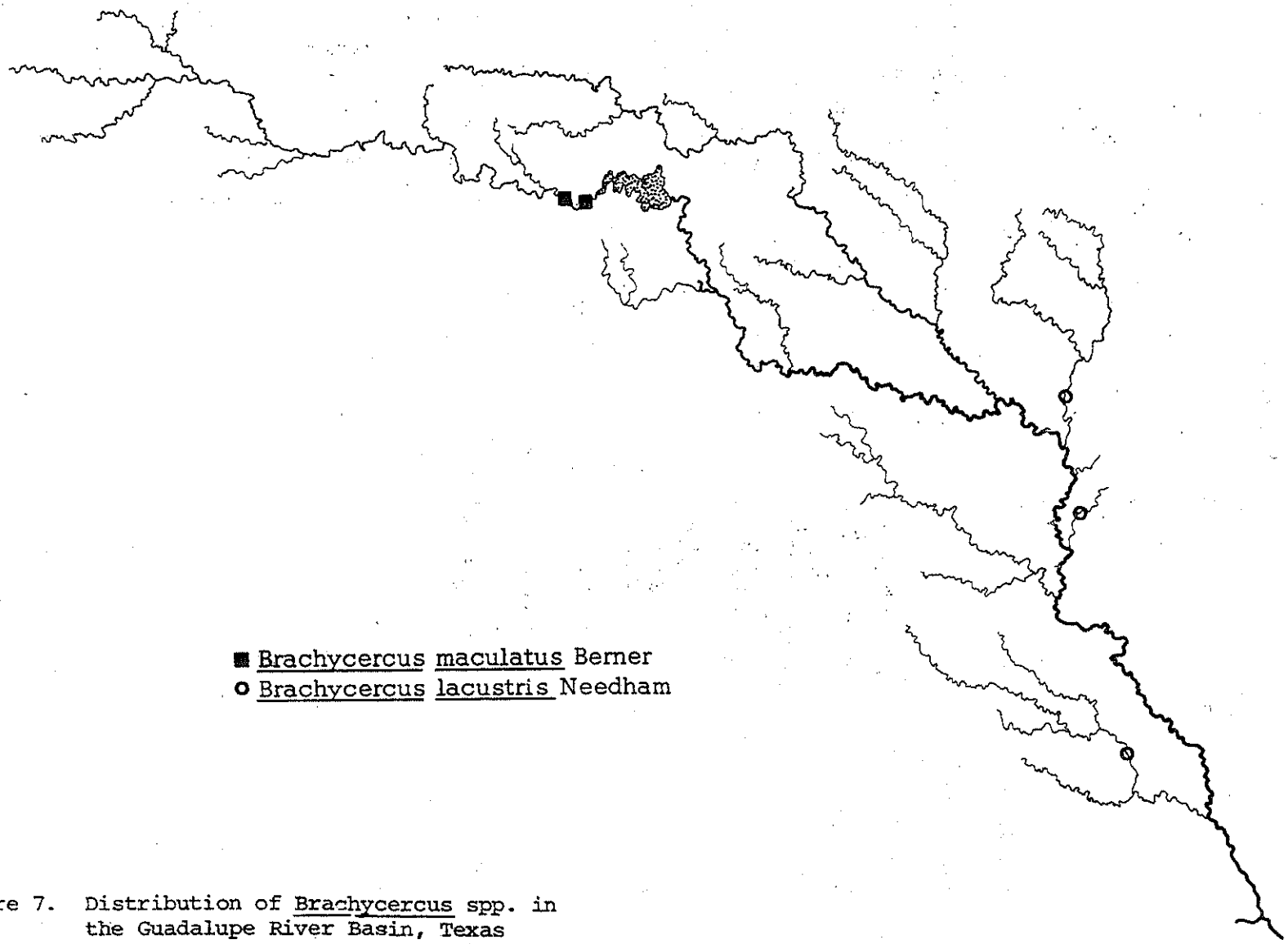


Figure 7. Distribution of Brachycercus spp. in the Guadalupe River Basin, Texas

Collection records:

TEXAS: Gonzales County; Peach Creek; US 90-A Crossing; 7 IV 73 MP.
TEXAS: Goliad County; Coleto Creek; FM 622 Crossing; 24 VIII 73 MP.
TEXAS: DeWitt County; McCoy Creek; US 183 Crossing; 23 VIII 73 MP.

Caenis Stephens

Caenis has presented obstacles to taxonomists since many of the species were described in the nineteenth century without retention of type specimens (McDunnough, 1931a). Most of the species descriptions are limited to the adults of these species, the nymphs not being described until 1950 (Berner, 1950). Specific characteristics for nymphal identifications have not been clearly established but shape and size of the pronotum, total body length (Macan, 1955), promotal colorings and non-morphological characters (Berner, 1950) have been used to separate some of the species.

Several sources have cited the presence of the genus in the Guadalupe River Basin. The Academy of Natural Sciences of Philadelphia (1949, 1963) reported specimens below station 62 and near station 27 of this study. Kent (1971) reported Caenis sp. at stations 18 and 19 of this study. Caenis sp. was also reported from the San Antonio River Basin (Moore, 1950).

Organisms collected were found throughout the basin, with a preference to thos habitats with slower, more turbid waters, and complete arboral canopy. The organisms were not identifiable to species and until further work correlates adults with nymphs, the species of the nymphs will remain unknown. Separate forms were not discerned, so all the organisms may be of one species. The specimens collected in this study will probably represent several new species (Dr. R. K. Allen, State University of California at Los Angeles, personal communication).

SUPERFAMILY LEPTOPHLEBOIDEA

Family Leptophlebiidae

Choroterpes Eaton

(Neochoroterpes) Allen

Choroterpes (Neochoroterpes) mexicanus Allen

The nymph of Choroterpes (Neochoroterpes) mexicanus Allen was described in 1974 (Allen, 1974). Nymphs of the subgenus Neochoroterpes are separated from Choroterpes nymphs by the setation on the labrum (Allen, 1974); the C. mexicanus nymph is distinguished by the markings on the femora. The species was described from nymphs obtained to the north and south of the study area, but no records were given for the Guadalupe River Basin. Traver (1935) described Choroterpes nanita from an adult and a subimago from Austin, Texas. Allen (1974) reported that nymphs of C. nanita have not been reported or described.

C. mexicanus, when present, was found in large numbers. This species was found exclusively in streams on the Edwards Plateau. Ecological features influencing distribution seem to be winter temperature minimum, high alkalinity waters, gravel, rubble, or hardpan substrate, and a slow to moderate flow (0.5-5 km/hr). The older larger specimens were not found in intermittent or semi-permanent streams. Populations were larger where macrophytes were scarce. A distribution map for this organism is given in Figure 8.

Collection records:

TEXAS: Hays County; Blanco River; RR 12 Crossing; 19 XII 73 MP. TEXAS: Kendall County; Blanco River; 8 km upstream from Blanco County line at road crossing. TEXAS: Comal County; Guadalupe River; FM 311 Crossing; 27 XII 73 MP. TEXAS: Kerr County; North Fork of Guadalupe River; 8 km W Hunt; 12 III 74 MP. TEXAS: Blanco County; Blanco River, FM 165 Crossing; 18 XII 73 MP.

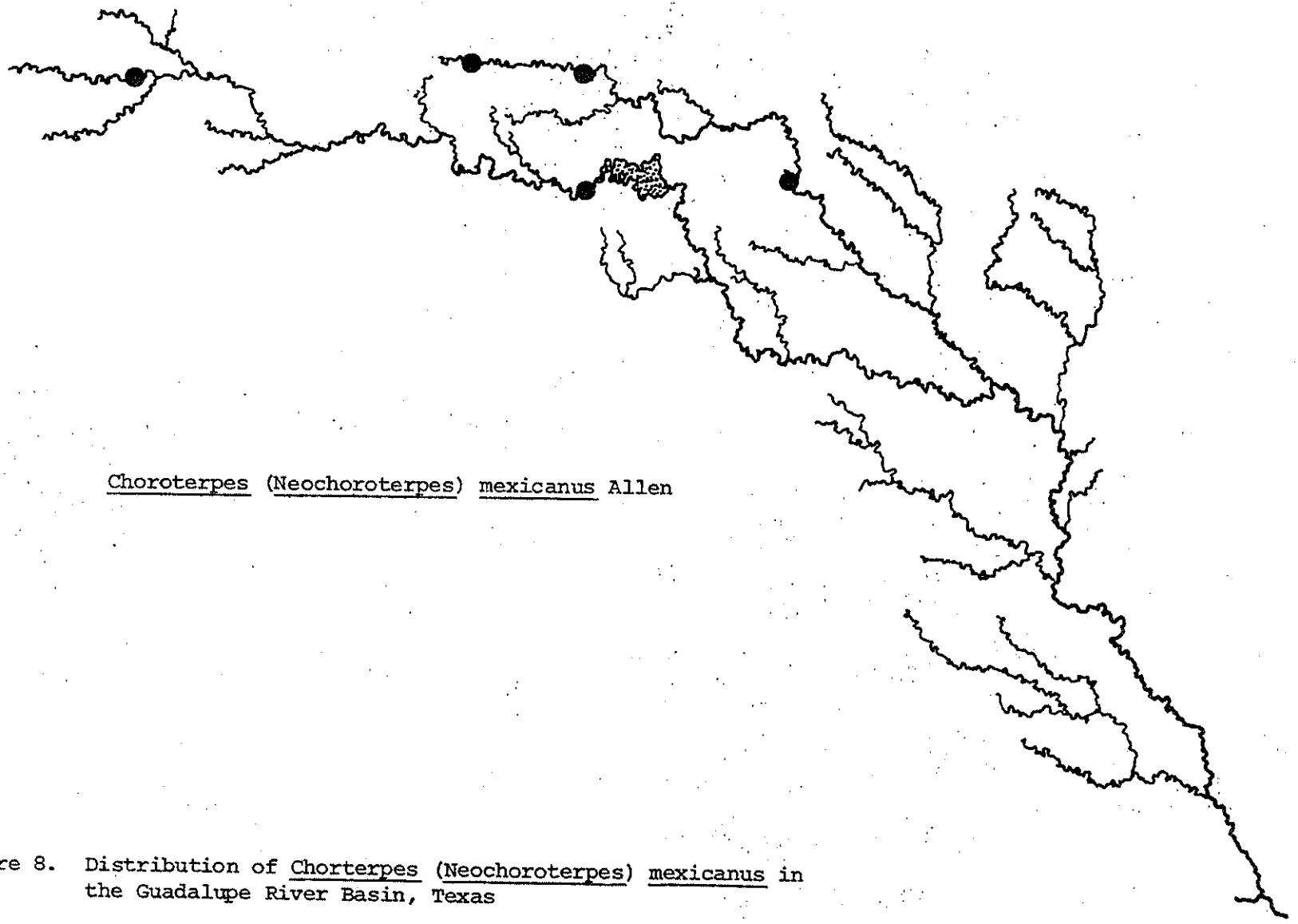


Figure 8. Distribution of Chorterpes (Neochoroterpes) mexicanus in the Guadalupe River Basin, Texas

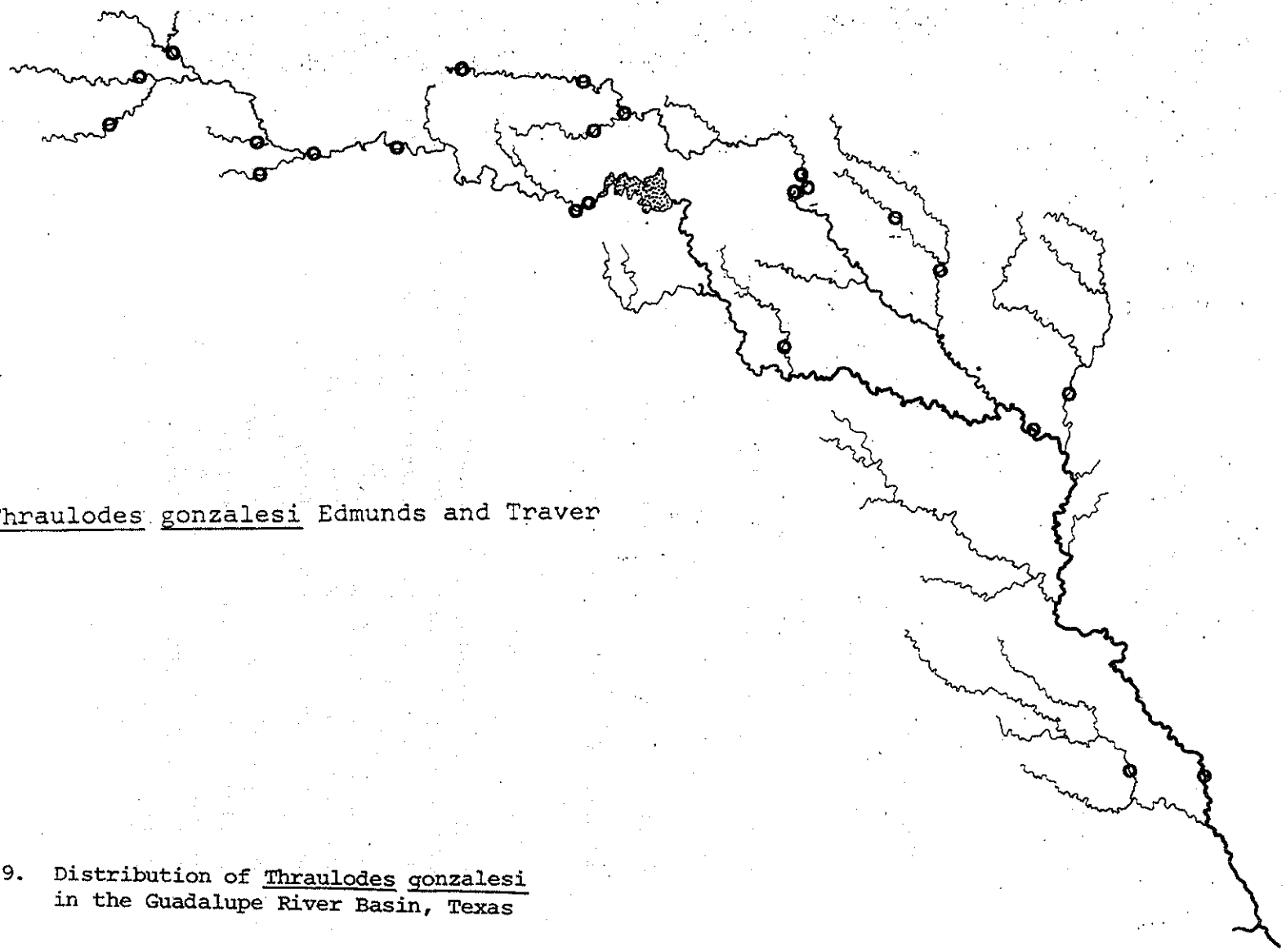
Thraulodes Ulmer

Thraulodes gonzalesi Traver and Edmunds

This species was described in 1967 by Edmunds and Traver from specimens collected near Gonzales, Texas. The nymph of this species is distinguished by the coloration and markings on the abdominal tergites. T. gonzalesi is the only species of the genus found in the Guadalupe River Basin during this study and it was dispersed throughout the basin (Figure 9). Previous records indicate Thraulodes as occurring in the San Marcos River (Moore, 1950) and above and below Canyon Reservoir (Kent, 1970). No other records were found of this genus in Texas. The species seemed to prefer streams of moderate width (5-20 m) and swift currents (5-10 km/hr), moderate temperature regime (a winter temperature minimum of 10-20 C to a summer maximum of 20-30C), and macrophytes in moderate amounts of 10-50%, based on the occurrence of specimens found during this study.

Collection records:

TEXAS: Kerr County; Turtle Creek; FM 2771 Crossing; 1 II 74 MP. TEXAS: Kerr County; Johnson Creek; Mr. Keith Meadows Property; 27 VIII 73 MP. TEXAS: Kerr County; Turtle Creek; FM 2771 Crossing; 28 VIII 73 MP. TEXAS: Kendall County; Guadalupe River; Waring Crossing; 28 VIII 73 MP; 24 II 73 MP; 19 I 74 MP. TEXAS: Kerr County; Turtle Creek; FM 1273 Crossing; 28 VIII 73 MP. TEXAS: Kendall County; Blanco River; 8 km upstream from Blanco County Line; 15 VIII 73 MP. TEXAS: Kerr County; South Fork of Guadalupe River; 9 km SW Hunt; 24 II 73 MP. TEXAS: Kerr County; Guadalupe River; SH 16 Crossing; 27 VIII 73 MP. TEXAS: Kerr County; North Fork of Guadalupe River; 8 km W. Hunt; 12 III 74 MP; 24 II 74 MP. TEXAS: Kerr County; Guadalupe River; Center Point; 1 II 74 MP; 28 VII 73 MP. TEXAS: Kerr County; Verde Creek; FM 173 Crossing; 1 II 74 MP. TEXAS: Comal County; Guadalupe River FM 311 Crossing; 27 XII 73 MP; 16 III 73 MP; 15 VIII 73 MP. TEXAS: Blanco County; Blanco River; FM 165 Crossing; 10 VII 73 MP; 15 VIII 73 MP. TEXAS: Guadalupe County; Geronimo Creek; SH 20 Crossing; 16 VIII 73 MP; 18 V 73 MP. TEXAS: Hays County; San Marcos River; Cheatham Street Crossing; 27 I 73 MP; 6 VI 73 MP. TEXAS: Hays County; Blanco River; SH 80 Crossing; 26 IX 73 MP. TEXAS: Hays County; Blanco River; RR 12 Crossing; 19 XII 73 MP. TEXAS: Caldwell County; Plum Creek; FM 1386 Crossing; 17 I 74 MP. TEXAS: Gonzales County; Peach Creek; SH 90-A Crossing; 7 IX 74 MP. TEXAS: Guadalupe River; US 183 Crossing; 23 VIII 73 MP; 7 IV 74 MP. TEXAS: Goliad County;



Thraulodes gonzalesi Edmunds and Traver

Figure 9. Distribution of Thraulodes gonzalesi in the Guadalupe River Basin, Texas

Coleto Creek; FM 622 Crossing; 24 VIII 73 MP. TEXAS: Victoria County; Guadalupe River; Victoria City Park; 14 III 73 MP; 23 VIII 73 MP. TEXAS: Hays County; Blanco River; RR 12 Crossing; 11 VI 73 MP. TEXAS: Blanco County; Little Blanco River; SH 32 Crossing; 28 VIII 73 MP; TEXAS: Caldwell County; Clear Fork of Plum Creek; Road crossing upstream from SH 20 Crossing; 16 VII 73 MP; 18 I 74 MP.

Traverella Edmunds

Traverella presidiana (Traver)

Traver (1939) described this species from the male imago; Edmunds (1948) described the nymphal stage. Several features such as clypeal projections, maxillary palpi, relative proportion of the pronotum to head width, and the shape of the fimbrate lamelliform gills characterize this genus. Species are easily separated by the shape of the clypeal projection, body and leg markings, relative size, spination, and geographic distribution (Allen, 1973).

Edmunds (1948) described Traverella nymphs from collections made by Needham and Berner in Zapata, Texas (Rio Grande) 1936 and in Tamaulipas Province, Mexico (Rio Guayalejo) in 1939. Subsequent to the Edmunds (1948) discussion of the genus, the geographic distribution has been widened to include north-central Texas (Allen, 1973). Records within the Guadalupe River Basin locate this species at stations 1 and 35 of this study, in Caldwell County, in the San Marcos River at the State Highway 80 Crossing, Guadalupe River at the State Highway 80 Crossing (Allen, 1974), between stations 26 and 27, and also below station 62 of this study (ANSP, 1949). Of the seven species of Traverella known from North and Central America, Traverella presidiana is the only species recorded from any point in Texas (Allen, 1973).

Traverella presidiana (Traver) was the only species of the genus found during this study and it is distributed basin-wide. Larger

populations were found in streams on the Edwards Plateau or in streams with sources in the Edwards or Glen Rose limestones (Figure 10). More individuals were found in stations with stream width between 50 and 200 meters, relatively swift current (5-10 km/hr), and gravel to boulder substrate. Aquatic and streamside vegetation were not significantly selected for, in contrast to other members of the family Leptophlebiidae. The organism was not found in streams that go dry during the summer, possibly indicating a biennial nymphal stage.

Collection records:

TEXAS: Kerr County; North Fork of the Guadalupe River; 8 km W. Hunt; 27 VII 73 MP; 12 III 74 MP. TEXAS: Kerr County; Guadalupe River; SH 16 Crossing; 27 VII 73 MP. TEXAS: Kerr County; Turtle Creek; FM 2771 Crossing; 1 II 74 MP; 28 VIII 73 MP. TEXAS: Kerr County; Verde Creek; FM 173 Crossing; 28 VII 73 MP. TEXAS: Kerr County; Guadalupe River; Center Point dam; 28 VII 73 MP; 1 II 74 MP. TEXAS: Kendall County; Guadalupe River; Waring Crossing; 28 VIII 73 MP; 19 I 74 MP. TEXAS: Kendall County; Blanco River; 8 km upstream from Blanco County line; 15 VIII 73 MP. TEXAS: Blanco County; Little Blanco River; 8 km upstream from Blanco County line; 15 VIII 73 MP. TEXAS: Comal County; Guadalupe River; FM 311 Crossing; 15 VIII 73 MP. TEXAS: Hays County; Blanco River; RR 12 Crossing; 19 IX 73 MP. TEXAS: Hays County; Blanco River; SH 80 Crossing; 26 IX 73 MP. TEXAS: Hays County; Green Valley Crossing south of San Marcos; 8 VI 73 MP. TEXAS: Guadalupe County; Geronimo Creek; SH 20 Crossing; 18 V 73 MP; 16 VIII 73 MP. TEXAS: Guadalupe County; York Creek; US 183 Crossing; 23 VIII 73 MP; 7 IV 74 MP. TEXAS: Victoria County; Guadalupe River; Victoria City Park; 23 VIII 73 MP.

Superfamily Leptophlebioidea

Family Tricorythidae

Tricorythodes Ulmer

This genus is known from Uruguay to Southern Canada (Allen, 1967) and is confined to the Western Hemisphere. The adult stage was described by Traver (1958, 1959) and the nymph described as Caenis allecta by Needham (1905). The distinguishing feature of this genus is the triangular

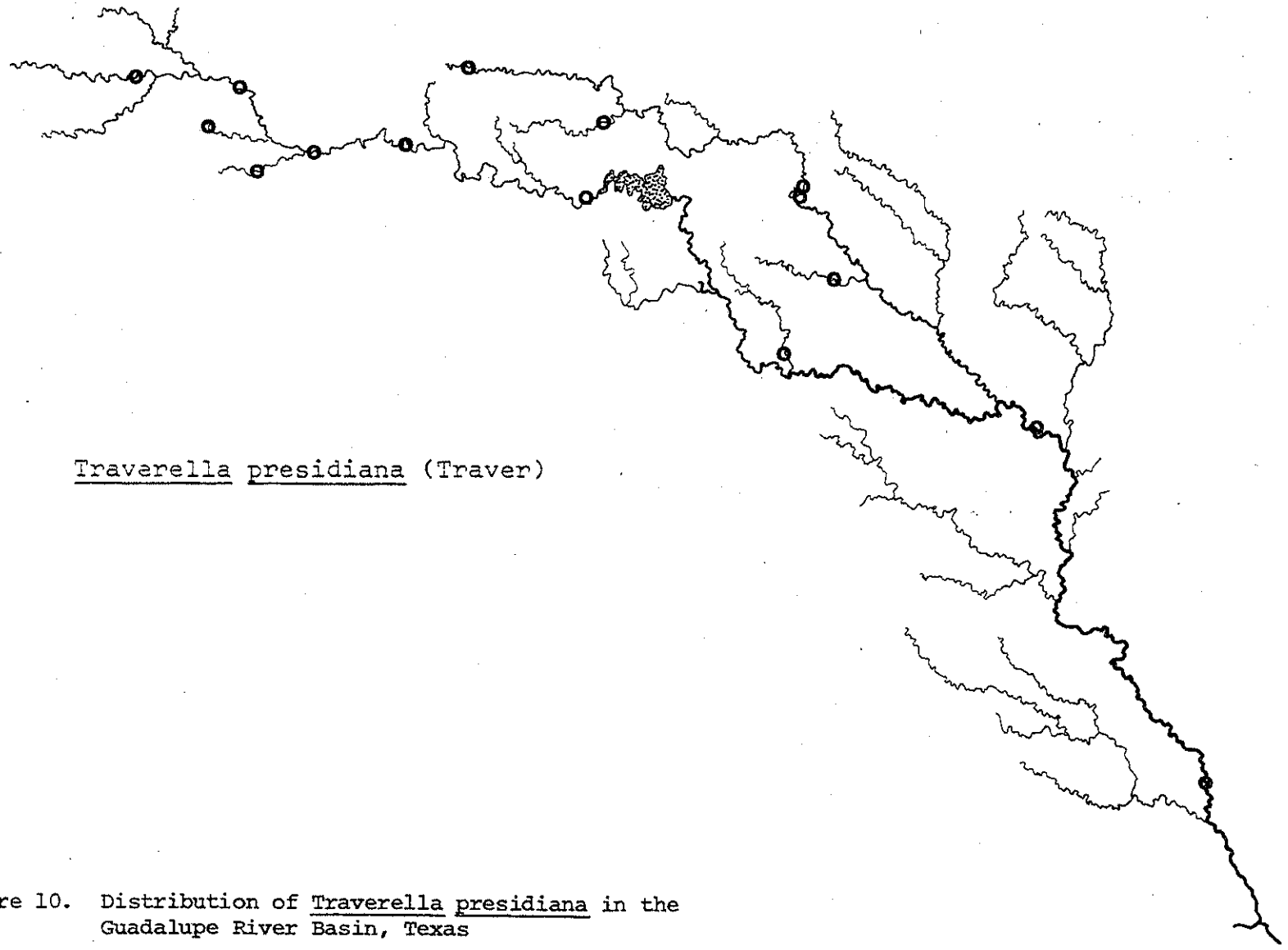


Figure 10. Distribution of Traverella presidiana in the Guadalupe River Basin, Texas

shaped operculate gills of abdominal segment 2 that covers gills on segments 3-6 and does not overlap at the mid-line of the dorsum. Traver (1959) described five new species from adults. Allen (1967) described Tricorythodes condylus and T. dimorphus from Arizona. The ranges for these species were later extended eastward (Kilgore and Allen, 1973). Kilgore and Allen (1973) and Allen Brusca (1973) also described mexican species, including nymphal descriptions. Allen (1967) used five main distinguishing characteristics and described several new species for Texas and the southwest.

The Academy of Natural Sciences of Philadelphia (ANSP, 1949, 1963), Moore (1950), and Kent (1971) cited the presence of the genus in the Guadalupe River Basin from stations 18, 22, 37, and below station 62 of this study. Tricorythodes texanus Traver was described from the Devil's River in West Texas (Traver, 1935). The nymph of T. texanus is not known (Allen, 1967).

Specimens obtained during this study could not be identified as any of these species, though several definite forms were noted. The characteristics used by Allen indicate there may be three species or subspecies in this complex. Until rearing and other verification techniques are done, more specific identification of the organisms of this genus will not be possible.

Collection records:

TEXAS: Kendall County; Guadalupe River; Waring Crossing; 19 I 74 MP; 25 II 73 MP; 28 VII 73 MP. TEXAS: Kendall County; Sister Creek; FM 473 Crossing; 28 VII 73 MP; 19 I 73 MP. TEXAS: Kendall County; Curry Creek; FM 3160 Crossing; 19 I 74 MP. TEXAS: Kendall County; Blanco River; upstream 8 km from Blanco County Line; 15 VIII 73 MP. TEXAS: Hays County; Southwest Texas State University; Aquatic Station Ponds; 18 VI 73 MP. TEXAS: Hays County; San Marcos River; Cheatham Street Crossing; 6 VI 73 MP. TEXAS: Hays County; Blanco River; RR 12 Crossing; 7 III 73 MP; 19 XII 73 MP. TEXAS: Hays County; Confluence of Blanco River & Cypress Creek; 5 III 73 MP. TEXAS: Kerr County; Guadalupe River;

South Fork-North Fork Confluence; 24 II 73 MP. TEXAS: Kerr County; North Fork; Guadalupe River; 8 km W. Hunt; 24 II 73 MP; 12 III 73 MP. TEXAS: Kerr County; Verde Creek; FM 173 Crossing; 28 VII 73 MP. TEXAS: Kerr County; Verde Creek; SH 16 Crossing; 1 II 74 MP. TEXAS: Kerr County, Johnson Creek; Keith Meadows Property; 27 VII 73 MP; 25 II 73 MP; 12 III 73 MP. TEXAS: Kerr County; Turtle Creek; FM 1273 Crossing; 28 VII 73 MP. TEXAS: Kerr County; Guadalupe River; Center Point; 28 VII 73 MP; 1 II 74 MP. TEXAS: Kerr County; South Fork of Guadalupe River; 9 km SW Hunt; 12 III 74 MP; 24 II 73 MP; 27 II 73 MP; 27 VII 73 MP. TEXAS: Kerr County; Fessenden Creek; State Fish Hatchery Road; 27 VII 73 MP. TEXAS: Guadalupe County; Geronimo Creek; SH 20 Crossing; 18 V 73, 16 VIII 73 MP. TEXAS: Guadalupe County; Guadalupe River; Riverine stretch between Lakes Dunlap and McQueeney; 11 IV 73 MP. TEXAS: Comal County; Guadalupe River; US 281 Crossing; 16 III 73 MP. TEXAS: Comal County; Comal River; New Braunfels; 16 III 73 MP. TEXAS: Comal County; Guadalupe River; Canyon tailrace 16 III 73 MP. TEXAS: Comal County; Little Blanco River; SH 32 Crossing; 28 VII 73, 19 XII 73 MP. TEXAS: Comal County; Guadalupe River; Hueco Springs Road; 1st Crossing; 15 VIII 73, 24 III 73, 27 XII 73 MP. TEXAS: DeWitt County; Guadalupe River; Road crossing N of Cuero; 14 III 73 MP. TEXAS: DeWitt County; Clear Creek; US 87 Crossing; 24 VIII 73 MP. TEXAS: Gonzales County; Sandies Creek Road; Crossing off 1116, 7 IV 74, 15 III 73 MP. TEXAS: Gonzales County; Guadalupe River; US 183 Crossing; 7 IV 74, 15 III 73 MP. TEXAS: Gonzales County; Peach Creek; FM 532 Crossing; 23 VIII 73 MP. TEXAS: Gonzales County; Peach Creek; 90-A Crossing; 7 IV 74 MP. TEXAS: Victoria County; Guadalupe River; Victoria City Park; 14 III 73; 23 VIII 73 MP. TEXAS: Blanco County; Blanco River; FM 165 Crossing; 18 XII 73; 15 VIII 73 MP. TEXAS: Blanco County; Guadalupe River; FM 311 Crossing; 27 XII 73 MP. TEXAS: Blanco County; Blanco River; Road crossing 8 km W Blanco; 19 XII 73 MP. TEXAS: Caldwell County; Plum Creek Road; Crossing of FM 1386; 17 I 74 MP. TEXAS: Caldwell County; Clear Fork, Plum Creek; Road crossing upstream of FM 20 Crossing; 18 I 74; 17 V 73 MP. TEXAS: Goliad County; Coleto Creek; FM 662 Crossing; 2 II 74; 24 VIII 73 MP. TEXAS: Goliad County; 24 km Coleto Creek; US 81 Crossing; 24 VIII 73, 2 II 74 MP.

Leptohyphes Eaton

The neotropical genus Leptohyphes was first described from Guatemala (Eaton, 1892) and was not confirmed as occurring further north until 1958 (Traver, 1959). The nymph of the genus was first described by Needham and Murphy (1924) with additional descriptions found in Traver (1944) and Burks (1953). The genus can be distinguished from others in the subfamily Leptohyphinae by the presence of the elongate ovoid operculate gills on abdominal segment one that cover underlying gills on segments two through six (Burks, 1953).

Four morphological types were noted while examining specimens collected for this study. These were previously undescribed new species and specimens were sent to Dr. R. K. Allen, State College of California at Los Angeles, for description. The factors dictating distribution patterns of the genus were not discernable. Until the descriptions by Allen are published, little can be said concerning the status of this genus in the Guadalupe River Basin.

References to species in this genus can be found in many sources. The earliest reference to Leptohyphes in North America was Burks (1953) and included data on specimens found in San Antonio, Texas. Traver indicated the specimens referred to by Burks were Leptohyphes sabinus based on identification of adults. To this date, the nymph of L. sabinus has not been described. Kent (1971) reported the presence of the genus above Canyon Reservoir (station 18 of this study) and a report by the ANSP reported this genus from below station 63 of this study (ANSP, 1963). Allen and Roback (1969) extended the range of Leptohyphes dolani Allen as far west as Texas, reporting it from the Guadalupe River near Victoria (station 62 of this study). None of the specimens collected for this study were identified as L. dolani. Leptohyphes robacki Allen was indicated (Allen, 1967) as occurring in the eastern U.S., and Leptohyphes apache Allen, Leptohyphes merius (Allen, 1967), and Leptohyphes baumanni Kilgore and Allen (1972) have been reported from southwestern U.S.

Collection records:

TEXAS: Kerr County; West Fork; Guadalupe River, 3rd Crossing, FM 1340; 12 III 74 MP. TEXAS: Kerr County; Turtle Creek, FM 1273 Crossing; 28 VII 73 MP. TEXAS: Kerr County; Johnson Creek; Keith Meadows Property; 27 VII 73 MP. TEXAS: Kerr County; Guadalupe River; Center Point; 1 II 74 MP. TEXAS: Kerr County; Verde Creek; FM 173 Crossing; 28 VII 73 MP. TEXAS: Guadalupe County; Geronimo Creek, SH 20 Crossing; 16 VIII 73, 18 V 73 MP. TEXAS: Hays County; Blanco River; RR 12 Crossing; 7 III

73 MP. TEXAS: Hays County; San Marcos River, Cheatham Street Crossing; 27 I 73 MP. TEXAS: Kendall County; Blanco River; 8 km upstream from Blanco County Line; 15 VIII 73 MP. TEXAS: Kendall County; Sister Creek; FM 473 Crossing; 19 I 73 MP. TEXAS: Kendall County; Guadalupe River; Waring Crossing; 19 I 74 MP. TEXAS: Caldwell County; Clear Fork of Plum Creek Road Crossing upstream from FM 20 Crossing; 16 VIII 73 MP. TEXAS: Caldwell County; Plum Creek Road Crossing of FM 1847; 16 VIII 73 MP. TEXAS: Victoria County; Guadalupe River; Victoria City Park; 23 VIII 73 MP. TEXAS: Gonzales County; Guadalupe County-US 183 Crossing; 7 IV MP. TEXAS: Blanco County; Blanco River at FM 165 Crossing; 15 VIII 73 MP. TEXAS: Comal County; Guadalupe River; FM 311 Crossing; 15 VIII 73, 28 VII 73 MP.

SUPERFAMILY EPHEMEROIDEA

Family Ephemeridae

Hexagenia Walsh

Hexagenia limbata venusta Eaton

The H. limbata was originally described in Eaton (1883) as a separate species of Hexagenia from specimens collected in Texas. The species was reduced to a subspecies of H. limbata Spieth (1941). Hexagenia pallens was synonomized with H. limbata venusta (Spieth, 1941). The distinguishing characteristics of the subspecies are the abdominal markings (Spieth, 1941).

Several references can be found to Hexagenia limbata and some to Hexagenia limbata venusta in Texas and Guadalupe River Basin by using Hexagenia venusta records. Traver (1935) listed several Texas cities where H. venusta was collected along with the collector: Huntsville (V. A. Little), Austin (H. B. Parks), Waco (F. F. Bibby), Winter Haven (S. E. Jones), and College Station (H. J. Reinhard). Reports by the ANSP reported H. limbata near Victoria (station 62 of this study) (ANSP, 1963). Spieth (1941) cited a San Marcos collection.

This burrowing species was found throughout the basin in micro-habitats of inorganic silt and mud. Population numbers were larger in

wide (5-20 m) streams with slow current (less than 0.5 km/hr). It was found in large numbers in the mainstream impoundments in the mid-section of the basin. Fremling (1973) reported that H. limbata avoids zones of degradation and therefore is a clean-water indicator. Leonard (in Fremling, 1973) supported Fremling's comments that H. limbata is an inhabitant of small streams and that H. bilineata prefers larger streams such as the lower Mississippi River. A map of the distribution of Hexagenia limbata venusta is given in Figure 11.

Collection records:

TEXAS: Kerr County; Johnson Creek; Keith Meadows Property; 12 III 73 MP. TEXAS: Kerr County; North Fork of the Guadalupe River; 8 km W. Hunt; 24 II 73 MP; 12 III 74 MP. TEXAS: South Fork of the Guadalupe River; 9 km SW Hunt; 24 II 73 MP. TEXAS: Kerr County; Fessenden Creek; State Fish Hatchery Rd.; 24 VIII 73 MP. TEXAS: Kerr County; Turtle Creek; FM 1273 Crossing; 28 VIII 73 MP. TEXAS: Kerr County; Turtle Creek; FM 2771 Crossing; 28 VIII 73 MP; 1 II 74 MP. TEXAS: Kerr County; Verde Creek; FM 173 Crossing; 28 VIII 73 MP. TEXAS: Kerr County; Guadalupe River; SH 16 Crossing; 1 II 74 MP. TEXAS: Kerr County; Guadalupe River; Center Point Dam; 1 II 74 MP. TEXAS: Blanco County; Blanco River; Road Crossing 8 km W. Blanco; 19 XII 73 MP. TEXAS: Blanco County; Blanco River; FM 165 Crossing; 15 VIII 73 MP, 18 XII 73 MP. TEXAS: Comal County; Guadalupe River; tailrace from Canyon Reservoir; 16 III 73 MP. TEXAS: Hays County; Blanco River; RR 12 Crossing; 19 XII 73 MP, 7 III 73 MP. TEXAS: Caldwell County; Clear Fork of Plum Creek; Road crossing upstream from FM 20 Crossing; 17 V 73 MP; 18 I 74 MP. TEXAS: Caldwell County; Plum Creek; Road Crossing of FM 1386; 17 I 74 MP. TEXAS: Guadalupe County; Ullrich Farm Pond; 10 I 73 MP. TEXAS: Guadalupe County; Guadalupe River; Riverine stretch between lakes Dunlap and McQueeney; 11 IV 73 MP. TEXAS: Gonzales County; Copperas Creek; FM 1115 Crossing; 17 V 73 MP. TEXAS: Gonzales County; Peach Creek; FM 532 Crossing; 7 IV 74 MP. TEXAS: Comal County; Guadalupe River; US 281 Crossing, 16 III 73 MP. TEXAS: DeWitt County; Guadalupe River; road crossing north of Cuero; 14 III 73 MP. TEXAS: Goliad County; Coleto Creek; FM 522 Crossing; 24 VIII 73 MP. TEXAS: Goliad County; 24 km Coleto Creek; US 87 Crossing; 24 VIII 73 MP.

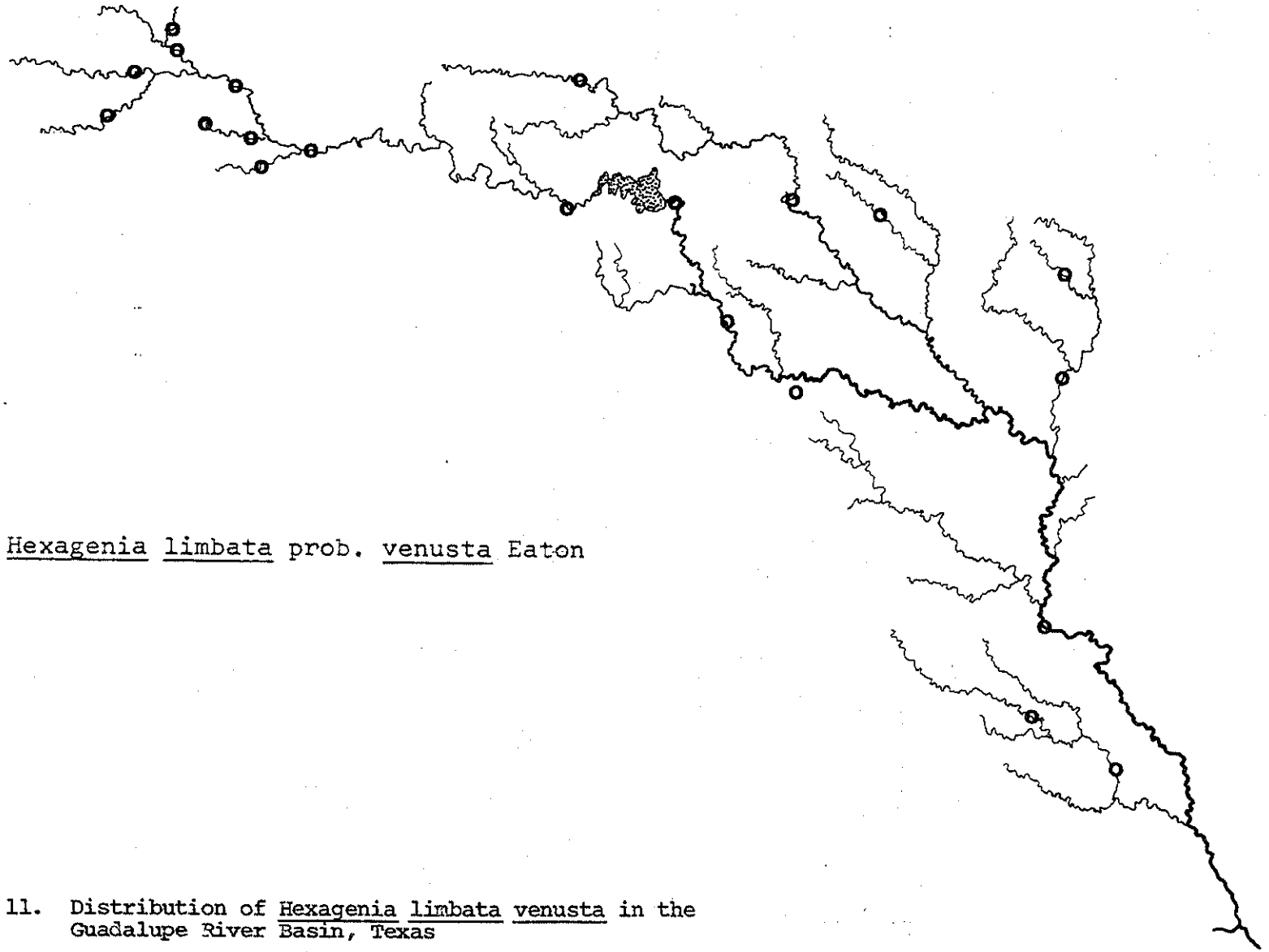


Figure 11. Distribution of Hexagenia limbata venusta in the Guadalupe River Basin, Texas

Hexagenia bilineata (Say)

This species is distinguished in the nymphal stage by the angular frontal projection in contrast to the rounded projection of H. limbata venusta. This species was reported in the Guadalupe River Basin by the Academy of Natural Science of Philadelphia (1949). They found it in the lower portion of the basin, below Victoria (station 62) and also upstream, near Seguin (near station 27). Traver (1935) reported the collection of Hexagenia bilineata by F. F. Bibby at Waco, Texas.

Hexagenia bilineata was found only in two mainstream impoundments near Seguin (stations 25 and 27). Samples were not obtained from the Guadalupe River downstream from Victoria. In this segment, near its mouth, the river has slowed and widened, making the occurrence of H. bilineata very likely. At streams where the species was taken, river flow was significantly slowed and thick organic layers formed microhabitats. The literature (Burks, 1953; Fremling, 1970; and Traver, 1935) indicates that this species is expected to occur in larger streams. At these two stations, the river was approaching 200 meters in width.

Collection records:

TEXAS: Guadalupe Co., Lake McQueeney; 13 II 73 MP. TEXAS: Guadalupe Co.; Meadow Lake; 13 II 73 MP.

Hexagenia sp.

Specimens that could not be positively identified as either of the two previously mentioned species or any other described species were found in spring-run sections at three stations in two streams, the Comal River and the Guadalupe River. The Comal River is spring-fed and cool (22 C). The Guadalupe River station is immediately downstream from Hueco Springs, a major spring flowing from the Edwards Limestone. The unidentified specimens resembled H. limbata venusta but the frontal process

was not well-rounded enough to definitely place these organisms into this species and subspecies, nor was it angular enough to definitely place these organisms in the H. bilineata species. Therefore, until further research indicates otherwise, these organisms should be referred to as an intergrade between the two sympatric species, H. bilineata and H. limbata venusta.

Collection records:

TEXAS: Comal County; Comal River; Landa Park Railroad Trestle; 16 III 73 MP. TEXAS: Comal County; Guadalupe River; Road crossing NE New Braunfels; 15 VIII 73 MP. TEXAS: Comal County; Guadalupe River; Hueco Springs road crossing; 24 III 73 MP.

Pentagenia Walsh

Pentagenia vittigera Walsh

This genus of Ephemeridae is easily identified by the presence of a two-pronged frontal projection, as opposed to the dome-shaped projection of Hexagenia. The species P. vittigera Walsh is one of two species in the genus and is the only one known from outside Ohio.

Reports of the adults are from College Station, Austin, and Waco by V.A. Little (Traver, 1935), a general "State" reference (Burks, 1953), and Guadalupe River Basin records from near Seguin (near station 27 of this study) and below Victoria (near station 62 of this study, ANSP, 1949, 1963).

During this study, no representatives of this genus were found. Intensive sampling of the recorded locations did not reveal any specimens of this species. Pentagenia vittigera can apparently be found in substrates suitable of supporting Hexagenia, but seem to prefer a faster current than the Hexagenia species (Fremling, 1970). At present, there

is insufficient data to either support or question the literature references to the presence of this genus in the Guadalupe River Basin.

Family Polymitarcidae

Tortopus Needham and Murphy

Tortopus prob. circumfluus Ulmer

The adult of the genus Tortopus was described in 1924 (Needham and Murphy, 1924), but not until 1959 was a description of the nymph of this genus published (Scott, et al., 1959). The characteristics that distinguish Tortopus nymphs from those of the other genus in the subfamily Campsurinae, Campsurus, are the presence of an unilobed gill on abdominal segment one and dentation pattern on the mandibular tusks. Ulmer (1942) described Tortopus circumfluus from males collected by Belfrage from the Rio Grande River that had been mis-identified as Campsurus decoloratus Hagen. Only the C. decoloratus specimens from the Rio Grande River were mis-identified. The Bosque County records are valid. The nymph of Tortopus circumfluus Ulmer has not been described.

Records of these organisms in Texas and the Guadalupe River Basin are limited. The description and records of U.mer (1942) of Tortopus circumfluus were the only species records of this genus for Texas. The other three species in this genus have not been reported from Texas. Only generic records exist for the presence of this organism in the Guadalupe River Basin. The ANSP reported the genus at a sample point downstream from station 62 of this study (ANSP, 1949).

Specimens identified as Tortopus probably circumfluus Ulmer were found during one visit to station 61. This station is very near the ANSP station. This station was nearly identical to the habitat description of the type locality of Ulmer (1942).

Collection records:

TEXAS: Victoria County; Coleto Creek; US 77 Crossing; 23 VIII 73 MP.

Campsurus Eaton

Campsurus probably decoloratus Hagen

The only species of this genus known to occur in North America is Campsurus decoloratus Hagen. Five species were listed in Traver (1935) and Burks (1953) but these were later reduced to two species by synonomyzing C. incertus, and C. manitobiensis with C. primus and then transferring the genus to Tortopus (McDunnough).

The Campsurus nymph can be distinguished from the Tortopus nymph by the presence of a bilobed gill on abdominal segment one and by the multiple denticles on the frontal processes. Further descriptions of the Campsurus nymph can be found in Ulmer (1920) and Needham and Murphy (1924).

Texas records of this species were given by Traver (1935). Ulmer (1942) discounted the Rio Grande River records of C. decoloratus, leaving only the Bosque County collections as verified Campsurus decoloratus identifications. The genus was noted near station 62 of this study in collection records of the Academy of Natural Science of Philadelphia (ANSP, 1963).

Specimens identified as Campsurus probably decoloratus Hagen were found in the Guadalupe River at stations 25 and 27. The locations were two mainstream impoundments. The reservoirs had thick organic bottom deposits, low flow, and greater width and depth than at almost any other point in the basin except near the mouth. Positive identifications by rearing nymphs to imago are extremely difficult and were not done.

Based on the literature records, these organisms have been tentatively identified as Campsurus decoloratus.

Collection records:

TEXAS: Guadalupe County; Guadalupe River; Lake McQueeney; 13 II 73 MP.
TEXAS: Guadalupe County; Guadalupe River; Meadow Lake; 13 II MP.

A distribution map for Tortopus probably circumfluus and Campsurus probably decoloratus Hagen is given in Figure 12.

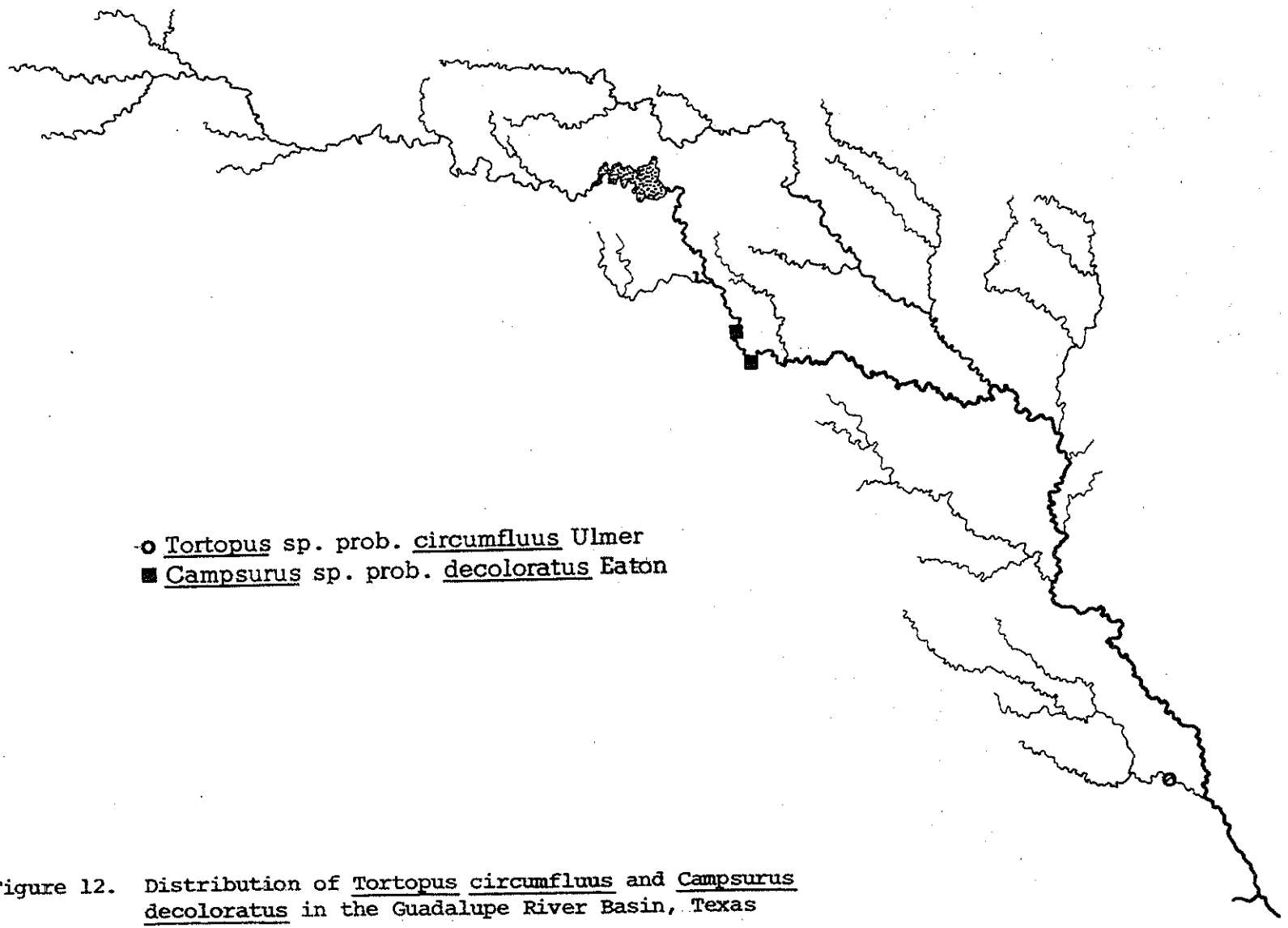


Figure 12. Distribution of Tortopus circumfluus and Campsurus decoloratus in the Guadalupe River Basin, Texas

Key to families, genera, and described species of mayfly nymphs in the Guadalupe River Basin, Texas

This key was constructed by combining various sources (Edmunds, 1959; Berner, 1950; Burks, 1953; Traver, 1935) with more recent taxonomic papers, classroom handouts, and personal experience as an aid for future mayfly nymph investigators. Its use is intended for Guadalupe River Basin specimens only since some couplets are not totally exclusive but are more than adequate for nymphs found in this basin. The taxonomic arrangement and nomenclature is that of Edmunds and Traver (1958). Figure 13 presents key characteristics that were used throughout the key. Figures of the whole nymph are presented in many instances. No dimensions are given with these figures and they are intended as an illustration of gross morphology, with an emphasis on taxonomic detail.

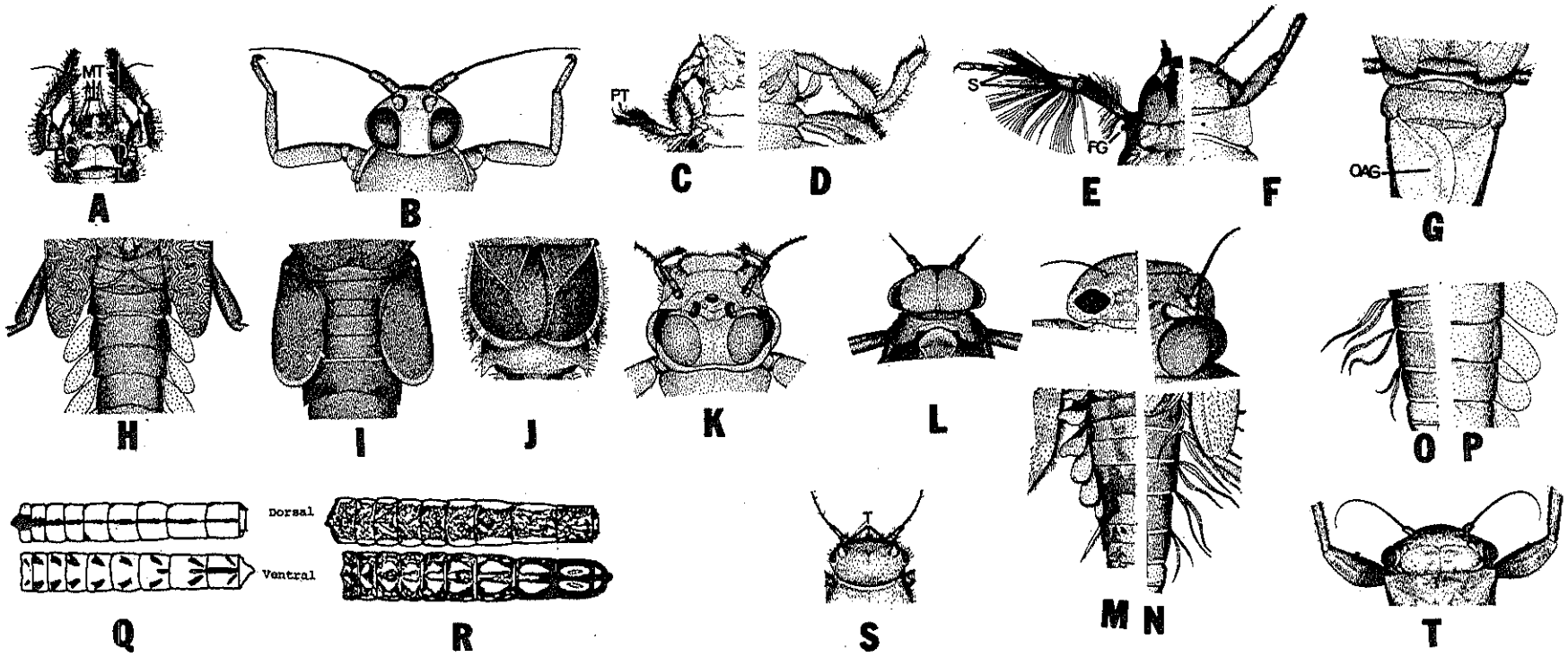


Figure 13. Taxonomic characters of mayfly nymphs.

a. Head of Hexagenia limbata venusta illustrating mandibular tusks (MT). b. Head of Pseudocloeon sp. for contrast. c. Hind leg of Hexagenia limbata venusta showing pointed apex of tibia (PT). d. Hind leg of Campsurus decoloratus for contrast. e. Foreleg of Isonychia sicca manca showing double row of setae (S) and forecoxal gills (FG). f. Foreleg of Baetis sp. for contrast. g. Operculate abdominal gills (OAG) of Caenis. h. Non-operculate gills of Baetis for contrast. i. Operculate, non-meeting abdominal gill of Leptohyphes. j. Operculate, meeting-medially gill of Caenis sp. k. Prognathous head of Choroterpes mexicanus. l. Hypognathous head of Baetis. m. Heptageniid gills and head of Stenonema sp. n. Leptophlebiid gills and head of Choroterpes mexicanus. o. Leptophlebidd gills of Thraulodes gonzalesi. p. Baetid gills of Pseudocloeon sp. q. Abdominal patterns of Hexagenia limbata venusta (Spieth, 1941). r. Abdominal patterns of Hexagenia bilineata (Spieth, 1941). s. Head of Brachycercus showing tubercules (T). t. Head of Caenis for contrast.

1 -Mandibles with large tusks projecting forward and visible from above head. Fore tibiae and tarsi more or less flattened, adapted for burrowing. (Figure 13a). 2

-Mandibles without such tusks. Fore tibiae and tarsi cylindrical, unmodified. (Figure 13b) 3

2(1) -Ventral apex of hind tibiae projected into distinct acute point. (Figure 13c) Mandibular tusks curved upward as viewed laterally. . . . . Ephemeridae, 10

-Ventral apex of hind tibiae rounded. (Figure 13d) Mandibular tusks curved downward apically as viewed laterally . . . . . Polymitarcidae, 12

3(1) -Forelegs with double row of long setae on inner surface. (Figure 13e) Tufts of gills present at bases of maxillae. Gills may be present at bases of forecoxae 4

-Forelegs with setation other than above. (Figure 13f) Gill tufts absent from bases of macillae and forecoxae 5

4(3) -Gills ventral on abdominal segment one. Gill tufts absent from bases of forecoxae . . . . . Oligoneuridae, Homoeoneuria sp.

-Gills dorsal on abdominal segment one. Gill tufts present at bases of forecoxae. (Figure 14) . . Siphlonuridae, Isonychia sicca manca

5(3) -Gills on abdominal segment two operculate or semioperculate, covering succeeding pairs. (Figure 13g) 6

-Gills on abdominal segment two neither operculate nor semi-operculate; either similar to those on succeeding segments or absent. (Figure 13h) 7

6(5) -Gills on abdominal segment two triangular; semi-triangular, or ovoid, not meeting medially. (Figure 13i) Gill lamellae on segments 3-6 simple or bilobed, without fringed margins. . . . . Tricorythidae, 13

-Gills on abdominal segment 2 quadrate; meeting or almost meeting medially. (Figure 13j) Gill lamellae on segments 3-6 with fringed margins. . . . . Caenidae, 14

7(5) -Nymph distinctly flattened, head prognathous, eyes and antennae dorsal. (Some Leptophlebiidae may separate here; either half of couplet may give Leptophlebiidae, however.) Figure 13k 8

-Nymph not flattened or slightly flattened, being more cylindrical. Head hypognathous; eyes and/or antennae lateral, antero-lateral, or on front of head. (Figure 13l) 9

8(7) -Abdominal gills of single lamella, usually with fibrilliform tufts at or near bases. Rarely, pointed. Rarely, narrow lanceolate

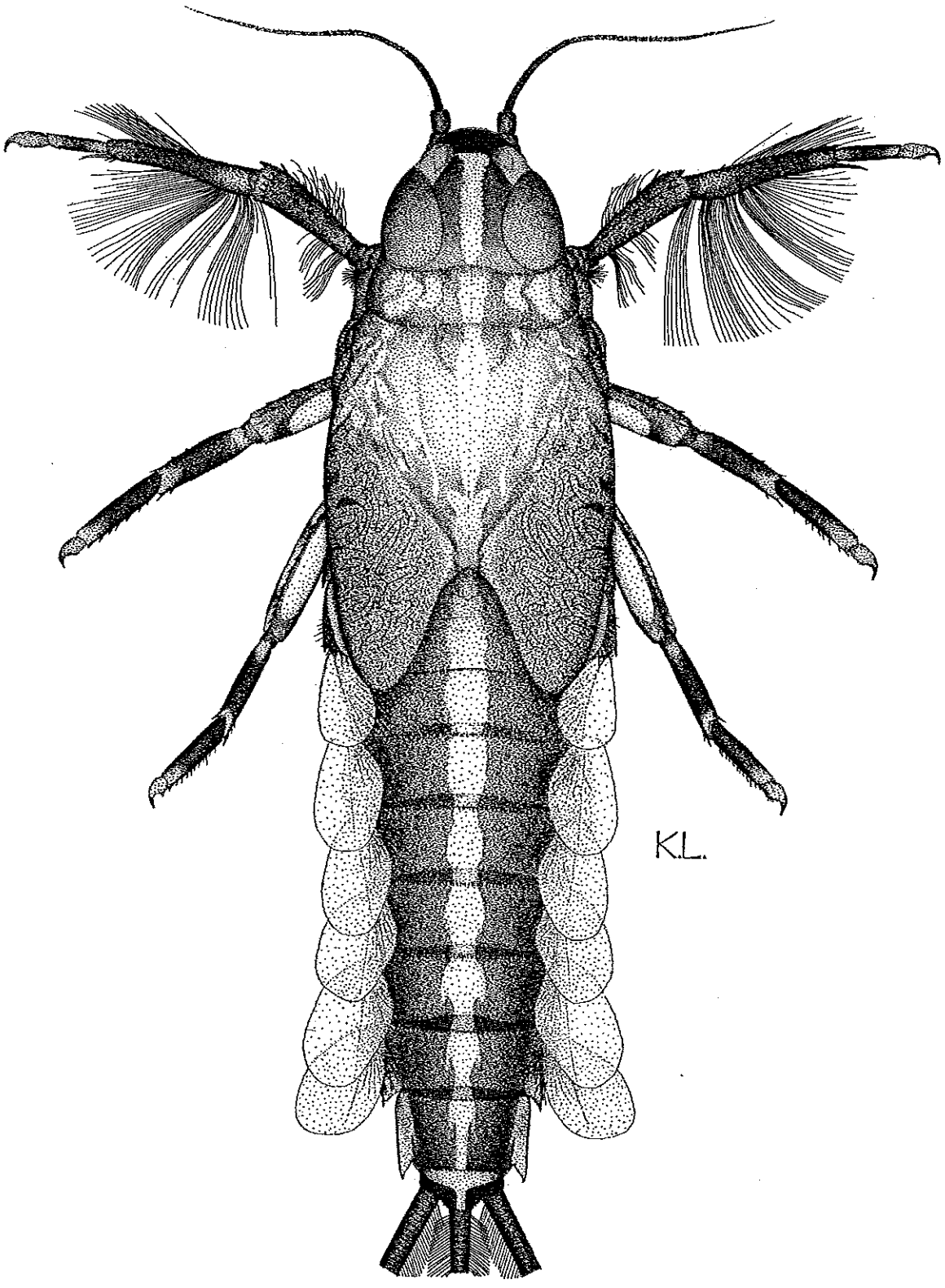


Figure 14. Isonychia sicca manca

branch making gills appear forked. Mandibles concealed beneath flattened head capsule. (Figure 13m) . . . . . Heptageniidae, 16

-Abdominal gills forked, formed of 2 lamellae with margins fringed, or terminating in filaments or points, never having a lamella and fibrilliform tuft. Mandibles visible and forming part of upper surface of head. (Figure 13n) . . . . Leptophlebiidae, in part, 19

9(7) -Abdominal gills on segments 2-7 either forked, in tufts, with all margins fringed, or double lamellae terminating in filaments or points. (Figure 13o) . . . . . Leptophlebiidae, in part, 19

-Abdominal gills not as above; gills either obovate, cordate or subcordate. Lamellae never terminating in filaments or points when double and may be single. Inner margin of gills usually entire, rarely finely dissected. (Figure 13p) . . . . . Baetidae, 21

10(2)-Mandibular tusks crenate on outer or upper margin. Labial palpi two-segmented. Frontal process bifid. . . . . Pentagenia vittegara

-Frontal process of head rounded. Gills on abdominal segment 1 forked. Antennae with whorls or long setae. . . . . Hexagenia, 11

11(10)-Frontal process strictly dome-shaped. Abdominal color patterns as in Figure 13q. (Figure 15) . . . . . Hexagenia limbata venusta

-Frontal process angular on lateral margins, even if only slightly so. Abdominal patterns as in Figure 13r. . . . . Hexagenia bilineata

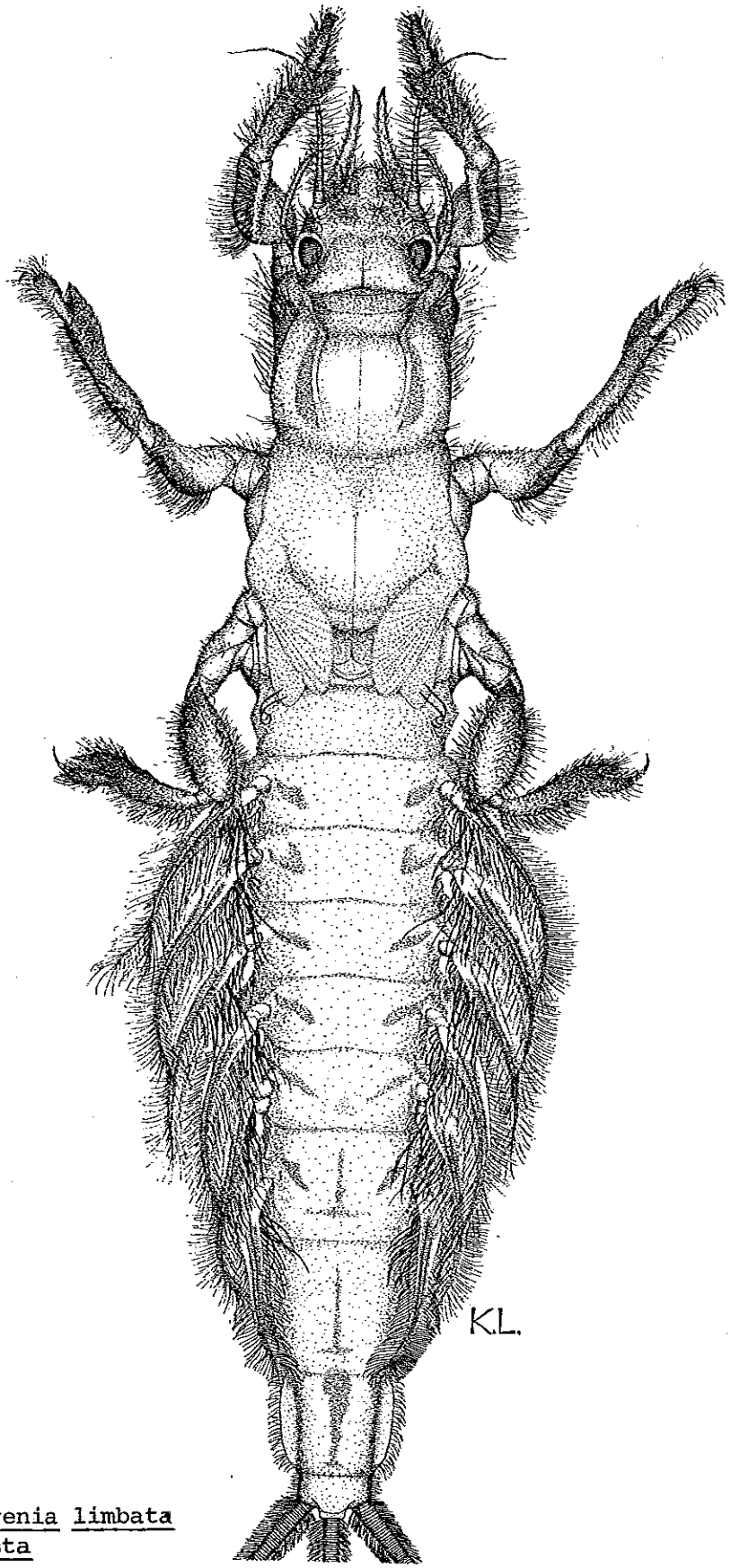


Figure 15. Hexagenia limbata venusta

12(2)-Mandibular tusks with a singular prominent subapical tubercle on median margin although single tubercle occasionally may occur basal to this. (Figure 16) . . . . . Tortopus circumfluus

-Mandibular tusks with a prominent basal or sub-basal tubercle on median margin and several to many smaller apical crenations. Bilobed gill present on abdominal segment 1. (Figure 17) . . . . . Campsurus decoloratus

13(6)-Femora with setae, operculate abdominal gill on segment 2 triangular or subtriangular in shape, always widest in basal 1/3. (Figure 18) . . . . . Tricorythodes sp.

-Femora with spines, opercular abdominal gill on segment 2 usually ovoid in shape, not triangular or subtriangular. (Figure 19) . . . . . Leptohyphes sp.

14(6)-Head with 3 prominent ocellar tubercles; (Figure 13s) maxillary and labial palpi two segmented . . . . . Brachycercus, 15

-Head without ocellar tubercles; (Figure 13t) maxillary and labial palpi three segmented. (Figure 20) . . . . . Caenis sp.

15(14)-Ocellar tubercles reduced and laterally marginal . . . . . Brachycercus maculatus

-Ocellar tubercles prominent; legs distinctly dark banded. (Figure 21) . . . . . Brachycercus lacustris

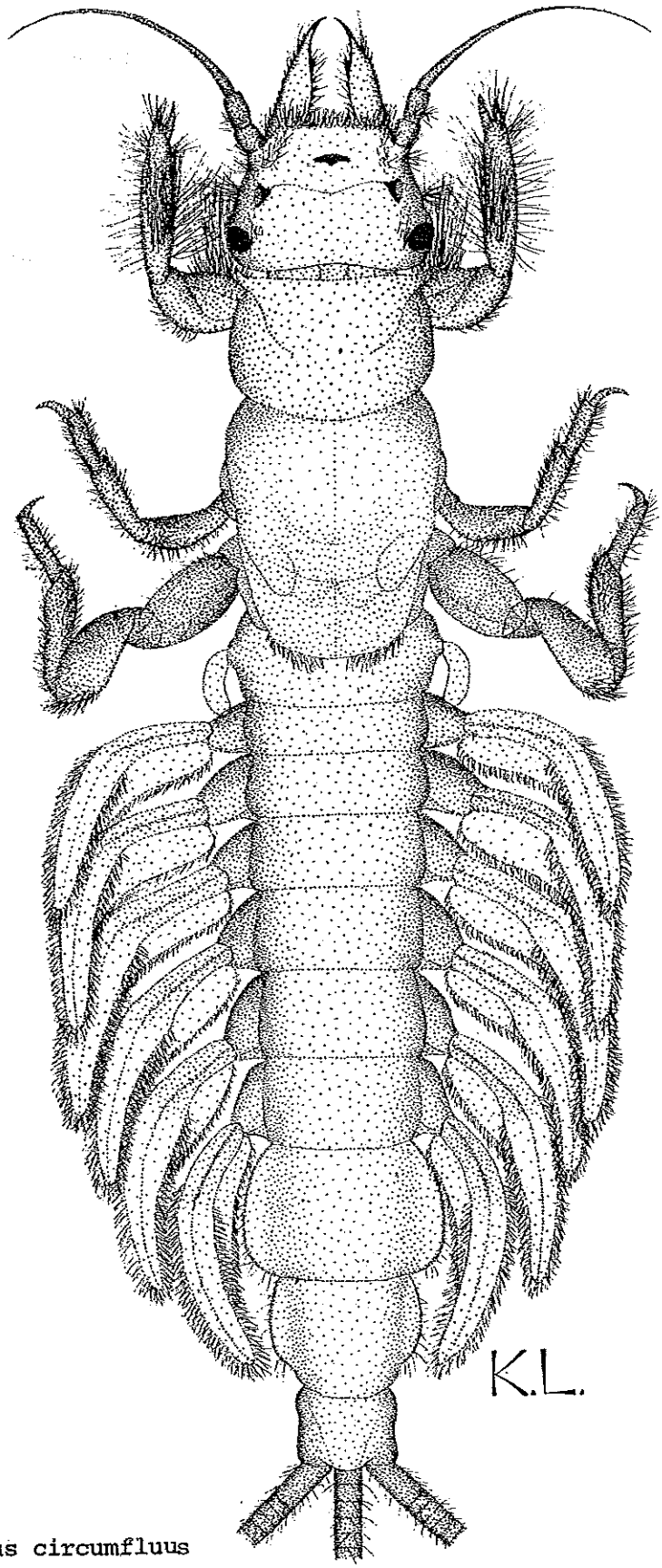


Figure 16. Tortopus circumfluus

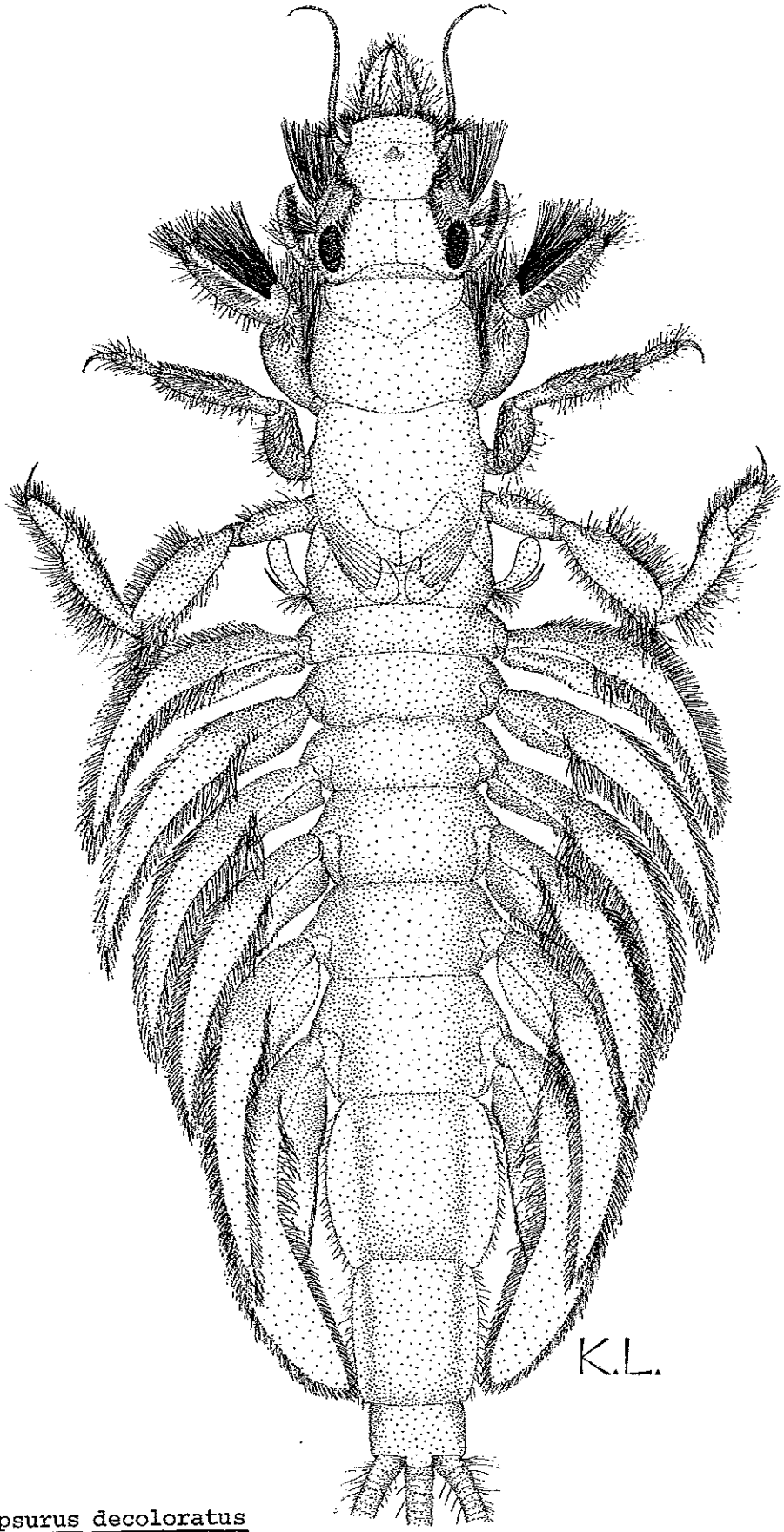


Figure 17. Campsurus decoloratus

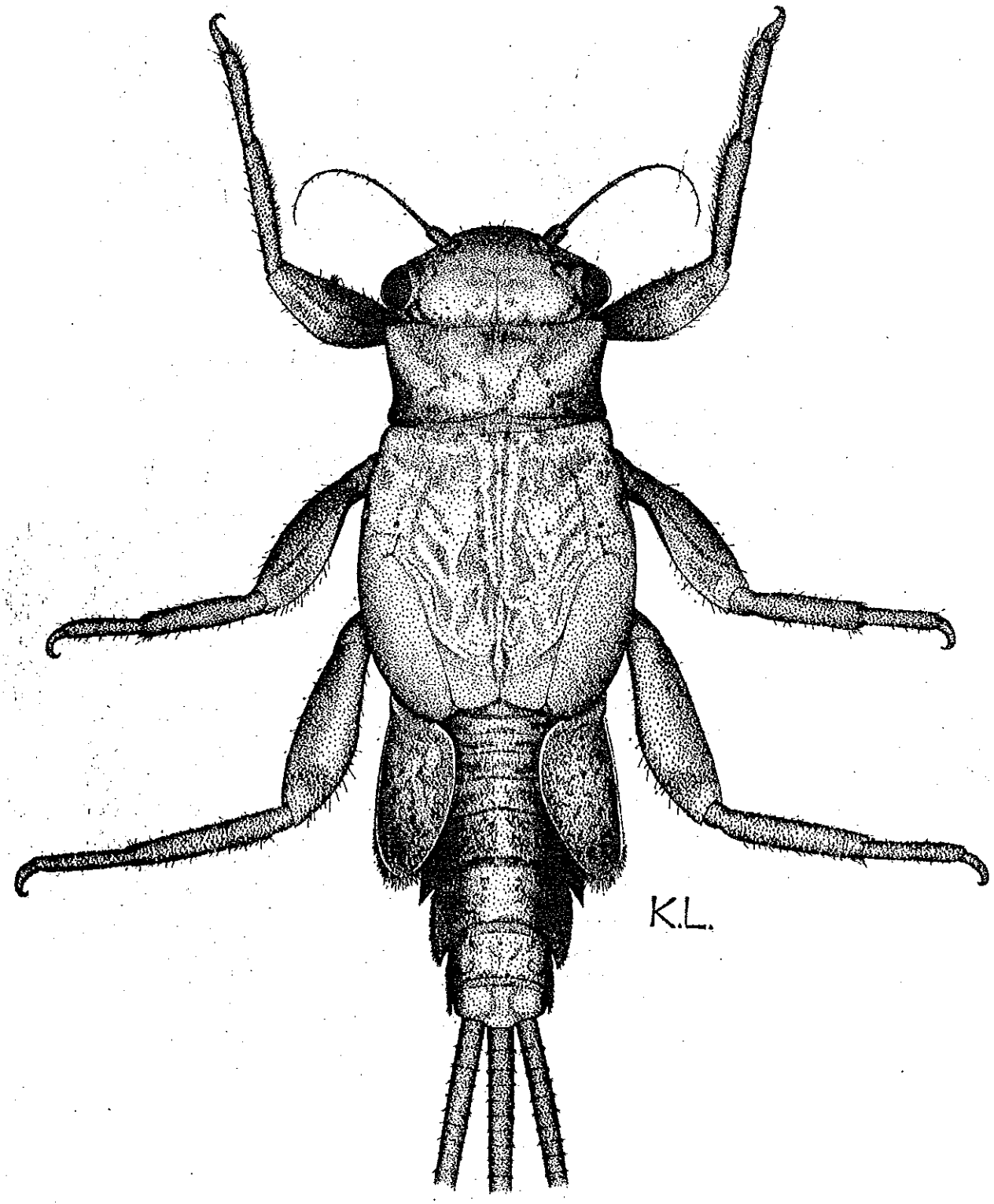


Figure 18. Tricorythodes sp.

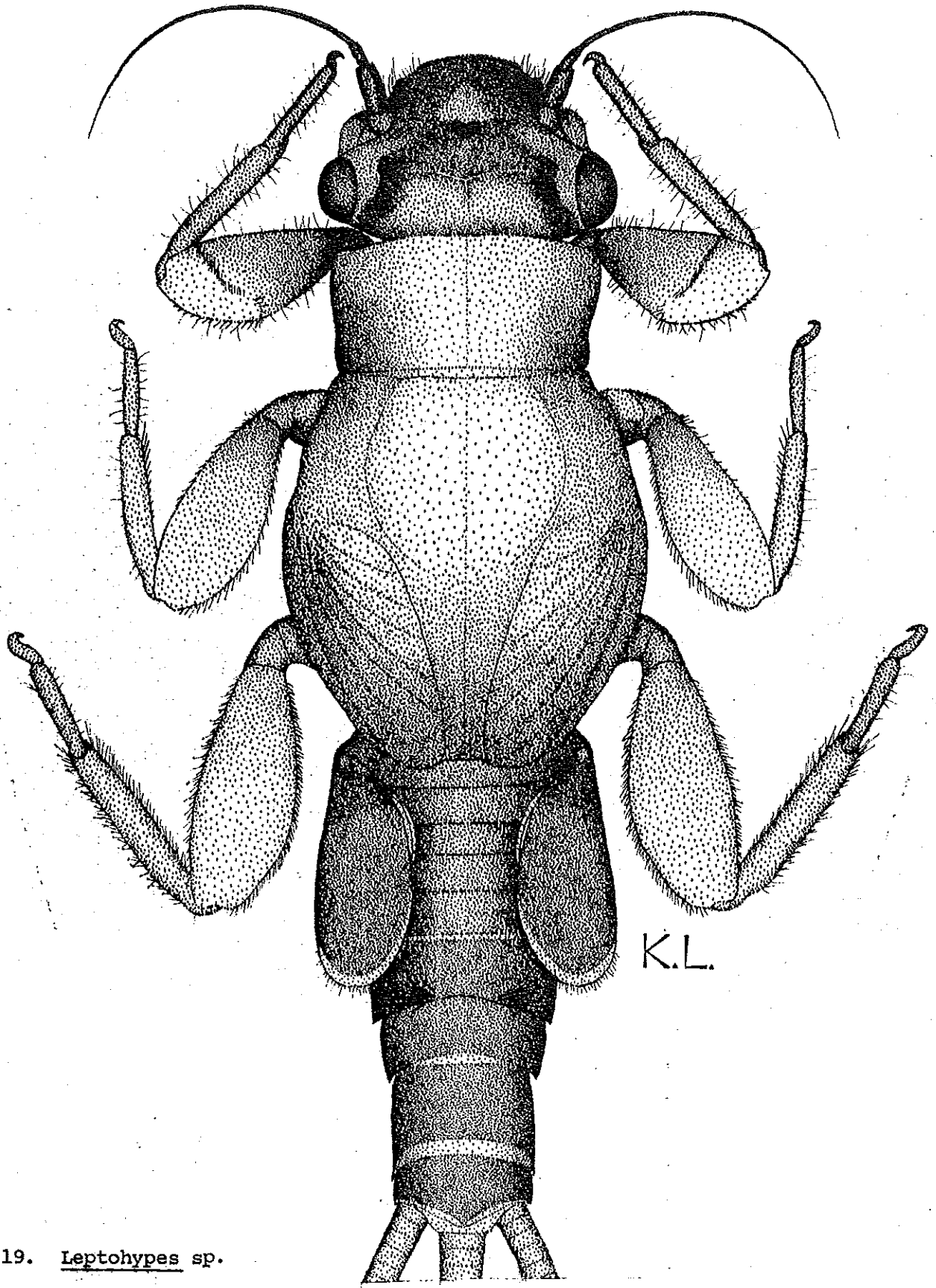


Figure 19. Leptohypes sp.

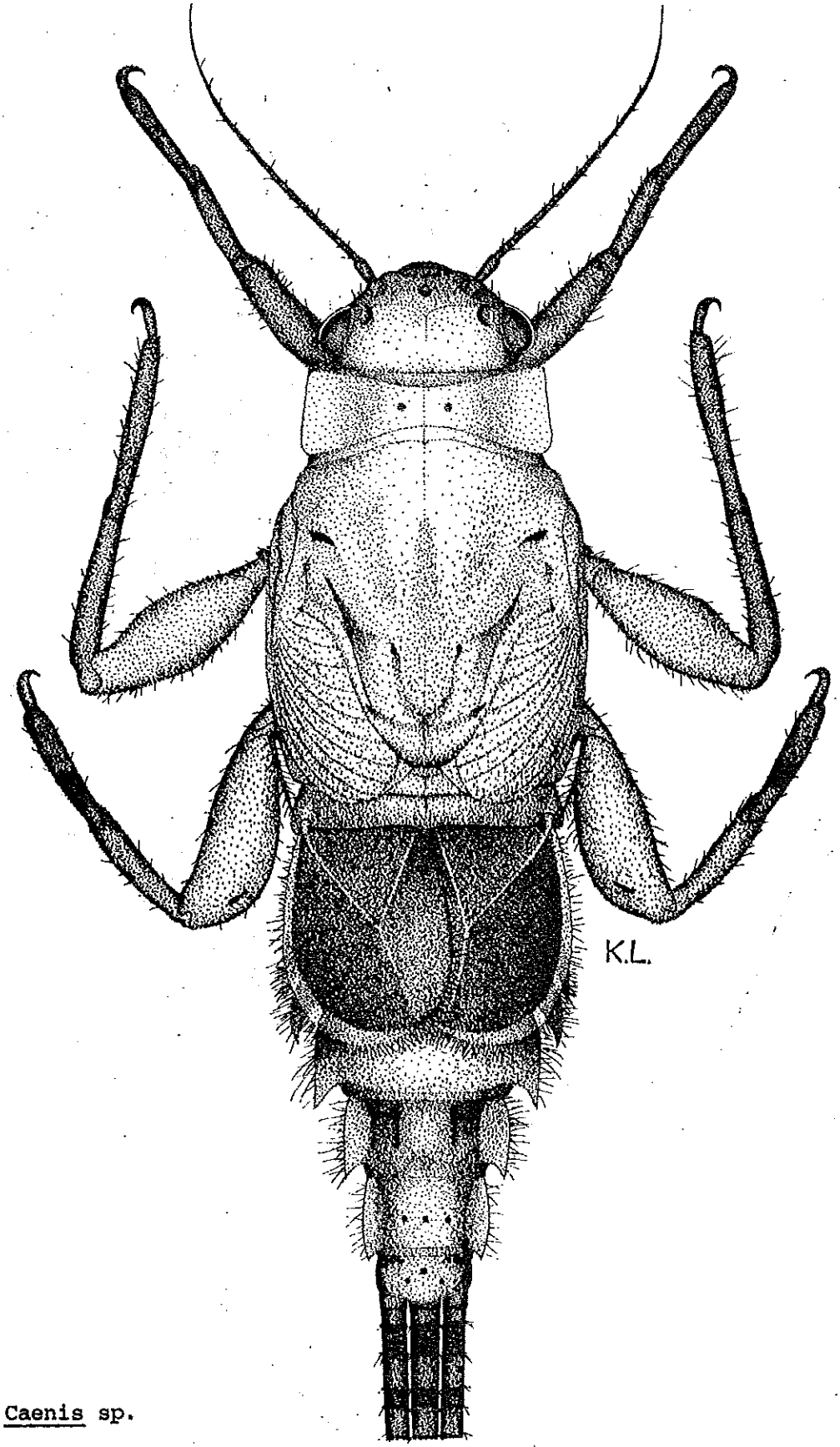


Figure 20. Caenis sp.

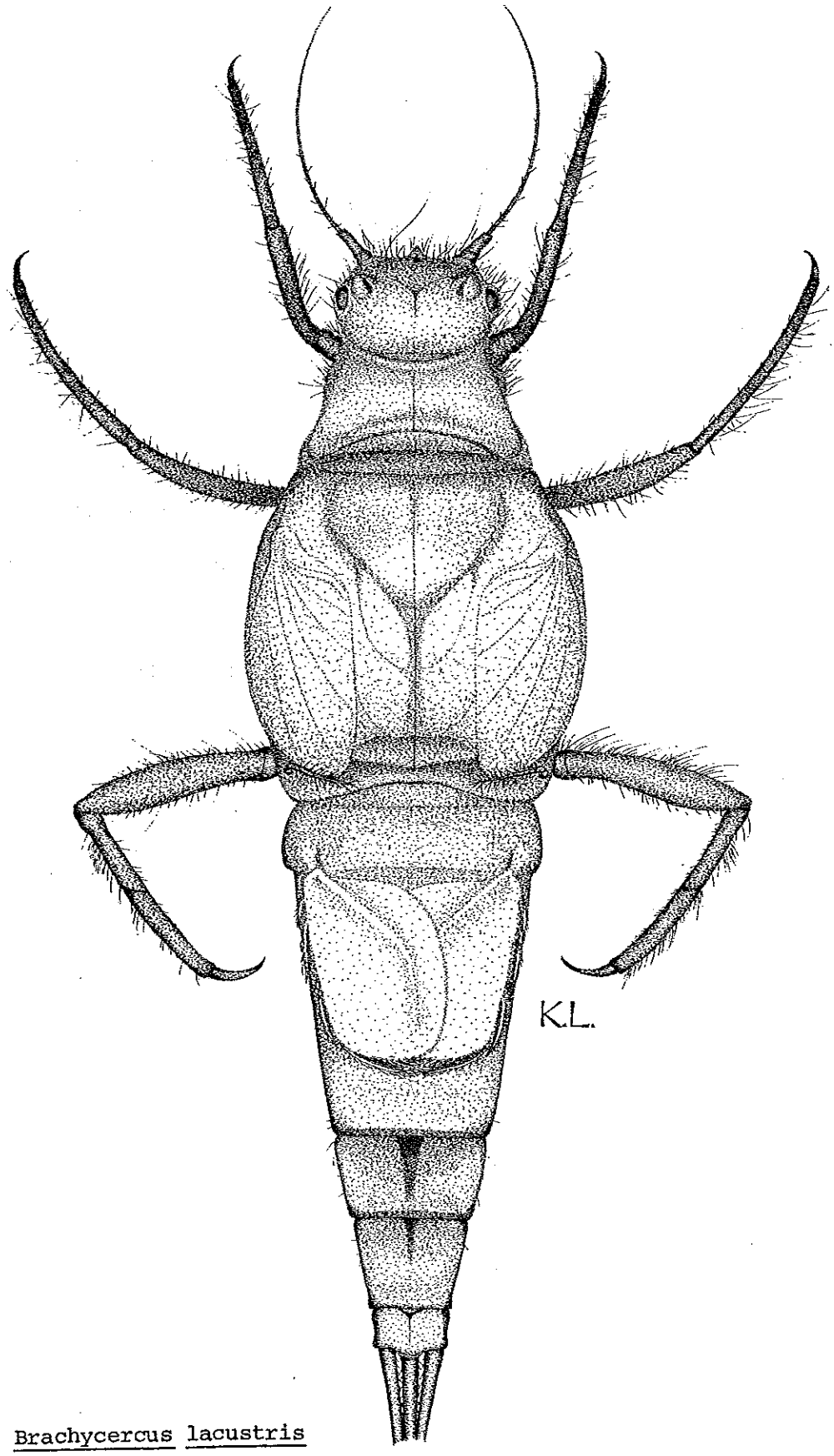


Figure 21. Brachycercus lacustris

16(8)-Gills on abdominal segment 7 reduced to a slender filament. Tracheae, if present in gill 7, with no lateral branches 17

-Gills on abdominal segment 7 similar to preceding pairs but smaller, trachea of gill 7 with lateral branches. . . *Heptagenia flavescens*

17(16)-Gills on abdominal segments 1-6 with apex rounded or truncate. Maxillae with setae or plumose hairs on crown of galea-lacinia. . . . . *Stenonema*, 18

-Gills on abdominal segments 1-6 with apex pointed. Maxillae with stout spines on crown of galea-lacinia. *Stenacron heterotarsale*

18(17)-Gills borne by abdominal segments 1-6 with apex rounded. Median pale spot usually present on anterior margin of head. Sublateral brown spots present on sternites 2-8. . . . *Stenonema femoratum tripunctatum*

-Gills on abdominal segments 1-6 with apex truncate. Abdominal sternites white except for slight vague brown along lateral of posterior sternites. (Figure 22) . . . . . *Stenonema ares*

19(8,9)-Labrum as broad or broader than width of head capsule. Abdominal gills with margins fringed. (Figure 23) . . *Traverella presidiana*

-Labrum narrower than width of head capsule. 20

20(19)-Gills assymetrically forked, with gills on segments 2-7 terminating in three filaments, the middle one longest and broadest. (Figure 24) *Choroterpes* (*Neochoroterpes*) *mexicanus*

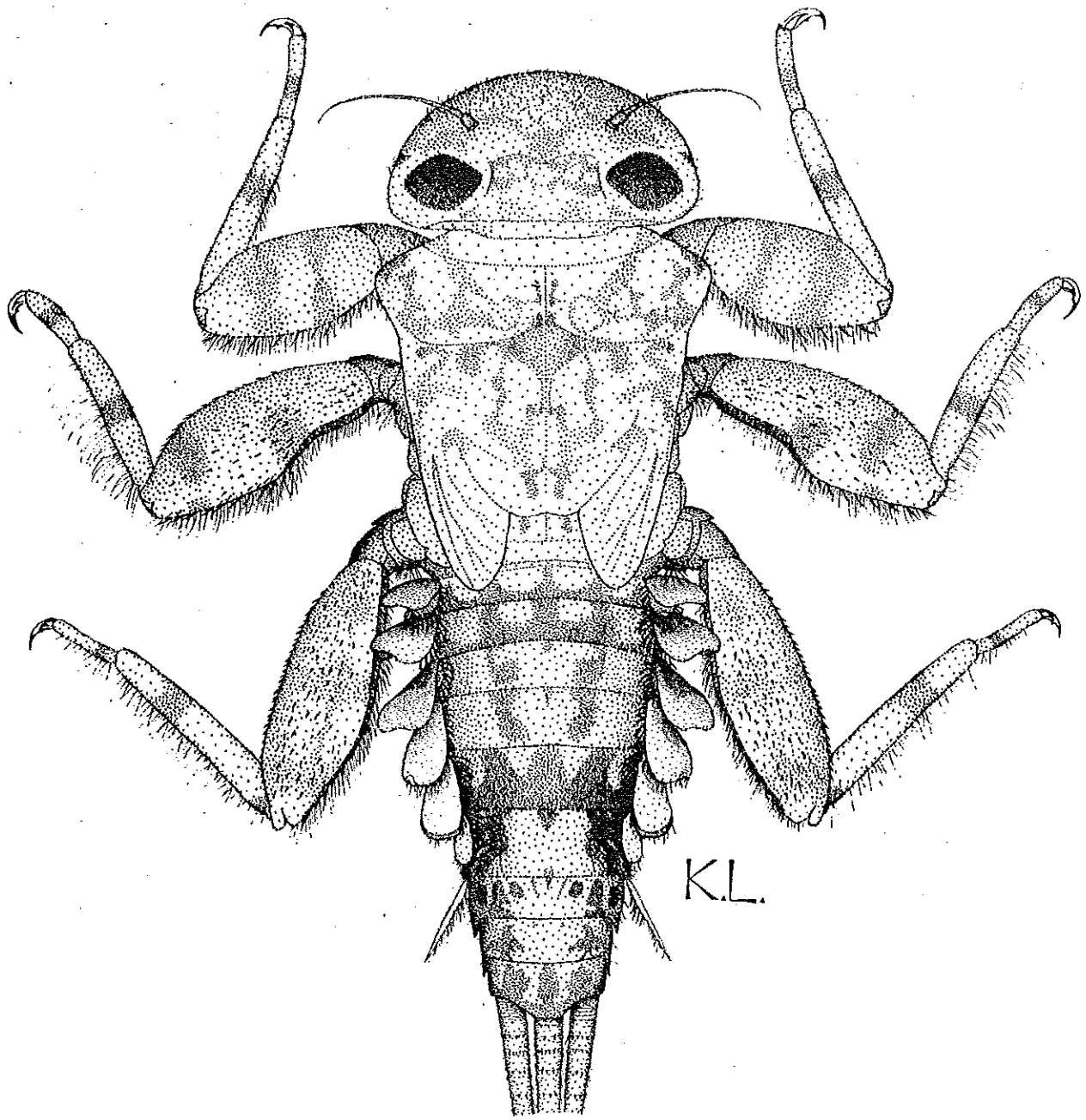


Figure 22. Stenonema ares

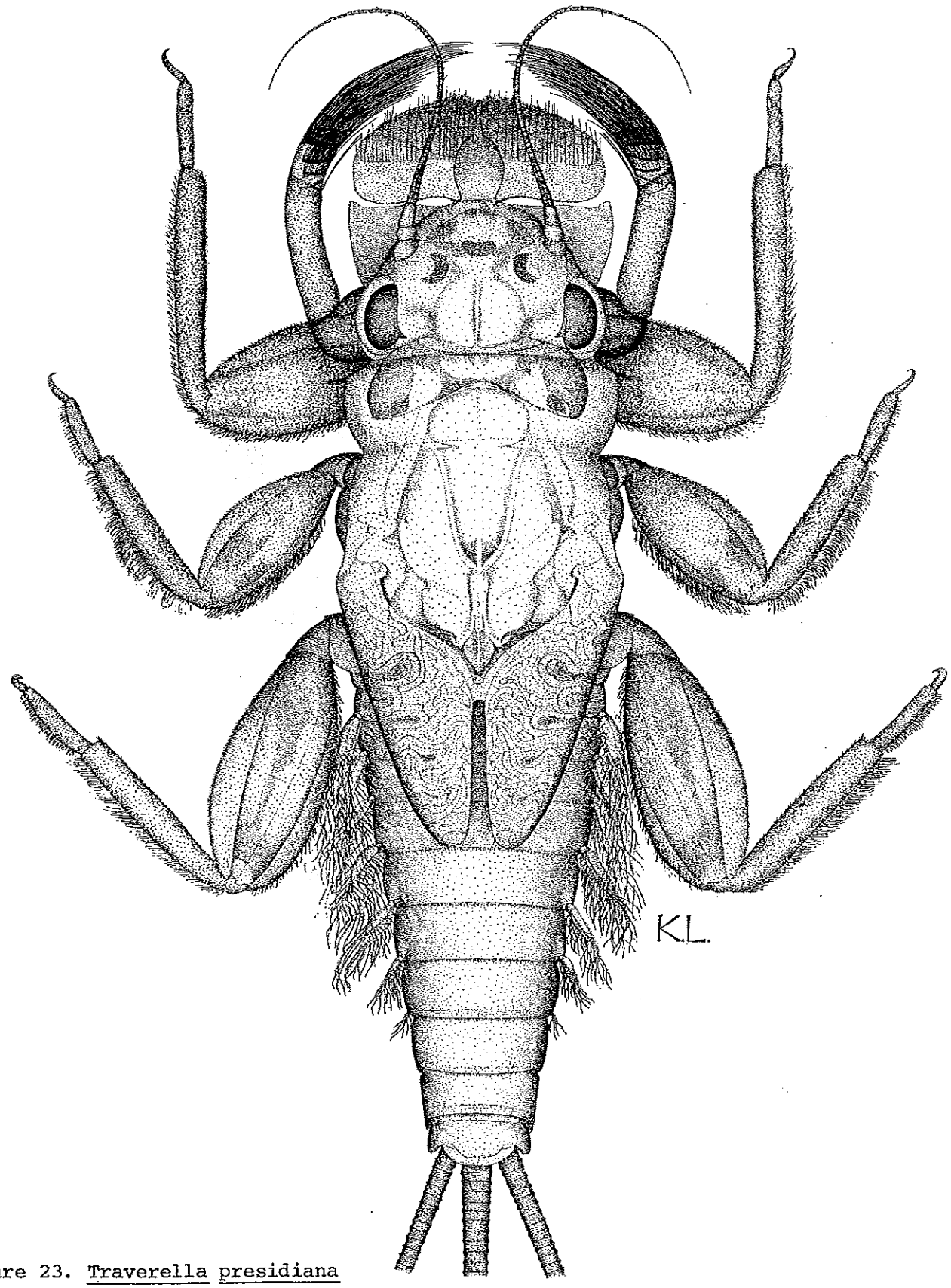


Figure 23. Traverella presidiana

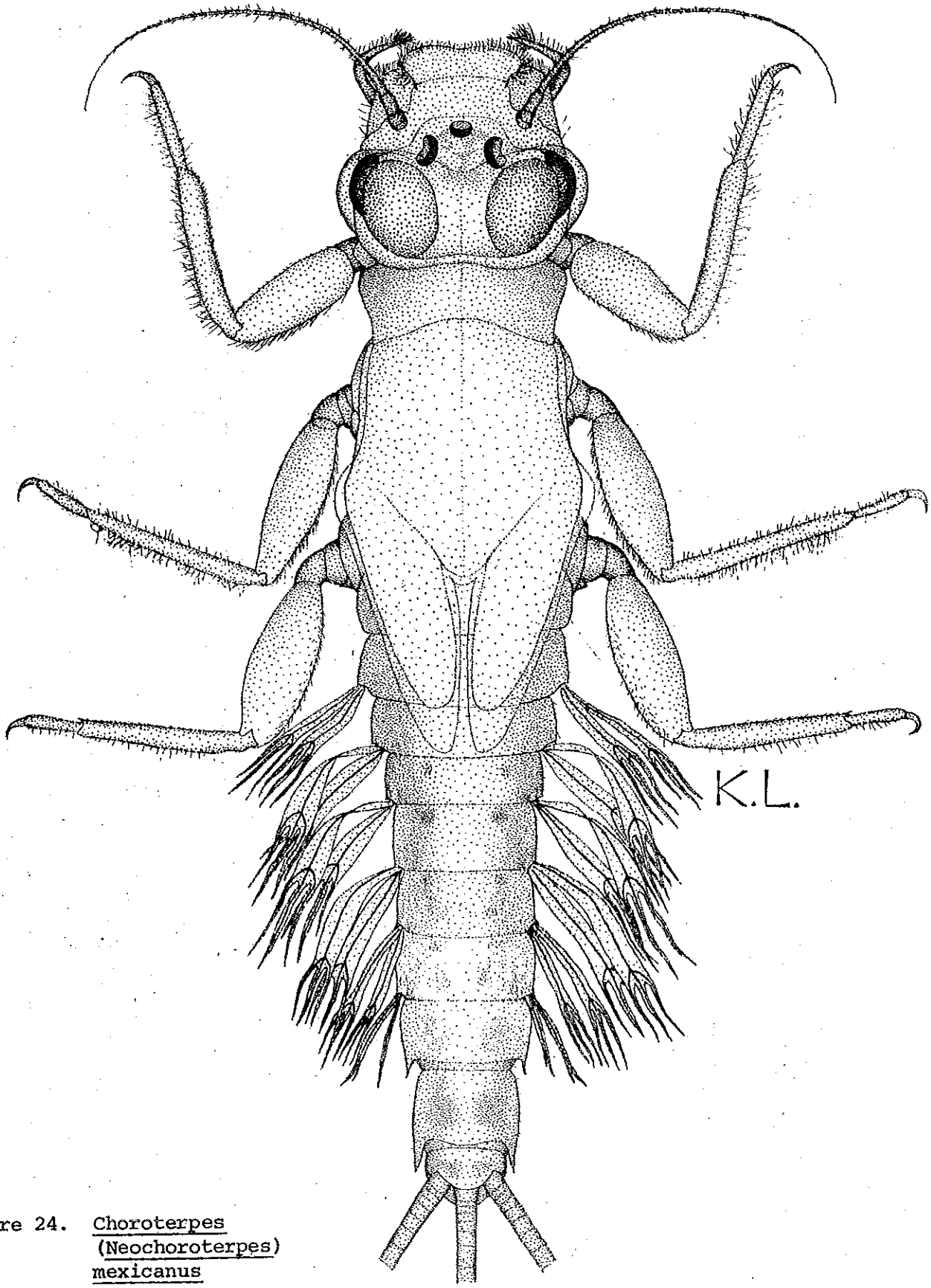


Figure 24. Choroterpes (Neochoroterpes) mexicanus

-Bilammelate gill consisting of lanceolate lammellae with little or no subtracheation. (Figure 25) . . . . . Thraulodes gonzalesi

21(9)-Claws distinctly spatulate with large apical denticles, tarsi distinctly bowed. (Figure 26) . . . . . Dactylobaetis mexicanus

-Claws sharply pointed; denticles, if present smaller and ventral 22

22(21)-Abdominal gills present on segments 1-5 only, extending ventrally from the pleura; caudal filaments bare or with only a few setae; distinct tubercle or tuft of setae present on each abdominal tergite 1-7, 8, or 9 . . . . . Baetodes sp.

-Abdominal gills present on segments 1-7 or 2-7 and held laterally and somewhat dorsally. Caudal filaments usually with fringe of hairs on inner margin. Tubercles or tufts of setae absent from abdomen 23

23(22)-Gills on abdominal segments 1-7 appear double 24

-Gills on abdominal segments 1-7 appear single 26

24(23)-Double gills on abdominal segments 1-7. Anterior (dorsal) portion only slightly smaller than posterior (ventral) portion. 25

-Gills on one or more abdominal segments recurved. Posterior (ventral) flap smaller than anterior (dorsal) portions. . . . Callibaetis sp.

25(24)-Hind wing pads present. . . . . Centroptilum sp.

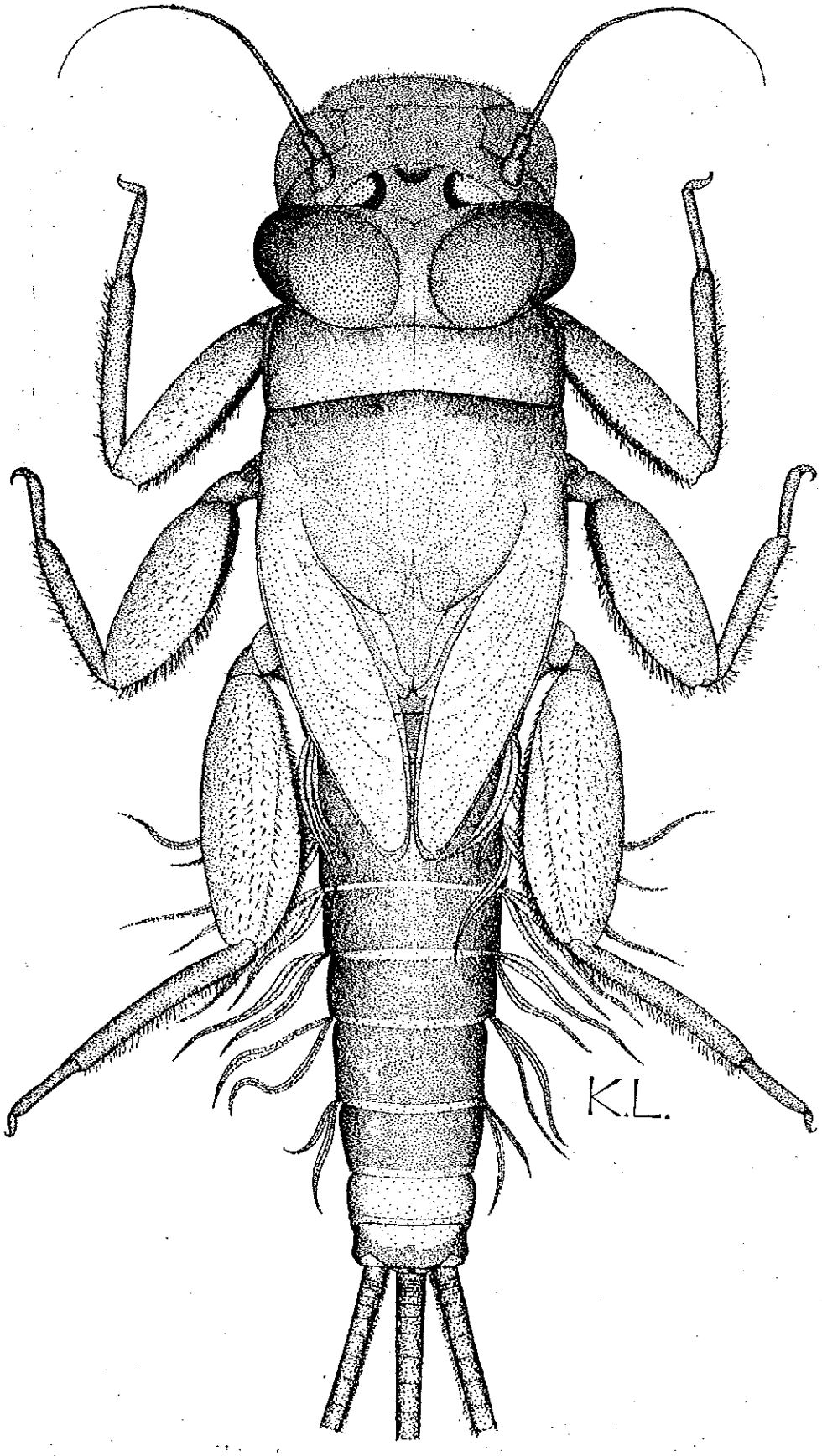


Figure 25. Thraulodes gonzalesi

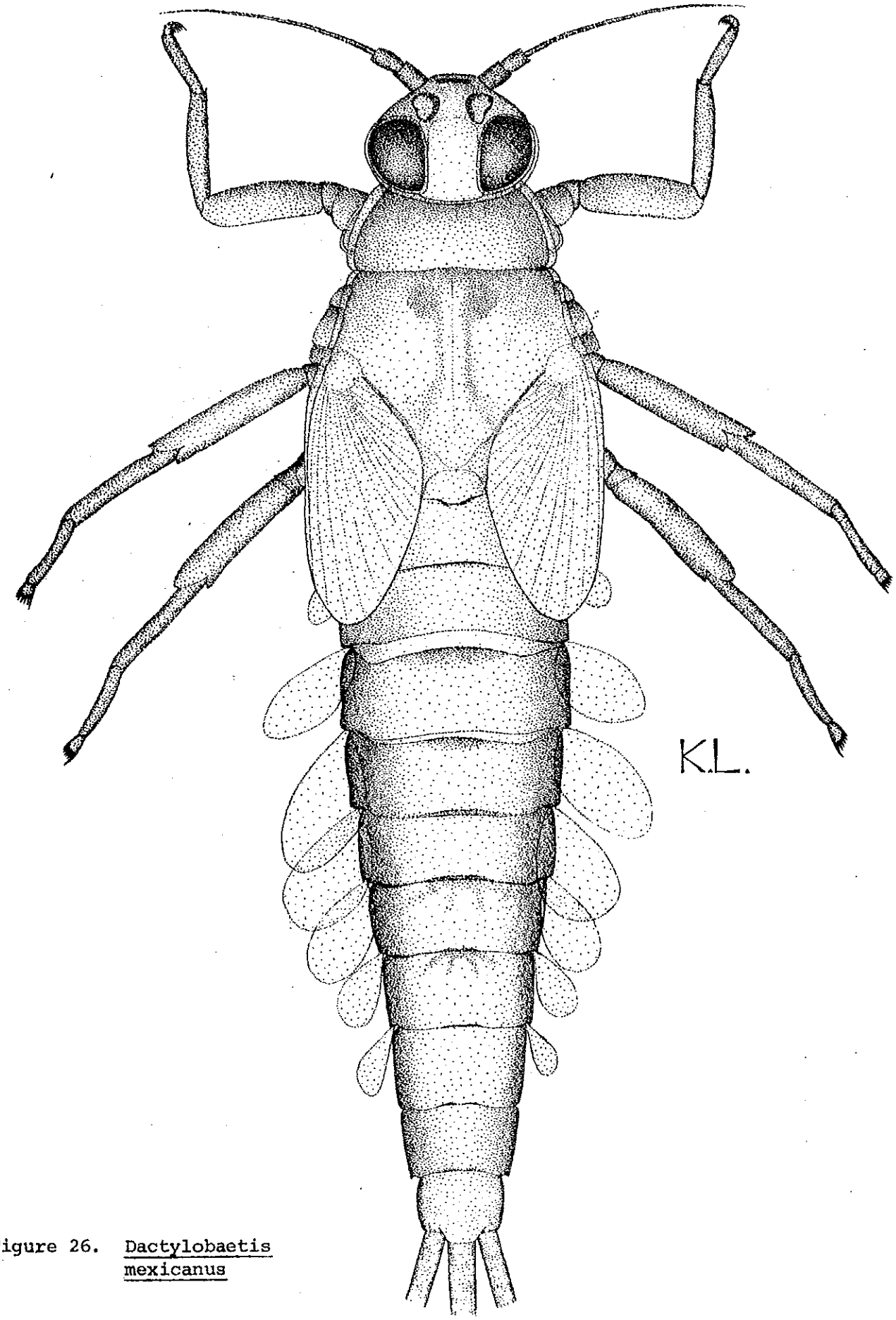


Figure 26. Dactylobaetis mexicanus

-Hind wing pads absent. . . . . Cloeon sp.

26(23)-Middle cerci may or may not be present; developing hind wing pads present although may be minute in small organisms. (Figure 27) . . . . . Baetis sp.

-Middle cerci may or may not be present. (not present in all specimens collected in Guadalupe River study); developing hind wing pad absent. . . . . Pseudocloeon sp.

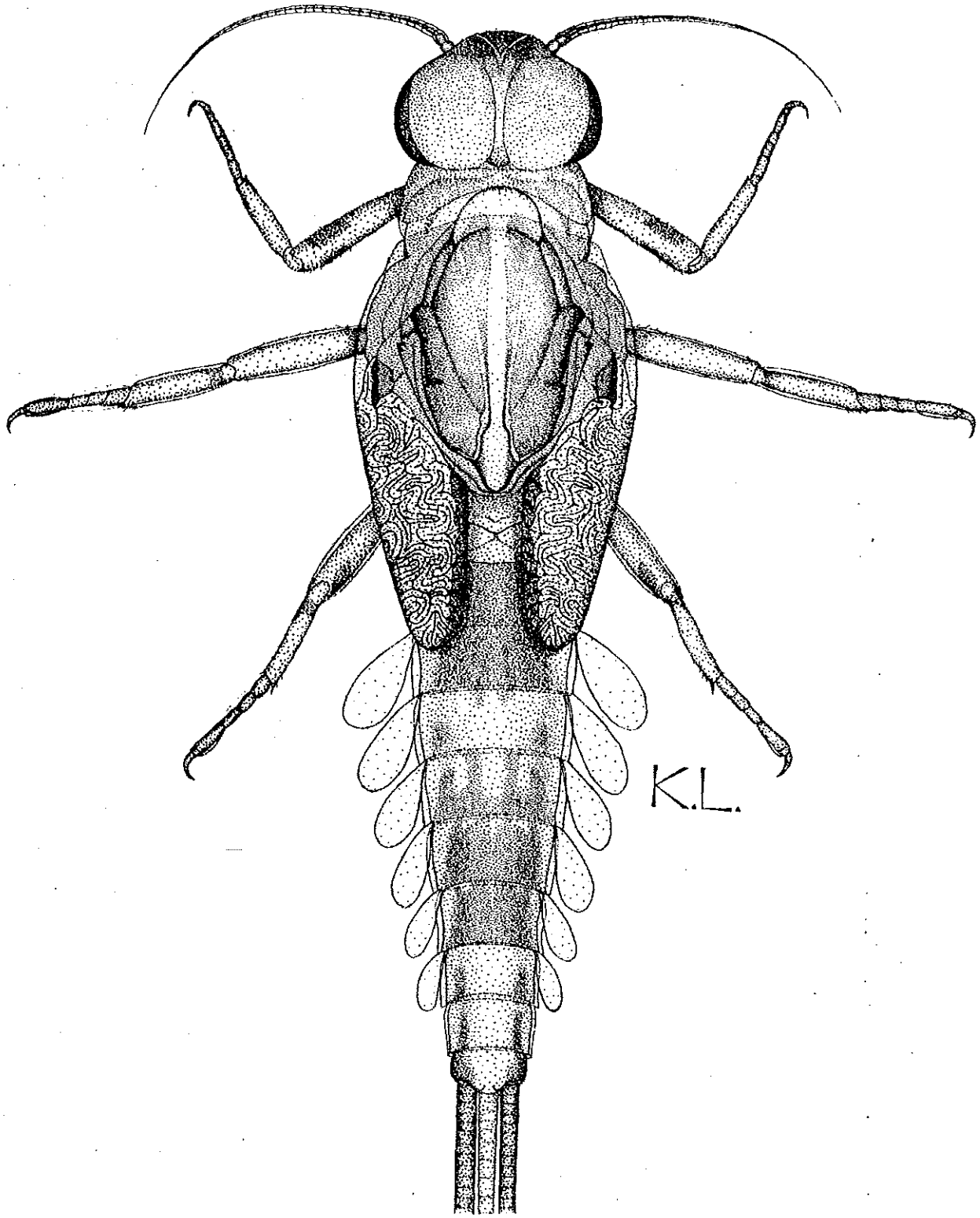


Figure 27. Baetis sp.

CONCLUSIONS

Through a literature review and field and laboratory work for this study, the mayfly fauna of the Guadalupe River Basin of Texas was investigated in detail. Several specie's records previously reported were not verified by field samples while several new specie's records were established. Table 2 is a compilation of findings of this study.

1. Organisms collected during this study were identified as belonging to 25 taxonomic units (genera, species, or subspecies). Nine families, 21 genera, 15 species, and 3 subspecies were discerned.
2. As a result of this study, nine new species and subspecies records are reported.
3. Eight species previously reported for the Guadalupe River Basin were not found. Recent literature records do not verify the presence of these species in the Guadalupe River Basin.

Table 2. Summary of results

TAXA	Found	Identified *	New Record	Range Extension	No Change	Questioned Presence
HEPTAGENIOIDEA						
Siphlonuridae						
Isonychia						
Isonychia sicca manca Eaton	+++	SSP	nymph	GRB	---	---
Isonychia aurea Traver	---	---	---	---	---	+++
Oligoneuridae						
Homeoneuria						
Homeoneuria sp.	+++	G	---	---	+++	---
Heptageniidae						
Heptagenia						
Heptagenia flavescens Walsh	+++	SP	G & SP	S to GRB	---	---
Stenacron						
Stenacron heterotarsale (McDun.)	+++	SP	G	s to GRB	---	---
Stenonema						
Stenonema femoratum tripunctatum (Banks)	+++	SSP	---	---	+++	---

Table 2. Continued

TAXA	Found	Identified *	New Record	Range Extension	No Change	Questioned Presence
Stenonema femoratum femoratum (Say)	+++	SSP**	SSP	(TX)	---	---
Stenonema ares Burks	+++	SP	sp. grp.	TX	---	---
Stenonema pudicum (Hagen)	+++	SP***	sp. grp.	(TX)	---	---
Baetidae						
Baetis	+++	G				
Baetis flavistriga McDun.	---	---	---	---	---	+++
Baetis intercalaris McDun.	---	---	---	---	---	+++
Baetis vagans McDun.	---	---	---	---	---	+++
Baetis erebus Traver	---	---	---	---	---	+++
Baetodes						
Baetodes edmundsi Koss	---	---	---	---	+++	---
Baetodes sigallatus Allen and Chao	---	---	---	---	+++	---
Baetodes arizonensis Koss	---	---	---	---	+++	---

Table 2. Continued

TAXA	Found	Identified *	New Record	Range Extension	No Change	Questioned Presence
Callibaetis	+++	G				
Callibaetis pictus Eaton	---	---	---	---	---	+++
Callibaetis montanus Eaton	---	---	---	---	---	+++
Dactylobaetis						
Dactylobaetis mexicanus Traver and Edmunds	+++	SP	SP	U.S.	---	---
Pseudocloeon	+++	G				
Pseudocloeon veteris McDun.	---	---	---	---	---	+++
Centroptilum	+++	G				
Centroptilum album McDun.	---	---	---	---	---	+++
CAENOIDEA						
Caenidae						
Brachycercus						
Brachycercus maculatus Berner	+++	SP	G & SP	SW	---	---
Brachycercus lacustris (Needham)	+++	G	G & SP	SW	---	---

Table 2. Continued

TAXA	Found	Identified *	New Record	Range Extension	No Change	Questioned Presence
Caenis	+++	G				
LEPTOPHLEBOIDEA						
Leptophlebiidae						
Choroterpes						
Choroterpes (Choroterpes)						
Choroterpes nanita Traver	---	---	---	---	+++	---
Choroterpes (Neochoroterpes)						
Choroterpes mexicanus Allen	+++	SP	SP	GRB	---	---
Thraulodes						
Thraulodes gonzalesi Traver and Edmunds	+++	SP	---	---	+++	---
Traverella						
Traverella presidiana (Traver)						
Tricorythidae						
Tricorythodes	+++	G				
Tricorythodes texanus Traver	---	---	---	---	---	+++
Leptohyphes	+++	G				
Leptohyphes sabinus Traver	---	---	---	---	---	+++

Table 2. Continued

TAXA	Found	Identified *	New Record	Range Extension	No Change	Questioned Presence
EPHEMEROIDEA						
Ephemeridae						
Hexagenia						
Hexagenia limbata venusta Eaton	+++	SSP	SSP	---	---	---
Hexagenia bilineata (Say)	+++	SP	---	---	+++	---
Pengagenia						
Pentagenia vittigera Walsh	---	---	---	---	+++	---
Polymitarcidae						
Campsurus						
Campsurus decoloratus Hagen	+++	SP	---	---	+++	---
Tortopus						
Tortopus circumfluus Ulmer	+++	SP	---	---	+++	---

*Lowest taxonomic level to which this organism was identified
G = Genus
SP = Species
SSP = Subspecies
**Identification unverified
+++ = Yes
--- = No
S = South
SW = Southwest
GRB = Guadalupe River Basin

LITERATURE CITED

Academy of Natural Sciences of Philadelphia. 1949. A biological survey of the Guadalupe River at Victoria and San Antonio Bay, Tex. A report to E.I. du Pont de Nemours and Co., by Acad. Nat. Sci. Philadelphia. 49 p.

_____. 1963. Guadalupe River, Tex., stream survey report. Report to E.I. du Pont de Nemours Co., by Limnology Dept., Acad. Nat. Sci. Philadelphia. 67 p.

American Public Health Association. 1976. Standard methods for the examination of water and wastewater. 14th Ed. Amer. Publ. Health Assoc., Wash., D.C. 1193 p.

Allen, R.K. 1967. New species of New World Leptohyphinae (Ephemeroptera: Tricorythidae). Can. Entomol. 99:350-375.

_____. 1973. Generic revisions of mayfly nymphs. I. Traverella in North and Central America (Leptophlebiidae). Ann. Entomol. Soc. Amer. 66:1287-1295.

_____. 1974. Neochoroterpes, a new subgenus of Choroterpes Eaton from North America (Ephemeroptera: Leptophlebiidae). Can. Entomol. 106:161-168.

Allen, R.K., and R.C. Brusca. 1973. The known geographic distribution of the Mexican mayfly genera in North America (Insecta: Ephemeroptera). Proc. 1st Int. Conf. Ephem. 49-63.

Allen, R.K., and E.S. Chao. 1972. A new species of Baetodes from Arizona (Ephemeroptera: Baetidae). Bull. Southern Calif. Acad. Sci. 71:52.

Allen, R.K., and S.S. Roback. 1969. New species and records of New World Leptohyphinae (Ephemeroptera: Tricorythidae). J. Kans. Entomol. J. Soc. 42:372-379.

Bayer, R.W. 1975. The dragonfly nymphs (Odonata: Anisoptera) of the Guadalupe River Basin, Tex. Unpub. M.A. thesis, Southwest Tex. State Univ., San Marcos. 117 p.

Berner, L. 1940. Baetime mayflies from Florida (Ephemeroptera). Fla. Entomol. 23:49-62.

_____. 1950. The mayflies of Florida. Fla. Univ. Studies, Biol. Ser. 4:1-267.

_____. 1958. A list of mayflies from the lower Apalachicola River drainage. J. Fla. Acad. Sci. 21:25-31.

_____. 1959. A tabular summary of the biology of North American mayfly nymphs (Ephemeroptera). Bull. Fla. St. Mus. Biol. Sci. 4:1-58.

Brusca, R.C., and R.K. Allen. 1973. A new species of Choroterpes from Mexico (Ephemeroptera: Leptophlebiidae). J. Kans. Entomol. Soc. 46:137-139.

Burks, B.D. 1953. The mayflies, or Ephemeroptera, of Illinois. Bull. Ill. Nat. Hist. Surv. 26:1-216.

Cohen, S.D., and R.K. Allen. 1972. New species of Baetodes from Mexico and Central America (Ephemeroptera: Baetidae). Pan-Pac. Entomol. 48:129-135.

Day, W.C. 1956. Ephemeroptera. In Aquatic insects of California. Ed. by R.L. Usinger. Calif. Press, Berkeley and Los Angeles. 79-105.

Eaton, A.E. 1871. A monograph on the Ephemeridae. Entomol. Soc. London Trans. 19:1-164.

Eaton, A.E. 1892. Ephemeridae. In Biologia Centrali Americana. Insecta. Neuroptera. 1-16.

Edmunds, G.F., Jr. 1948. A new genus of mayflies from Western North America (Leptophlebiidae). Proc. Entomol. Soc. Wash. 61:141-148.

_____. 1950. New records of the mayfly genus Baetodes, with notes on the genus. Entomol. News 61:203-205.

_____. 1959. Ephemeroptera. In Freshwater biology, 2nd Ed. Ed. by W.T. Edmondson. John Wiley and Sons, Inc., N.Y. 908-916.

_____. 1961. A key to the genera of known nymphs of the Oligoneruiidae (Ephemeroptera). Proc. Entomol. Soc. Wash. 63:255-256.

Edmunds, G.F., Jr., and J.R. Traver. 1954. An outline of the reclassification of the Ephemeroptera. Proc. Entomol. Soc. Wash. 56:236-240.

Edmunds, G.F., Jr., L. Berner, and J.R. Traver. 1958. North American mayflies of the family Oligoneuriidae. Ann. Entomol. Soc. Amer. 51:375-382.

Fremling, C.R. 1970. Mayfly distribution as a water quality index. Water Pollution Control research series 16030 DQH 11/70. 39 p.

_____. 1973. Factors influencing the distribution of burrowing mayflies along the Mississippi River. Proc. 1st. Int. Conf. Ephem. 12-25.

Jensen, S.L. 1974. A new genus of mayflies from North America (Ephemeroptera: Heptageniidae). Proc. Entomol. Soc. Wash. 70:225-228.

Kent, D.H. 1971. The effects of a deep-storage reservoir on the benthic community of the Guadalupe River, Tex. Unpubl. M.A. thesis, Southwest Tex. State Univ., San Marcos, Tex. 75. p.

Kilgore, J.I., and R.K. Allen. 1973. Mayflies of the Southwest: new species, descriptions, and records (Ephemeroptera). Ann. Entomol. Soc. Amer. 66:321-332.

Koss, R.W. 1972. Baetodes: new species and new records for North America (Ephemeroptera: Baetidae). Entomol. News 83:93-102.

Kuehne, R.A. 1955. Stream surveys of the Guadalupe and San Antonio Rivers. Tex. Game and Fish Comm. I.F. Rep. Ser. No. 1. 56 p.

Kunze, H.L., and J.T. Smith. 1966. Base-flow studies, Upper Guadalupe River Basin, Texas: quantity and quality, March, 1965. Tex. Water Dev. Bd. rep. 29. 33 p.

Lewis, P.A. 1969. Mayflies of the genus Stenonema as indicators of water quality. Presented at 17th Ann. meeting of the Midwest Benthological Society. 7 p.

Longley, G. 1973. Aquatic insects of the Guadalupe, San Antonio, and Nueces river basins. Presented at Ann. meeting of the Amer. Entomol. Soc. 34 p.

Macan, T.T. 1955. A key to the nymphs of the British species of the family Caenidae (Ephemeroptera). Entomol. Gaz. 6:127-142.

McDunnough, J. 1931a. New North American Caeninae with notes (Ephemeroptera). Canad. Entomol. 63:254-268.

_____. 1931b. New species of North American Ephemeroptera. Canad. Entomol. 63:82-93.

_____. 1931c. The genus Isonychia (Ephemeroptera). Canad. Entomol. 63:157-163.

_____. 1933. Notes on the Heptagenine species described by Clemens from the Georgia Bay region, Ont. (Ephemeroptera). Canad. Entomol. 65:16-24.

Moore, L.F., Jr. 1950. Distribution of mayfly nymphs in streams of Dallas County, Texas. Field and Laboratory 18:103-112.

Needham, J.G. 1905. Ephemeridae. In Mayflies and midges of New York. J.G. Needham, K.J. Morton, and O.A. Johannsen. N.Y. State Mus. Bull. 86:17-62.

_____. 1918. A new mayfly, Caenis, from Oneida Lake, New York. N.Y. State Coll. Forestry, Syracuse Univ. Tech. Pub. 9:249-251.

Needham, J.G., and H.E. Murphy. 1924. Neotropical mayflies. Lloyd Libr. Bot., Pharm., and Materia Med. Bull. 24, Entomol. Ser. 4:3-79.

Scott, D.C., L. Berner, and A. Hirsch. 1959. The nymph of the mayfly genus Tortopus (Ephemeroptera: Polymitarcidae). Ann. Entomol. Soc. Amer. 52:205-213.

Spieth, H.T. 1941. Taxonomic studies on the Ephemeroptera. II. The genus Hexagenia. Amer. Mdl. Nat. 26:233-280.

Traver, J.R. 1935. Part II. Systematics. In The biology of mayflies. J.G. Needham, J.R. Traver, and Yin-Chi Hsu. Comstock Publishing Co., Inc., N.Y. 759 p.

_____. 1944. Notes on Brazilian mayflies. Museu Nacional Boletim Zoologia 22:2-53.

_____. 1958. Some Mexican and Costa Rican mayflies. Bull. Brooklyn Entomol. Soc. 53:81-89.

_____. 1959. The subfamily Leptohyphinae. Part II. Five new species of Tricorythodes. Proc. Entomol. Soc. Wash. 61:121-131.

Traver, J.R., and G.F. Edmunds, Jr. 1967. A revision of the genus Thraulodes (Ephemeroptera: Leptophlebiidae). Misc. Pub. Entomol. Soc. Am. 5:349-402.

_____. 1968. A revision of the Baetidae with spatulate-clawed nymphs Ephemeroptera). Pacific Insects 10:629-677.

Truett, J.C., and B.J. Gallaway. 1975. Zoological and botanical survey of the Guadalupe-San Antonio river basins. Report submotted to Ecology Audits, Dallas, by LGL Limited-U.S., Inc., Bryan, Tex. 147 pp.

Ulmer, G. 1920. Über die Nymphen einiger exotischer Ephemeropteren. Festchr. für Zschokke 25:1-25.

_____. 1942. Alte und neue Eintagsliegen (Ephemeropteren) aus Süd- und Mittelamerika. Stettiner Entomologische Zeitung 103:98-128.

Young, W.C., B.G. Whiteside, G. Longley, and N.E. Carter. 1973. The Guadalupe-San Antonio-Nueces River Basins project. Phase I: Review of existing biological data. Final Rep. to Tex. Water Dev. Bd. 400 p.