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Michael L. Nulty[1]

ABSTRACT

The ecology of the Hydropsychidae larvae populating a Neosho River riffle near Emporia, Kansas, was monitored from 6 July 1972 through 20 September 1973. Three genera including at least six species of Hydropsychidae larvae were observed within the study riffle. Species present were *Hydropsyche simulans*, *H. orris*, *H. cuanis*, *H. frisoni*, *Potamyia flava*, and *Cheumatopsyche* spp. Adult caddisflies collected in the study area were *H. simulans*, *H. orris*, *H. valanis*, *Cheumatopsyche lasia*, *C. speciosa*, *C. campyla*, and *P. flava*. Studies of population age structure revealed most hydropsychids exhibit five instars, and all five instars tended to be present in most samples. *Cheumatopsyche* spp. and *P. flava* dominated the standing crop of caddisfly larvae in the study riffle. Preliminary data of stream drift and oxygen consumption by caddisflies were also recorded.

INTRODUCTION

In recent years many ecological investigations have been designed to obtain information which could be used in the construction of mathematical computer models of community systems. Most community models represent energy flow through the various trophic levels and require quantitative data on the population dynamics of the dominant organisms occupying each trophic level. The Hydropsychidae (Trichoptera) are a major component of benthic macroinvertebrate populations inhabiting many prairie streams

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(Ross 1944, Armitage 1961, Harrel 1969, Prophet and Edwards 1973, Ransom and Prophet 1974). Thus, any attempt to model a river system of the central and southwestern states would require some knowledge of the biology of these organisms.

Relatively little is known of the ecology of caddisflies in Kansas. Ross (1944) published estimates of the emergence times, species distributions, species descriptions, and taxonomic keys to larval and adult forms of the Trichoptera of Illinois. Many of the species of Hydropsychidae in Illinois reported by Ross also occur in Kansas, with members of *Hydropsyche, Cheumatopsyche,* and *Potamyia* being expecially abundant in streams.

Several studies of community structure of the benthic macroinvertebrates and environmental quality of streams in east-central Kansas have been conducted in recent years. Prophet and Ransom (1972) used Shannon's species diversity index to evaluate benthic community structure and water quality of the Walnut River (East Branch) in Butler County, Kansas. In a similar study, Ransom and Prophet (1974) characterized the environmental quality of Cedar Creek drainage basin in Chase County; and Prophet and Edwards (1973) employed the Shannon index to characterize benthic community structure and water quality along reaches of the Cottonwood River located above and below sources of commercial feedlot runoff. In each of these studies, the Hydropsychidae were found to be one of the dominant groups of benthic organisms inhabiting the study streams.

Although the above cited studies provided some insight into the species composition and standing crops of these organisms, information is lacking concerning such parameters as oxygen uptake, stream drift, growth, and population age structure. Drift in streams is a daily phenomenon of many benthic invertebrates, and numerous estimates of drift rates have been made (Waters 1968, Pearson and Franklin 1968, Dimond 1972). Most drift studies have been conducted on small streams with low rates of trichopteran drift reported. However, Anderson (1967) recorded an abundance of Trichoptera in drift samples from an Oregon river. Measurements of oxygen uptake have been made on a variety of benthic invertebrates (Fox et al. 1937, Phillipson 1954, Reuger et al. 1969, Ransom et al. 1970), but there are few quantitative data available regarding oxygen uptake by larval hydropsychids.

This study was undertaken to characterize the populational biology of the species of Hydropsychidae inhabiting a riffle community in the Neosho River in the vicinity of Emporia, Kansas. Specifically, this study was designed to determine which species inhabited a typical riffle community in the Neosho River and to record their respective standing crops and species associations. In addition, this study obtained information on oxygen consumption, drift, population age structure and growth of the caddisfly population.

DESCRIPTION OF AREA

The Neosho River, known as the Grand River in Oklahoma, is a left hand tributary of the Arkansas River and joins that stream northeast of Muskogee, Oklahoma. The origin of the Neosho River is in the Flint Hills upland of Morris and southwestern Wabaunsee counties, Kansas; and it flows in a southeasterly direction. The Cottonwood and Spring Rivers are its two major tributaries in Kansas, with the Cottonwood River joining the Neosho approximately 14 km southeast of Emporia in Lyon County. The Spring River has headwaters in Missouri. Channel length of the Neosho River is approximately 540 km; and the entire river system drains nearly 16,000 km^2; of which 4758 km^2 are drained by the Cottonwood River and 1313 km^2 by the Spring River (Kansas State Board of Agri. 1947). In its upper reaches, where the study riffle was located (Figure 1), its gradient averaged 2.84 m/km (Schoewe 1951).

Substrate varied little throughout the study riffle and consisted primarily of cobble mixed with sand. Larger rocks were present on the west bank of the channel but were exposed when water levels permitted sampling. At normal flow, the study riffle was 71.0 m long, 14.7 m wide, and 0.30 m deep. Unusually high river discharge characterized most of the study period (Figure 2). Although these data are based on flow at a point approximately 30 km below the study riffle, they are also representative of conditions upstream. Normal flow at the study riffle is approximately 300 cfs.

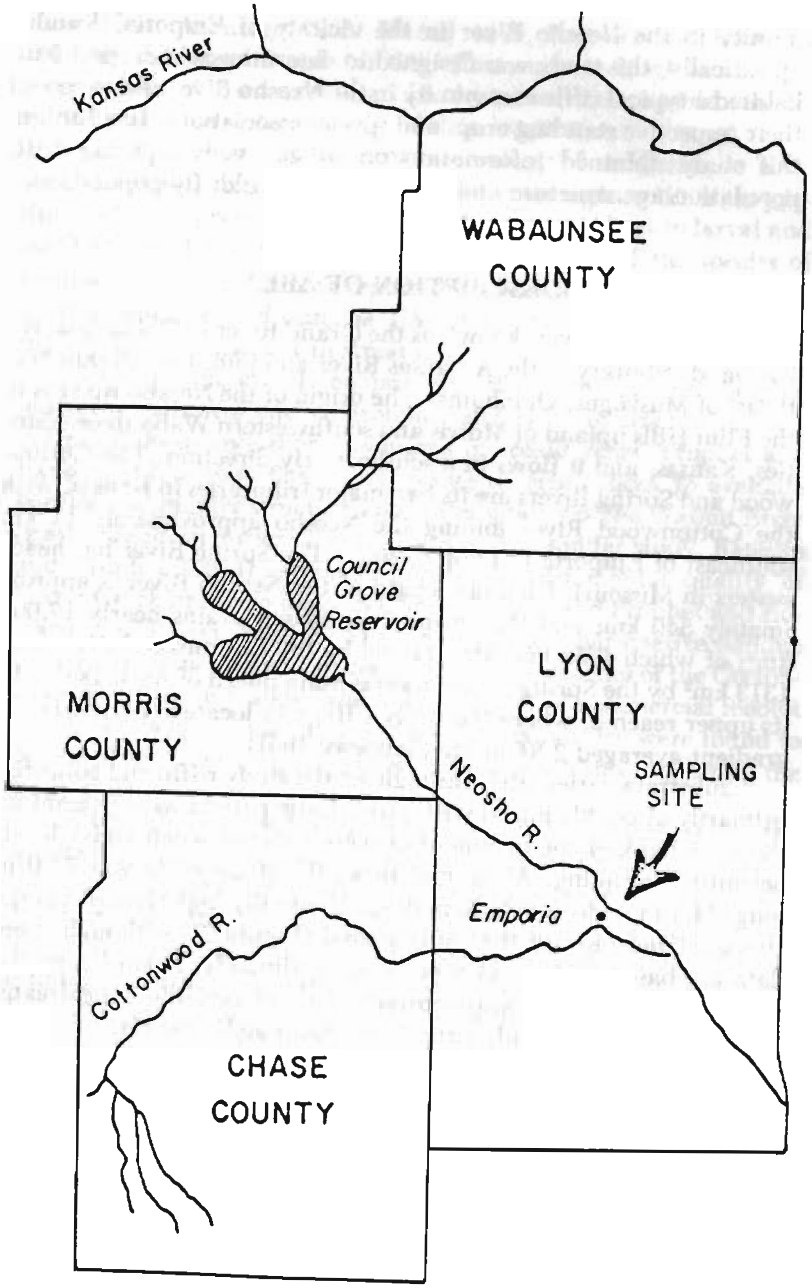

Fig. 1 Approximate location of the study area.

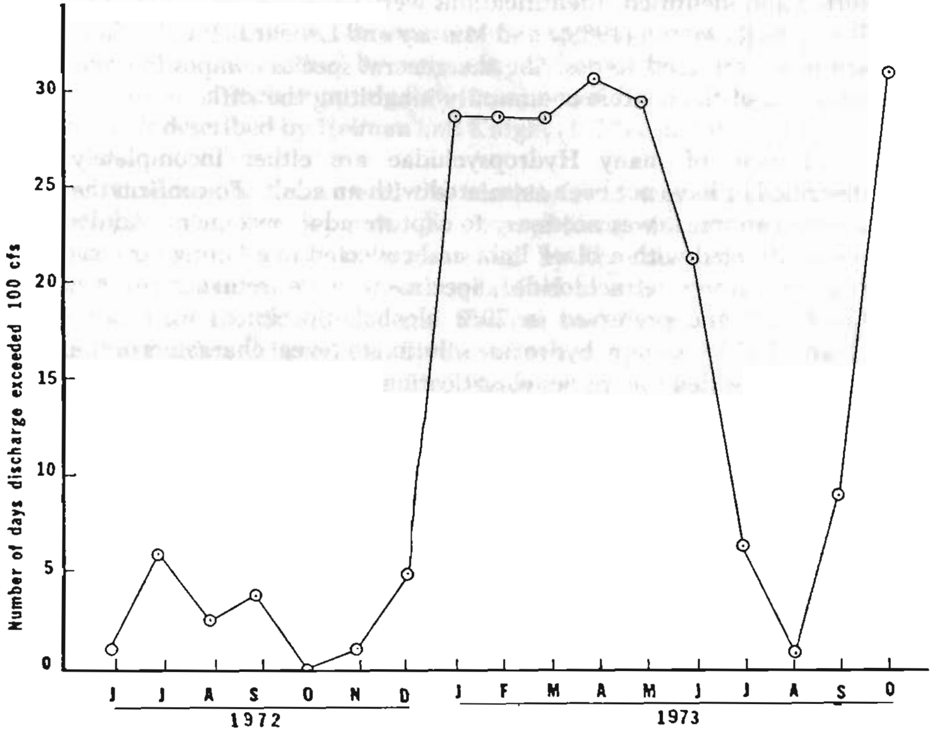

Fig. 2 Fluctuation in river discharge of the Neosho River at Hartford, Kansas. (Data from Corps of Engineers, Tulsa District.)

MATERIALS AND METHODS

Nine sets of Surber samples, each consisting of four randomly collected subsamples, were taken from the study riffle at irregular intervals from 6 July 1972 through 20 September 1973. Samples were transferred in the field to plastic containers, preserved in 5% formalin, and returned to the laboratory where the organisms were sorted and identified. Identifications were based on Pennak (1953), Ross (1944), Mason (1968), and Murray and Leonard (1962). These samples were used to describe the general species compostion and structure of the benthic community inhabiting the riffle.

Larvae of many Hydropsychidae are either incompletely described or have not been associated with an adult. To confirm the identifications, it was necessary to capture adult specimens. Adults were attracted with a black light and collected in a killing jar containing carbon tetrachloride. Specimens were returned to the laboratory and preserved in 70% alcohol. Specimens were later cleared in 10% sodium hydroxide solution to reveal characters of the genitalia needed for species classification.

Estimations of standing crops of taxa of the Hydropsychidae were made by drying the individuals collected in tared crucibles at 110°C for two hours. Ash-free biomass was determined by ashing the samples in a muffle furnace at 500°C for one hour. All biomass measurements were made on a Mettler H4 analytical balance.

Drift of larval hydropyschids was estimated by placing two drift traps adjacent to each other in the center of the riffle (Waters 1962). Drift traps consisted of a rectangular iron frame (30 by 45 cm) with a nylon net attached (Nitex #363, 21 mesh/cm). Measurements were made with traps being placed at each end of the riffle, in order to measure drift into and out of the study area. Sampling was initiated one hour before sunset and terminated three hours after sunset. This interval has been defined as the time period in which the greatest amount of drift occurs (Waters 1962, Elliott 1965, Chaston 1968, and Elliott 1969).

A YSI Model 53 Oxygen Polarigraph and a Model 159 Hitachi Perkin-Elmer recorder were used to estimate oxygen uptake by larval Hydropsychidae. Larvae were collected from nearby streams and retured to the laboratory where they were acclimated in distilled water. Oxygen uptake (Q_{O_2}) was reported in μl O_2/mg dry weight/hr. Calculations were made using methods described by Umbreit et al. (1957). Preliminary runs indicated there were no significant differences between O_2 uptake by larvae acclimated in distilled water and those larvae acclimated in filtered stream water.

Age structure of *Cheumatopsyche* spp. and *Potamyia flava* populations was studied by estimating the percentage of larvae in each instar on each sampling date. Larval instar was determined by methods described by Heiman and Knight (1970) and Elliott (1968).

Community structure of the benthic fauna was characterized using a species diversity index, $\overline{H}$, derived from information theory and based on the equation described by Shannon and Weaver (1949); the symbol $\overline{H}$ was later modified to $\overline{d}$ by Patten (1962), Wilhm and Dorris (1968), and Ransom and Dorris (1972). The diversity index, $\overline{d}$, is defined by the following equation, where N is the total number of individuals of all species in the sample, n_i is the number of individuals in species i and s is the number of species in the sample:

$$\overline{d} = -\sum_{i=1}^{s} \left[\frac{n_i}{N} \left(\log_2 \frac{n_i}{N}\right) \right]$$

RESULTS AND DISCUSSION

Benthic Community Composition and Structure

Nine sets of Surber samples, each consisting of four randomly collected subsamples, were taken from the study riffle at irregular intervals from 6 July 1972 through 20 September 1973. These samples were used to characterize the general species composition and structure of the benthic macroinvertebrate community inhabiting the riffle, as well as to assess possible adverse affects of periods of high river discharge on the structure of the benthic community.

A minimum of 58 taxa of benthic macroinvertebrates was collected from the study area (Table 1). Due to the preponderance of immature stages of insects present and the inadequacy of current taxonomic references regarding species identifications based solely on larval characteristics, most organisims observed in samples were identified only to the generic level. Fourteen species of clams (Unionidae) were collected by hand from the study riffle (Table 2). These species were not sampled quantitatively, and their numbers were not used in calculations of the diversity index. Only one unionid clam. _Truncilla donaciformis_ Lea, was collected with the Surber sampler. Of the unionid species identified, four species were represented by living specimens, while the remaining eight species were classified by examination of well preserved shells found in the study riffle. The empty shells may have washed into the riffle from upstream, therefore, only the presence of these species in the river system is indicated.

Although the total number of taxa present in samples varied from 25-36 from one sampling date to another, differences between sampling dates generally were due to either the presence or absence of taxa that were considered rare. That is, 27 taxa appeared in one-half or more samples while the rest were collected less frequently. Taxa considered as rare are marked with an asterisk in Table 1. During 1973, 16 taxa were observed which were not collected in 1972; only three taxa observed in the 1972 samples were not collected in 1973. Without exception, taxa which were not common to both years, when present, were represented by only a few individuals.

Taxa dominant throughout the study period were mayflies (Ephemeroptera), midges (Diptera: Chironomidae), blackflies (Diptera: Simuliidae), and net-spinning caddisflies (Trichoptera: Hydropsychidae). Prophet and Edwards (1973), in a study of the effects of feedlot runoff on benthic community structure in the Cottonwood River, noted these taxa plus _Sphaerium striatinum_ (Lamarck) to be abundant. Ransom and Prophet (1974) described these same taxa as major components of the benthos of Cedar Creek Basin in Chase County, Kansas.

In my study, most mayflies collected belonged to the genera _Caenis_, _Isonychia_, and _Ameletus;_ while caddisflies in greatest abundance were _Cheumatopsyche_ spp., _Potamyia flava_ (Hagen), _Hydropsyche frisoni_ Ross, and _H. cuanis_ Ross. Of 19 taxa of Diptera

Table 1. A checklist of benthic macroinvertebrate taxa inhabiting the study riffle 6 July 1972 through September 1973.

Taxa	Taxa
PLAYTHELMINTHES	ARTHROPODA
Dugesia sp.	Plecoptera
ASCHELMINTHES	_Neoperla clymene_ (Newman)
*Nematoda	Coleoptera
ANNELIDA	_Stenelmis_ sp.
*Hirudinea	*_Stenelmis sexlineatus_ (Sanderson)
Oligochaeta	*_Macronychus glabratus_ (Say)
Branchiura sowerbyi Bedd.	Megaloptera
Limnodrilus hoffmiesteri Clap.	*_Corydalus cornutus_ L.
Limnodrilus sp.	Lepidoptera
*_Tubifex tubifex_ (O.F.M.)	*Pyralidae
MOLLUSCA	Hemiptera
*_Physa anatina_ Lea	*Hebridae
*_Lymnaea bulimoides cockerelli_ (Pilsbry and Ferris)	Collembola
*_Heliosoma_ sp.	*_Isotomurus palustris_ (Muller)
Sphaerium sp.	Diptera
*_Truncilla donaciformis_ (Lea)	_Simulium vittatum_ (Say)
ARTHROPODA	*_Atherix variegata_ (Walker)
Trichoptera	*_Chaoborus_ sp.
Hydropsyche orris Ross	_Polypedilum_ sp.
Hydropsyche cuanis Ross	*_Chironomus_ sp.
Hydropsyche frisoni Ross	*_Endochironomus_ sp.
Potamyia flava (Hagen)	_Cryptochironomus_ sp.
Cheumatopsyche spp.	*_Pseudochironomus_ sp.
Athripsodes sp.	*_Glyptotendipes_ sp.
*_Mayatrichia_ sp.	*_Tanytarsus_ sp.
*_Ithytrichia_ sp.	_Ablabesmyia_ sp.
*_Hydroptila_ sp.	*_Tanypus_ sp.
Ephemeroptera	_Cricotopus_ sp.
Caenis sp.	_Psectrocladius_ sp.
Isonychia sp.	_Nannocladius_ sp.
Ameletus sp.	_Corynoneura_ sp.
Stenonema sp.	*Empididae
Paraleptophlebia sp.	
*_Potamanthus_ sp.	

*Indicates rare taxa collected during the study.

Table 2. Unionidae observed in the study riffle 6 July 1972 through 20 September 1973.

**Lasmigona complanata* (Barnes)
**Quadrula quadrula* Rafinesque
**Quadrula pustulosa* (Lea)
**Tritogonia verrucosa* (Say)
Leptodea laevissima (Lea)
Leptodea fragilis (Rafinesque)
Lampsilis ovata ventricosa (Barnes)
Lampsilis anodontoides anodontoides (Lea)
Amblema peruviana peruviana (Lamarck)
Amblema peruviana costata (Rafinesque)
Anodonta grandis Say
Elliptio dilatatus (Rafinesque)
Fusconaia flava (Rafinesque)
Strophitus rugosus (Swainson)
***Truncilla donaciformis* (Lea)

*Live specimens of these taxa were found in the study area, all other taxa were identified from well preserved shells.
**Live specimens collected in Surber samples.

identified, 13 were Chironomidae with the dominant genera being *Polypedilum*, *Cricotopus*, and *Chironomus (Cryptochironomus)*. From the standpoint of taxa collected, the composition of the study riffle community appeared to be similar to other riffle communities in this river system.

Ash-free biomass of major taxonomic groups of benthic macroinvertebrates are summarized in Table 3. In general, the Trichoptera contributed the greatest proportion of the standing crop of benthos. On most sampling dates the trichopteran biomass exceeded 1.00 g/m^2. Overall, the biomass of Ephemeroptera varied from 0.025 to 1.162 g/m^2, while that of the Sphaeridae ranged from 0.012 to 2.162 g/m^2.

During this study, ash-free biomass of most taxa was lowest on 26 June 1973, when high flow preceded sampling. The decrease in biomass of Ephemeroptera and Trichoptera from 6 July 1972 to 16 August 1972 was partially due to high flow conditions, however, emergence of adult forms was also occurring at that time. Variation in biomass of the fingernail clams (Sphaeridae) was probably in-

Table 3. Variation in ash-free biomass (g/m^2) of major benthic macroinvertebrate groups by sampling date.

Taxa	1972				1973				
	7/6	7/27	8/16	10/26	2/24	6/26	7/31	8/20	9/20
ELMIDAE	.039	.042	.092	.275	.130	.178	.028	.058	.117
SPHAERIDAE	.189	1.010	.054	.280	2.162	.061	.012	.434	.693
TRICHOPTERA	1.943	.211	1.074	1.050	1.097	.024	2.048	.861	1.010
EPHEMEROPTERA	.924	.046	.122	1.162	.408	.025	.037	.081	.339
DIPTERA	.067	.011	.014	.033	.014	.012	.030	.001	.028
MISCELLANEOUS	.031	.044	.046	.025	.140	.044	.006	.111	.212
TOTALS	3.192	1.363	1.402	2.824	3.951	.343	2.161	1.546	2.399

fluenced by the sampling procedure. Sphaeridae tended to be clumped and numbers of individuals in samples varied considerably depending on whether these "clumps" were sampled.

Stream Quality

Diversity per individual, $\bar{d}$, is a good index of existing environmental quality in a stream. Wilhm and Dorris (1968) reported $\bar{d}$ values for benthic macroinvertebrates greater than 3.0 are characteristic of unpolluted waters, values less than 1.0 indicate severe pollution, and intermediate values are indicative of moderate environmental stress. Diversity per individual fluctuated from one sampling date to the next, with values ranging from 2.06 to 3.32 (Table 4). Values recorded during this study exhibited no marked differences from $\bar{d}$'s reported from other reaches of the Neosho and Cottonwood Rivers (Prophet and Edwards 1973, and Ransom and Prophet 1974). In general, marked variations in $\bar{d}$ between sampling dates were probably due to insect emergence and adverse affects of high river discharge. The fact that $\bar{d}$ was greater than 3.0 from 26 October 1972 through 24 February 1973 supports the conclusion that overall environmental quality of the Neosho River along the study reach was good. The tendency for $\bar{d}$ to be lower during the warmer months was expected since it is during that time of year that many insect species emerge. Thus, some species either were not present or their early instars were too small to be retained by the sampling device used.

The adverse affect of high river discharge on benthic community structure is perhaps best represented by $\bar{d}$ values obtained on 27 July 1972 and 26 June 1973. In both cases, periods of high discharge preceded samples (Figure 2). The observed increases in $\bar{d}$ following these dates were probably the result of recolonization by drift organisms. Sublette (1956) reported temporary destruction of riffle communities in Clear Creek, Arkansas, during flooding; and Waters (1964) estimated a period of two weeks was required for benthic invertebrates to recolonize a denuded area.

Table 4. Number of taxa and $\bar{d}$ by sampling date.

Sampling Date	Number of Taxa	$\bar{d}$
6 Jul 1972	29	2.18
27 Jul 1972	27	2.81
16 Aug 1972	29	2.06
26 Oct 1972	26	3.12
24 Feb 1973	28	3.31
26 Jun 1973	24	2.52
31 Jul 1973	34	2.96
20 Aug 1973	34	2.35
20 Sep 1973	32	2.45
Mean		2.64

Population Characteristics of Hydropsychidae

Species Observed

Three genera, including at least six species, of Hydropsychidae larvae were collected in Surber samples during the study (Table 1). Taxa recognized were *Hydropsyche simulans* Ross, *H. orris* Ross, *H. cuanis* Ross, *H. frisoni* Ross, *Potamyia flava* (Hagen), and *Cheumatopsyche* sp.

Species Verification

Larvae of many Hydropsychidae are incompletely described and some larvae which have been described are not associated with an adult stage. Species identifications based solely on larval specimens are difficult, or impossible, at this time. In an attempt to confirm larval identifications, seven black light collections of adult caddisflies were taken at irregular intervals from 7 June 1973 through 17 October 1973 in the vicinity of the study riffle. The time period for collections was one hour. Trichopteran flight activity is influenced by meteorological factors including bright moonlight and heavy rains, therefore, collections were made when the effect of adverse factors was considered minimal. Most nights chosen satisfied Brindles' (1957) requirements for ideal trichopteran flight, i.e. were warm, humid, cloudy, and calm. Collections were made by directing a black fluorescent light towards a white sheet and capturing the adult caddisflies in a killing jar containing carbon tetrachloride.

Adult *Hydropsyche* collected by the above method were *H. simulans* Ross, *H. orris* Ross, and *H. valanis* Ross.

Herbert Ross (1944), who has extensively studied the Tichoptera of North America, published a study of the Trichoptera in Illinois which included estimates of the distribution of many species. At that time, Ross reported *H. simulans* in Kansas but he had no records of either *H. valanis* or *H. orris*. *Hydropsyche simulans* and *H. orris* most often inhabit large rivers and both are common in midwestern states. Although Ross did not collect *H. orris* in Kansas, it may have been overlooked since intensive sampling was not undertaken in the Great Plains states. Little was known of the range of *H. valanis* in 1944, but its distribution was believed restricted to Illinois, Indiana, and Minnesota, where it was collected along large streams and rivers. *Hydropsyche valanis* was the most abundant species of *Hydropsyche* in my black light collections.

The presence of *H. valanis* in the study area indicates wider range for this species than was initially suggested. That no larvae of this species were found in the study riffle can be explained by the lack of a description of its larval characteristics. Of course, these adults may also have been attracted from another area. No adults of either *H. cuanis* of *H. frisoni* were found in the black light collections. However, their larval characteristics are distinct so species separation is possible, and these identifications were confirmed by Ross. Since all samples were taken in early evening, the absence of adult *H. cuanis* and *H. frisoni* in these collections may have been due to their inactivity during early evening hours. Additional light trapping throughout the night would probably yield adult specimens.

Although it was not possible to distinguish species of *Cheumatopsyche* from the larvae collected, light trapping yielded adults of three species. Species collected were *C. lasia* Ross, *C. campyla* Ross, and *C. speciosa* (Banks). Both *C. lasia* and *C. campyla* were reported from Kansas by Ross (1944), while *C. speciosa* was found in the neighboring states of Missouri and Oklahoma. *Cheumatopsyche campyla* has been collected across the continent from large rivers and small streams, and this species has a wide ecological tolerance and inhabits many streams in which few other caddisflies are found. The range of *C. speciosa* also extends across the continent, and it is perhaps most abundant in the Corn Belt states; *C. lasia* is found primarily in the Great Plains states. *Cheumatopsyche speciosa* and *C. campyla* emerge from April through October, *C. lasia* emerges May to August (Ross, 1944).

Potamyia flava is one of the most common large-river species throughout the Middle West and was abundant in all black light collections. Apparently it is restricted to midwestern and southern states and exhibits a preference for large, slow flowing streams. Ross (1944) reported this species in Kansas and estimated emergence occurred between May and September.

Although individuals collected in light traps were not counted, *P. flava* and *C. campyla* were clearly the most numerous in collections. Harris (1971) reported these two species as being the most abundant in black light collections made in Illinois. Attempts to quantify emergence of species from the study riffle were unsuccessful because high river discharge throughout the spring and early summer prevented utilization of aquatic emergence traps.

Standing Crop Estimations

Trichoptera, expecially the larger Hydropsychidae, constitute an important food source for larger predaceous aquatic invertebrates and various fishes. The abundance of caddisflies and other benthos in riffles probably plays an important role in attracting some species of fish to such areas during feeding periods.

Cheumatopsyche spp. and *P. flava* dominated the standing crop of Hydropsychidae throughout the study. In general, the *Cheumatopsyche* appeared less numerous during 1973; *P. flava* tended to be more abundant during the last months of the study. Fluctuations in estimates of population densities between sampling dates were thought to be due primarily to emergence and reproductive patterns as well as to periods of high river discharge (Table 5). Caloric values reported were estimated from data recorded during an earlier study by Edwards (1970).

Dominance by *Cheumatopsyche* was expected as several species were grouped as a single taxon. Other values of density, biomass, and calorie content represented results for individual species. Riffle substrate was probably responsible for the large number of *Cheumatopsyche* present in the riffle as this genus prefers a habitat of cobble and small stones. Glass and Bovbjerg (1969) described dispersion of *Cheumatopsyche* as dependent on substrate type. They observed a relatively uniform dispersion in laboratory populations of *Cheumatopsyche* when larvae were placed on a surface with no refuge. Clumped dispersion was noted when refuge such as small stones was present. Apparently the cobble subtrate of the study riffle

Table 5. Standing crops of Hydropsychidae as mean density (m²), ash-free biomass (g/m²), and caloric content (cal/m²).

	7/6	7/27	8/16	10/26	2/24	6/26	7/31	8/20	9/20
Cheumatopsyche sp.									
density	14545	13750	13891	5211	2634	24	3822	5929	8950
ash-free biomass	1.912	.181	.593	.717	.785	.001	1.390	.581	.327
caloric content	17762	16668	17608	12952	8905	15	8145	5787	4377
Potamyia flava									
density	237	56	1568	1420	812	5	1200	1399	10058
ash-free biomass	.004	.016	.369	.178	.080	.001	.579	.249	.655
caloric content	42	277	4438	4427	3052	8	6392	3310	10842
Hydropsyche orris									
density	67	11	185	67	24	5	180	11	180
ash-free biomass	.007	.001	.019	.015	.002	.001	.021	.001	.008
caloric content	156	4	488	394	82	4	566	49	111
Hydropsyche frisoni									
density	191	27	907	234	132	8	73	110	183
ash-free biomass	.006	.002	.022	.019	.011	.001	.009	.007	.008
caloric content	160	25	668	430	414	12	266	246	275
Hydropsyche cuanis									
density	697	40	643	409	613	—	282	116	387
ash-free biomass	.014	.012	.031	.135	.193	—	.047	.023	.013
caloric content	426	197	603	3636	7768	—	74	906	398
Hydropsyche simulans									
density	—	—	54	48	62	—	3	—	86
ash-free biomass	—	—	.040	.037	.026	—	.002	—	.003
caloric content	—	—	1094	779	1205	—	37	—	20

provided the needed refuge to support a large population density without triggering intraspecific aggression which often occurs in crowded conditions.

The low densities of all species observed on 27 July 1972 and 26 June 1973 were due to high river discharge preceding the sampling dates, which scoured organisms from the substrate. Flood conditions were created by excessive rainfall and prolonged release of impounded water from an upstream reservoir at Council Grove. Emergence during summer also contributed to low population densities at these times.

Additional Observations on Trichopteran Biology

In recent years, many ecological studies have been directed toward obtaining information which can be utilized in the construction of mathematical computer models representing community systems. Such models are designed for a variety of reasons, but are most often constructed to predict changes in the system over time (Odum 1971). When one attempts to build a model that follows energy flow through different trophic levels, information on the population dynamics of taxa within each level is required. Hydropsychidae are most often placed in a trophic level with omnivorous species. Since these organisms constitute a major portion of the standing crop of benthic invertebrates in riffle communities in east-central Kansas, any attempt to model lotic communities in this area would require knowledge of population dynamics involved in energy flow through this trophic level. Thus, an effort was made to determine quantitatively some important population parameters of Hydropsychidae including growth, age structure, drift, emergence, and respiration (O_2 uptake). The unusually high flow conditions which existed throughout much of the study period either prevented or destroyed field studies designed to yield such data. it also made it impossible to collect organisms for many of the experiments planned for the laboratory; however, some preliminary data on oxygen uptake, stream drift, and population age structure of the Hydropsychidae were salvaged.

Stream Drift

Drift is a daily phenomenon in lotic environments which may have a significant affect on the standing crops of some benthic populations. The degree to which drift occurs depends on many physical factors such as flow rate, substrate, and time of day. In addition, biological factors such as insect activity, population density, changes in seasonal production, and animal behavior are also important. Previous studies indicate Hydropsychidae to be scarce in drift due to positive rheotaxis and the sedentary nature of larval forms (Bishop and Hynes 1970, Elliott and Minshall 1968, and Waters 1962). The net, which characterizes Hydropsychidae, apparently protects the larvae from swift current (Dodds and Hisaw 1925). However, a high standing crop of Hydropsychidae was found in the study riffle, and the direct relationship between drift and population density suggested that Hydropsychidae might be an important component of the drift along the study reach.

Two sets of drift samples were taken in August 1973. Each set consisted of two separate samples, one taken at each end of the riffle. This was done to compare the drift into the riffle (import) with drift out of the riffle (export). Due to the limited number of drift traps available, it was necessry that the import and export measurements were made on successive nights. During the first set of samples, import was measured on 1 August and export on 2 August; during the second set, import was measured on 20 August and export the following night. Flow rate was slightly higher during the second set of drift samples. The higher drift values obtained during this period is evidence of the scouring effect of increased river discharge.

Results of hydropsychid drift are presented in Table 6. Although most Hydropsychidae tended to have similar rates of import and export, *Cheumatopsyche* and *P. flava* exhibited higher export values, while *H. frisoni* exhibited the greatest import. *Hydropsyche frisoni* was the most active drifter, with a mean import value of 23.78 mg dry weight/hr across the riffle, and a mean export of 11.38 mg dry weight/hr across the riffle. *Hydropsyche simulans* was the least active drifter with a mean import of 1.82 mg dry weight/hr and an export of 0.46 mg dry weight/hr. Low values for *H. simulans* were expected since the standing crop of this species was small (Table 5). The quantity of Hydropsychidae in drift was small when compared to standing crops of these taxa in the study riffle, however, hydropsychids formed a much higher percentage of the total drift than in previous studies (Waters 1962, Bishop and Hynes 1970). Additional measurements are needed to substantiate these results, since import-export values influence the standing crop of Trichoptera.

Table 6. Estimations of drift of Hydropsychidae species in mg dry weight/hr for the cross section of the study riffle.

Species	1 Aug	2 Aug	20 Aug	21 Aug
Cheumatopsyche spp.	1.13	0.56	1.09	10.92
Potamyia flava	1.41		4.55	20.94
Hydropsyche orris	1.13		4.55	5.46
Hydropsyche cuanis	1.98	0.28	0.91	3.64
Hydropsyche frisoni	1.13		46.43	22.76
Hydropsyche simulans			.55	20.94

Population Age Structure

Larval instars were determined by plotting head capsule width against the dry weight of the individual. This procedure yielded aggregates of points which are considered to correspond to larval instars. Using this procedure, Elliott (1968) indicated that the development of *Hydropsyche instabilis* Curtis consisted of five instars. Results of head capsule measurements in the study indicated that *Cheumatopsyche*, *P. flava*, *H. simulans*, and *H. frisoni* have five instars, while *H. orris* and *H. cuanis* may have only four. Size ranges of larval instars are presented in Table 7.

Age distribution within the populations of *Potamyia flava* and *Cheumatopsyche* was estimated by determing which instars were present on each sampling date. Figure 3, which summarizes the population structure of *Cheumatopsyche* spp., gives an indication of the shift in age distribution during the year. Larvae over-wintered in all but the first instar. Instars II and III of *Cheumatopsyche* were present on all sampling dates; and Instars IV and V, the dominant forms in late summer, were found on all dates except 20 September.

Figure 4 illustrates the fluctuation of population structure of *Potamyia flava* (Hagen). Larvae apparently over-wintered in all instars; Instars II, III, IV, and V were present on each sampling date. Shifts in the population structure of *P. flava* were not as evident as that of *Cheumatopsyche*, but an increase in the percentage of fifth instar was noted during the winter. The relatively high percentage of fifth instar larvae during the summer months probably indicates that emergence is continous throughout the summer.

Oxygen Uptake

Oxygen uptake is an important source of energy loss at any trophic level. When a review of available literature indicated a lack of quantitative data concerning the rate of oxygen uptake by larval hydropsychids, measurements of oxygen uptake were made. Uptake of oxygen by *Hydropsyche* and *Cheumatopsyche* was measured at temperatures of 10-12°C and 20-23°C, to determine differences in uptake during the summer and winter. Different instars of *Cheumatopsyche* were studied at 20-23°C to detect differences in Q_{O_2} during development. Results are given in Table 8.

Table 7. Size ranges of larval instars of Hydropsychidae.*

Species	Instar I	Instar I	Instar I	Instar I	Instar I
Cheumatopsyche spp.	.20-.25	30.45	.50-.65	.70-85	.90-1.05
Potamyia flava	20-.30	.35-45	.50.65	.70-.85	.90-1.05
Hydropsyche orris		.40-.50	.60-.80	.90-1.20	
Hydropsyche frisoni	.20-.30	.40-.50	.60-.80	.90-1.00	1.10-1.30
Hydropsyche simulans			.50-.70	.80-1.00	1.10-1.30
Hydropsyche cuanis	.20-.30	.40-.50	.60-.80	.90-1.10	
Hydropsyche instabilis	.20-.22	.31-.35	.43-.68	.78-1.15	1.42-1.62

*Values of head capsule width are given to the nearest .01 mm.
**Size ranges of instars of *Hydropsyche instabilis* Curtis were taken from Elliott (1968).

Table 8. Oxygen uptake by larval forms of *Hydropsyche* and *Cheumatopsyche*.

Species	Temperature (°C)	Oxygen Uptake (µl O_2/mg/hr)
Cheumatopsyche spp.	10-12	1.7 (12)
Cheumatopsyche spp.	20-33	4.3 (11)
Instar II	20-23	3.5 (3)
Instar III	20-23	3.6 (3)
Instar IV	20-23	4.4 (3)
Cheumatopsyche spp.	*	3.0 (23)
Hydropsyche spp.	10-12	2.8 (6)
Hydropscyhe spp.	20-23	5.3 (9)
Hydropsyche spp.	*	4.3 (15)

Numbers in ( ) indicate the number of measurements. Each measurement represents 5 or more larvae.
* Q_{O_2} represents a mean of all measurements for the genus.

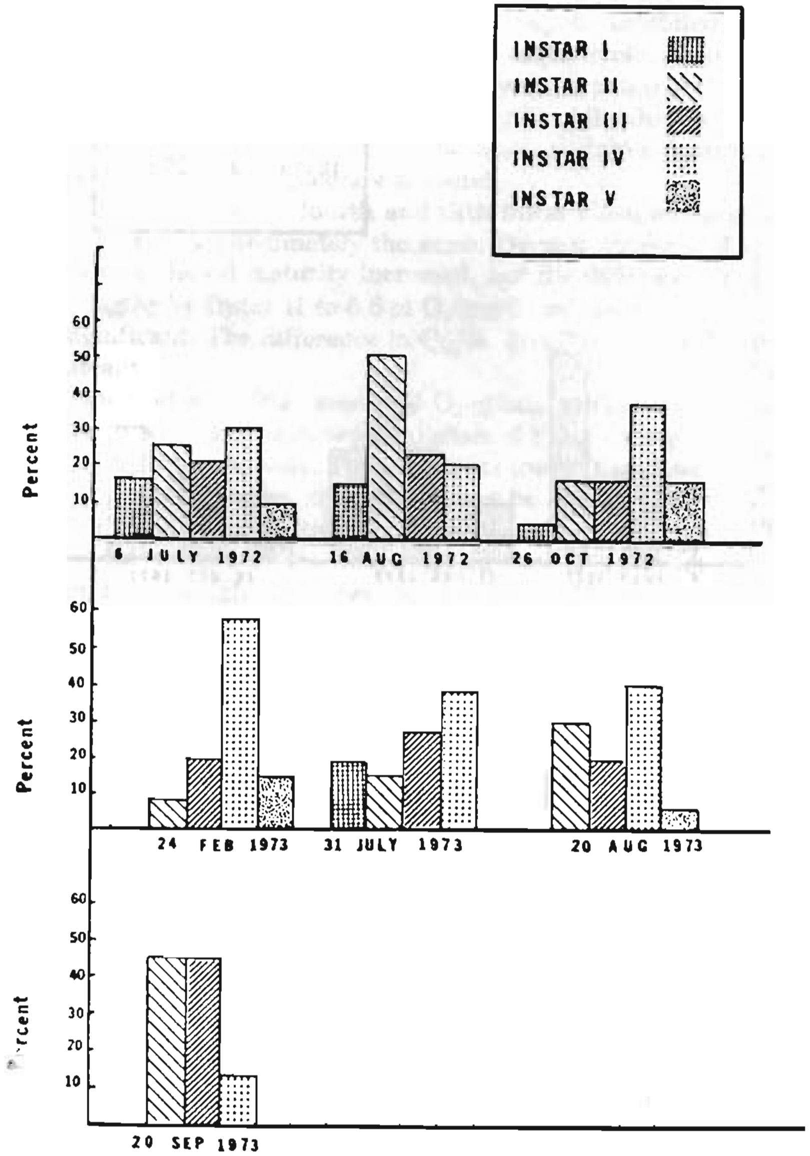

Fig. 3. Population age structure of *Cheumatopsyche* spp.

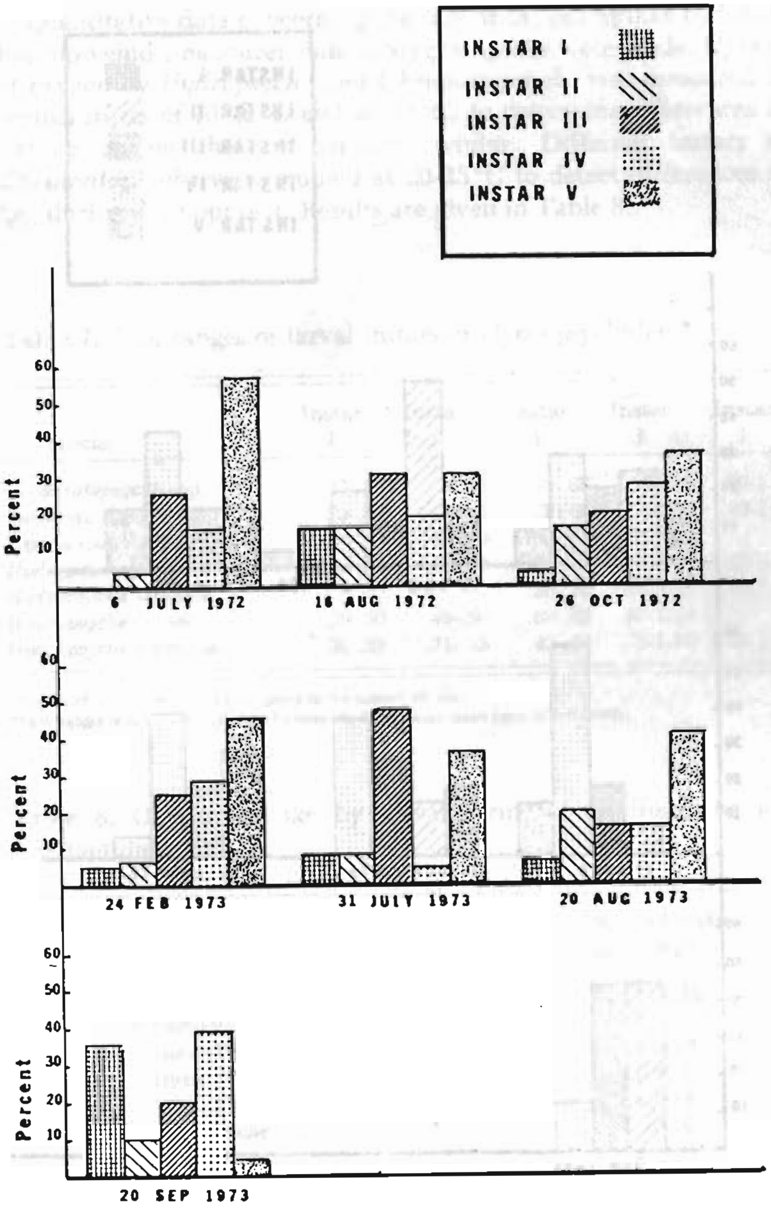

Fig. 4 Population age structure of *Potamyia flava* (Hagen).

Cheumatopsyche had a mean Q_{O_2} of 1.7 μl O_2/mg/hr at 10-12°C and 4.3 μl O_2/mg/hr at 20-23°C. *Hydropsyche* exhibited slightly higher values of 2.8 and 5.3 μl O_2/mg/hr, respectively. Mean Q_{O_2} for *Cheumatopsyche*, based on all measurements, was 3.0 μl O_2/mg/hr, while Hydropsyche Q_{O_2} was 4.3 μl O_2/mg/hr. All values were compared with multiple t-tests at the .05 level, and no significant difference between these genera was found.

The Q_{O_2} values of fourth and fifth instar *Cheumatopsyche at 10-12*°C were approximately the same. Oxygen uptake at 20-23°C increased as larval maturity increased, but the difference from 3.5 μl O_2/mg/hr by Instar II to 6.6 μl O_2/mg/hr by Instar V larvae was not significant. The difference in Q_{O_2} at 10-12°C and 20-23°C was significant.

Norris et al. (1964) measured O_2 uptake of *C. comis* larvae at 21°C and 30°C and reported Q_{O_2} values of 1.0 μl O_2/mg/hr and 1.5 μl O_2/mg/hr, respectively. These rates are lower than those reported in this study, however, differences may be due to a difference in methodology. In calculation of Q_{O_2}, total oxygen consumed is divided by the weight of the test animals; Norris used wet weight, whereas dry weight was used in this study. If dry weight were substituted for wet weight, the resulting Q_{O_2} would be higher because a smaller divisor was used.

A second factor which may account for the higher values in this study relates to the apparatus used. Norris et al. (1964) used a Warburg apparatus, a manometric technique, while an oxygen polarigraph, an electrochemical technique, was used in this study. Reuger et al. (1969), in an excellent review of oxygen uptake by benthic insects, indicated higher (Q_{O_2}) was obtained for *Cheumatopsyche* when electrochemical methods were used.

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