ECOLOGY OF CADDIS FLIES OF A NEOSHO RIVER RIFFLE

A Thesis

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by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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 (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 caddis flys 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 especially 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 the species diversity index, $\bar{d}$, 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 $\bar{d}$ 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 case, 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 inhabitating a riffles 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, the study was attempted to obtain information on oxygen consumption, drift, population age structure, and growth.

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 square km; of which 4758 square km are drained by the Cottonwood River and 1313 square km by the Spring River (Kansas State Board of Agri., 1947). In its upper reaches, where the study riffle was located (Figure 1), its gradient averages 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.

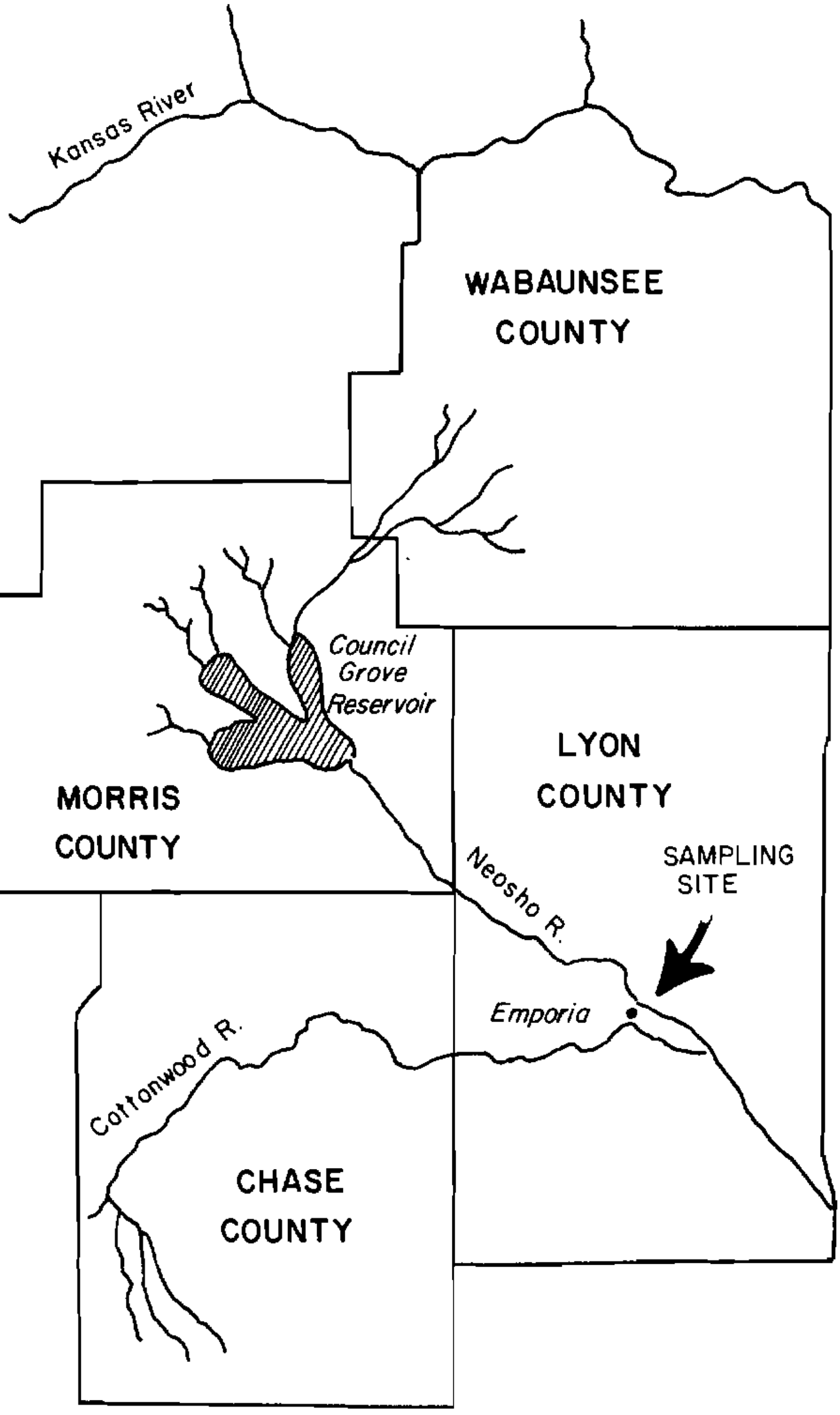

Fig. 1. Approximate location of the study area.

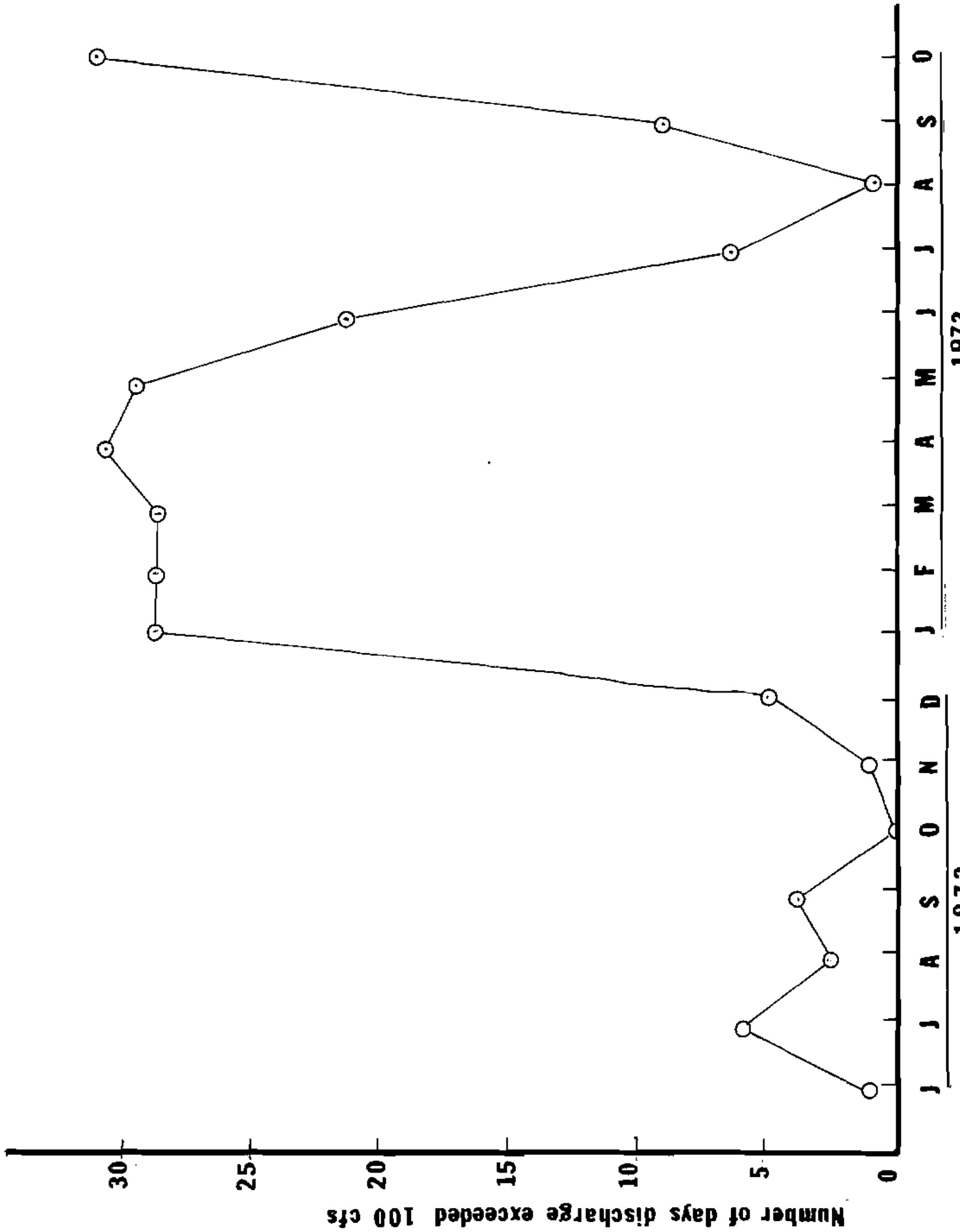

Fig. 2. Fluctuation in river discharge of the Neosho River at Hartford, Kansas. (Data from U. S. Army Corps of Engineers, Tulsa District.)

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 transfered in the field to plastic containers, preserved in 5 % formalin, and returned to the laboratory where the organisms were picked 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 composition 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 based solely on larval characteristics, 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 hydropsychids 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 returned to the laboratory where they were acclimated in distilled water. Oxygen uptake (Q_{O_2}) was reported in ul 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 derived from information theory and based on the equation described by Shannon and Weaver (1949) and modified by Patten (1962), Wilhm and Dorris (1968), and Ransom and Dorris (1972). The diversity index, $\bar{d}$, 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:

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

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 were collected from the study area (Table I). 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 organisms observed in samples were identified only to the generic level. Fourteen species of clams (Unionidae) were collected by hand from the study riffle (Table II). These species were not sampled quantitatively, and their numbers were not used in calculations of the diversity index. Only one unionid clam, *Truncillus donaciformes* 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,

Table I. A checklist of benthic macroinvertebrate taxa inhabiting the study riffle 6 July, 1972, through 20 September, 1973.

Taxa

PLATYHELMINTHES

Dugesia sp.

ASCHELMINTHES

*Nematoda

ANNELIDA

*Hirudinea
Branchiura sowerbyi Bedd.
Limnodrilus hoffmiesteri Clap.
Limnodrilus sp.
**Tubifex tubifex* (O.F.M.)

MOLLUSCA

**Physa anatina* Lea
**Lymnaea bulimoides cockerelli* (Pilsbry and Ferris)
**Heliosoma* sp.
Sphaerium sp.
**Truncillus donaciformes* (Lea)

ARTHROPODA

Trichoptera
- *Hydropsyche orris* Ross
- *Hydropsyche cuanis* Ross
- *Hydropsyche frisoni* Ross
- *Hydropsyche simulans* Ross
- *Potamyia flava* (Hagen)
- *Cheumatopsyche* sp.
- *Anthripsodes* sp.
- **Mayatrichia* sp.
- **Ithytrichia* sp
- **Hydroptila* sp.

Taxa

ARTHROPODA

Ephemeroptera
- *Caenis* sp.
- *Isonychia* sp.
- *Ameletus* sp.
- *Stenonema* sp.
- *Paraleptophlebia* sp.
- **Potamanthus* sp.

Plecoptera
- *Neoperla clymene* (Newman)

Coleoptera
- *Stenelmis* sp.
- **Stenelmis sexilineatus* (Sanderson)
- **Macronychus glabratus* (Say)

Megaloptera
- **Corydalus cornutus* L.

Lepidoptera
- *Elophila* sp.

Hemiptera
- *Hebridae

Collembola
- *Isotomurus palustris* (Muller)

Diptera
- *Simulium vittatum* (Say)
- **Atherix variegata* (Walker)
- **Chaoborus* sp.
- *Empididae
- *Polypedilum* sp.
- **Chironomus (Chironomus)* sp.

Table I. (Cont'd)

Diptera (Cont'd)

- *C. (Endochironomus) sp.
- C. (Cryptochironomus) sp.
- *Pseudochironomus sp.
- *Glypotendipes sp.
- *Tanytarsus sp.
- Ablabesmyia sp.
- *Tanypus sp.
- Cricotopus sp.
- *Psectrocladius sp.
- Nannocladius sp.
- Corynoneura sp.

* Indicates rare taxa collected during the study.

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

*Lasmigonia 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)
Crenodonta peruviana peruviana (Lamarck)
Crenodonta peruviana costata (Rafinesque)
Anodonta grandis Say
Elliptio dilatatus (Rafinesque)
Fusconaia flava (Rafinesque)
Strophitus rugosus (Swainsin)
**Truncillus donaciformes (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.

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 I. 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 caddis flies (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 caddis flies in greatest abundance were *Cheumatopsyche* sp., *Potamyia flava* (Hagen), *Hydropsyche frisoni* Ross, and *H. cuanis* Ross. Of 19 taxa of Diptera identified, 13 were Chironomidae

Table III. 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

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 III. 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 influenced 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 IV). 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 IV. 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	3.32
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 I). 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, if not impossible, at this time. In an attempt to confirm larval identifications, seven black light collections of adult caddis flies 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 caddis flies 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 Trichoptera 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 a 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 caddis flies 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, especially the larger Hydropsychidae constitute an important food source for larger predaceous aquatic invertebrates and various fishes. The abundance of caddis flies 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 V). 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

Table V. Standing crops of Hydropsychidae as mean density (m^2), ash-free biomass (g/m^2), and caloric content (cal/m^2).

	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

Table V. Cont'd

	7/6	7/27	8/16	10/26	2/24	6/26	7/31	8/20	9/20
Hydropsyche simulans									
density	—	—	54	48	62	—	3	—	86
ash-free biomass	—	—	.040	.037	.026	—	.002	—	.003
caloric content	—	—	1094	779	1205	—	37	—	20

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 substrate of the study riffle 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 observed at these times.

Additional Population Properties

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 necessary 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 VI. 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

Table VI. Estimations of drift by 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 sp.	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			4.55	20.94

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 V). 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.

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 were 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 this 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 VII.

Age distribution within the populations of *Potamyia flava* and *Cheumatopsyche* was estimated by determining which instars were present on each sampling date. Figure 3, which summarizes the population structure of Cheumatopsyche sp., 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 continuous 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 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 VIII.

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

Species	Instar I	Instar II	Instar III	Instar IV	Instar V
Cheumatopsyche sp.	.20-.25	.30-.45	.50-.65	.70- .85	.90-1.05
Potamyia flava	.20-.30	.35-.45	.50-.65	.70- .85	.90-1.20
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).

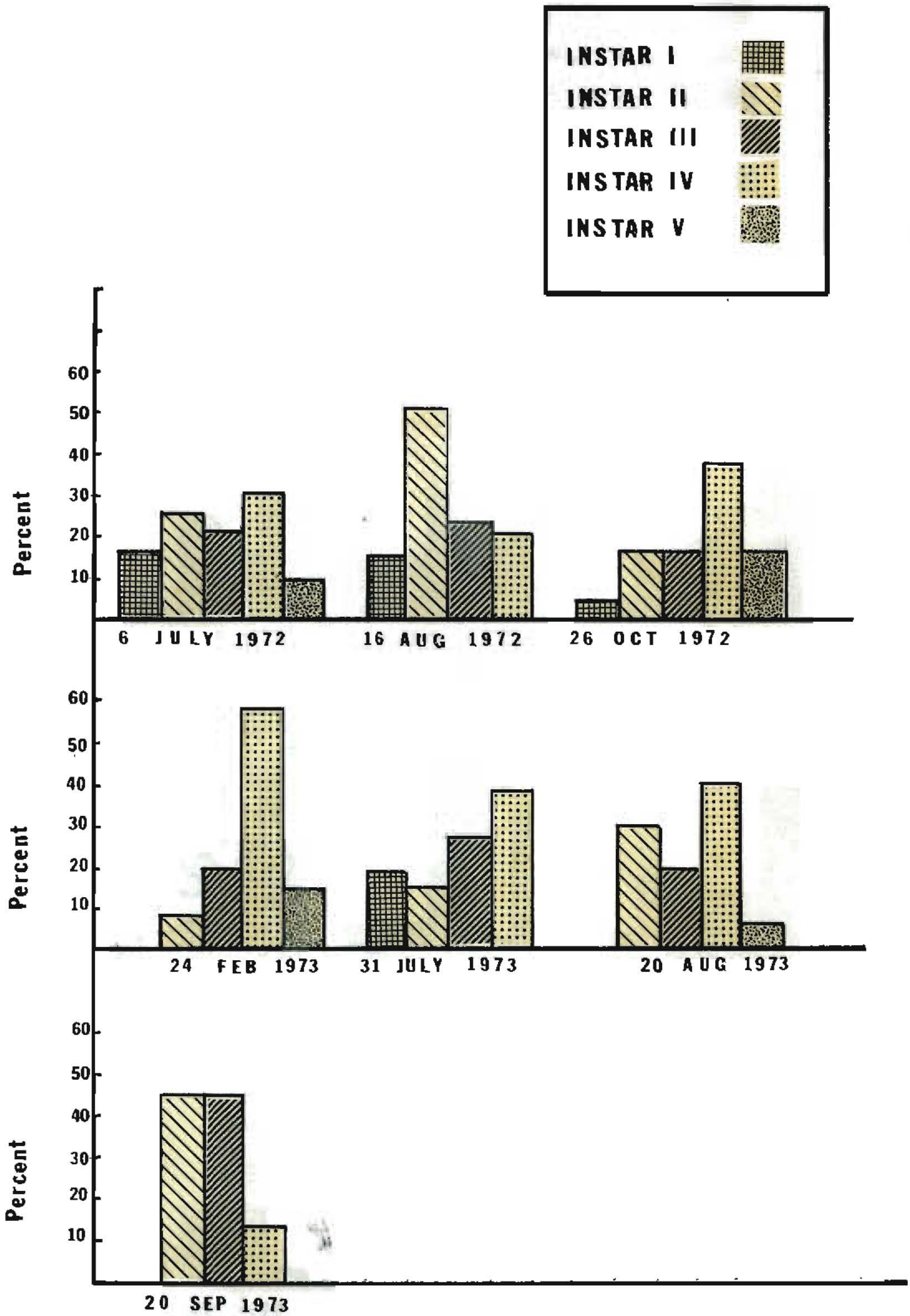

Fig. 3. Population age structure of Cheumatopsyche spp.

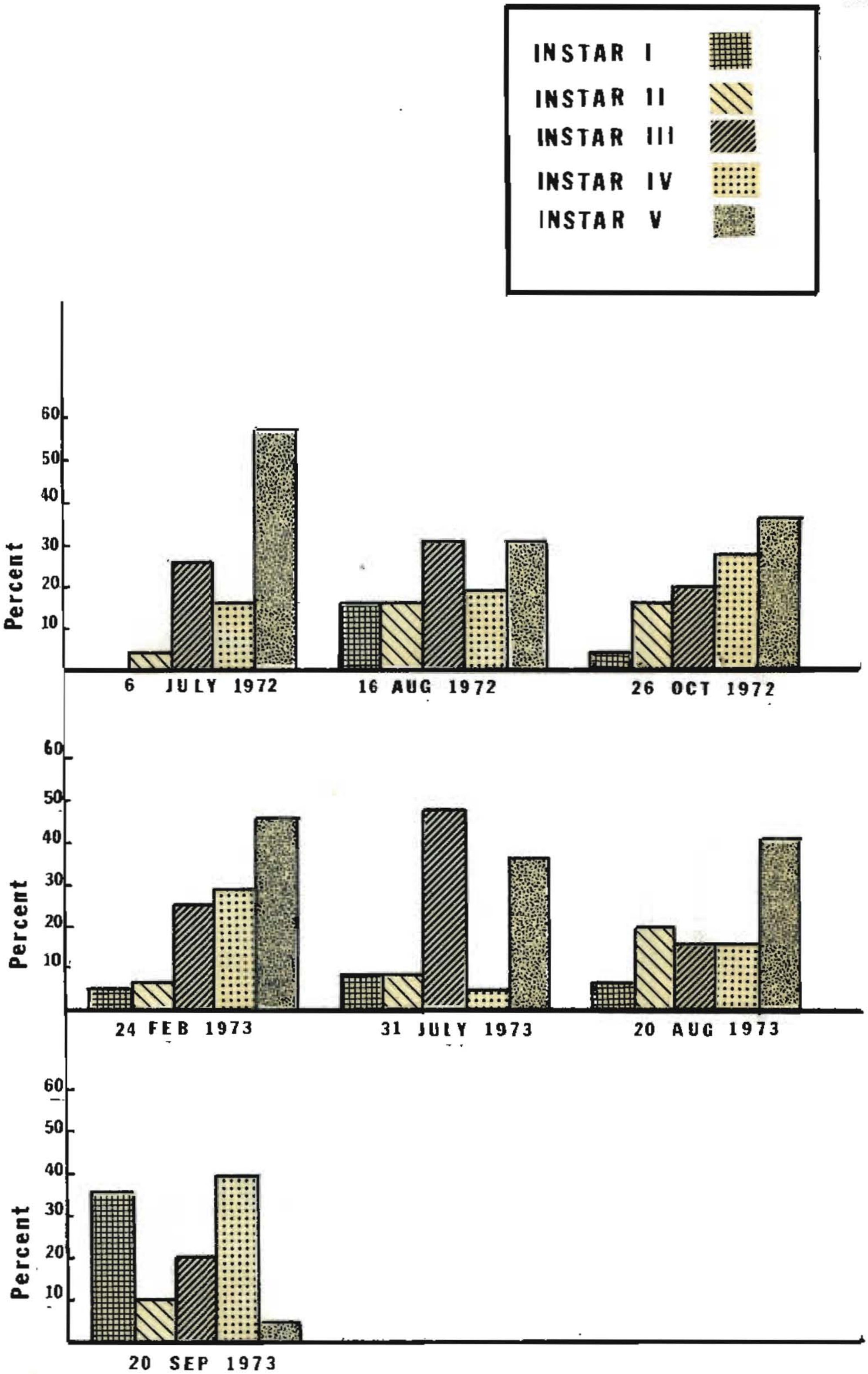

Fig. 4. Population age structure of Potamyia flava (Hagen).

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

Species	Temperature (C)	Oxygen Uptake (ul O_2/mg/hr)
Cheumatopsyche spp.	10-12	1.7 (12)
Cheumatopsyche spp.	20-23	4.3 (11)
Instar II	20-23	3.5 (3)
Instar III	20-23	3.6 (3)
Instar IV	20-23	4.4 (3)
Instar V	20-23	6.5 (2)
Cheumatopsyche spp.	*	3.0 (23)
Hydropsyche spp.	10-12	2.8 (6)
Hydropsyche 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 that genus.

Cheumatopsyche had a mean Q_{O_2} of 1.7 ul O_2/mg/hr at 10-12 C and 4.3 ul O_2/mg/hr at 20-23 C. Hydropsyche exhibited slightly higher values of 2.8 and 5.3 ul O_2/mg/hr, respectively. Mean Q_{O_2} for Cheumatopsyche, based on all measurements, was 3.0 ul O_2/mg/hr, while Hydropsyche Q_{O_2} was 4.3 ul 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 ul O_2/mg/hr by Instar II to 6.6 ul 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 ul O_2/mg/hr and 1.5 ul 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 <u>Cheumatopsyche</u> when electrochemical methods were used.

SUMMARY

1) Bottom samples were taken from a single riffle in the upper reaches of the Neosho River from 6 July, 1972, through 20 September, 1973, and used to analyze benthic community composition and structure.

2) Fifty-eight taxa of benthic macroinvertebrates were collected from the study area, with Trichoptera, Ephemeroptera, and Sphaeridae constituting the dominant groups.

3) Stream quality was characterized using a species diversity index, $\bar{d}$, whose values indicated the overall environmental quality along the study reach was good. High river discharge was observed to have an adverse affect on index values. Mean $\bar{d}$ during the study was 2.64.

4) Three genera, including at least six species, of Hydropsychidae larvae were collected in Surber samples during the study. Taxa recognized were *Hydropsyche simulans*, *H. orris*, *H. cuanis*, *H. frisoni*, *Potamyia flava*, and *Cheumatopsyche* spp. Adult caddis flies were collected to confirm larval identifications; taxa found in adult collections were *Hydropsyche simulans*, *H. orris*, *H. valanis*, *Cheumatopsyche lasia*, *C. speciosa*, *C. campyla*, and *P. flava*.

5) Estimates of standing crop indicated *Cheumatopsyche* spp., *P. flava*, *Hydropsyche cuanis* and *H. frisoni* to be most abundant in the study area.

6) Drift measurements indicated that most Hydropsychidae had similar rates of import and export. *Hydropsyche frisoni* was the most active drifter, while *H. simulans* was least active.

7) Studies on population age structure indicated that most Hydropsychidae had five instars. Shift in population age structure of _P. flava_ and _Cheumatopsyche_ was observed, but all instars were present on most sampling dates. _P. flava_ over-wintered in all instars, while _Cheumatopsyche_ over-wintered in all but the first instar. Both taxa developed at different rates throughout the year, and emerged during warmer months.

8) _Hydropsyche_ had a slightly higher Q_{O_2} than did _Cheumatopsyche_, but the difference was not significant at the .05 level. Both genera showed a significant increase in oxygen uptake with temperature. Mean Q_{O_2} for _Hydropsyche_ was 4.3 ul O_2/mg dry weight/hr and _Cheumatopsyche_ was 3.0 ul O_2/mg dry weight/hr.

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APPENDIX

Table IX. Standing crops of benthic macroinvertebrates collected from the study riffle 6 July, 1972, through 20 September, 1973, expressed as density/m^2.

Taxa	1972				1973				
	7/6	7/27	8/16	10/26	2/24	6/26	7/31	8/20	9/20
PLATYHELMINTHES									
Turbellaria									
Dugesia sp.	172	390	369	815	81	8	22	27	135
ASCHELMINTHES									
Nematoda									1
ANNELIDA									
Hirudinea							3		
Oligochaeta									
Branchiura sowerbyii Bedd.	40	48	38	13	239	3	38	13	159
Limnodrilus hoffmiesteri Clap.	19	43	8	38	30	19	35	51	81
Limnodrilus sp.	8				5	19	5	5	5
Tubifex tubifex (O.F.M.)						11			
MOLLUSCA									
Gastropoda									
Physa anatina Lea	3		3						5
Heliosoma sp.							3	3	
Lymnaea bulimoides cockerelli (Pilsbry and Ferriss)						3		3	5

Table IX. (Cont'd)

Taxa	1972				1973				
	7/6	7/27	8/16	10/26	2/24	6/26	7/31	8/20	9/20
Pelecypoda									
Sphaerium sp.	143	89	178	97	250	48	48	75	169
Truncillus donaciformes (Lea)									3
ARTHROPODA									
Trichoptera									
Hydropsyche orris (Ross)	67	11	186	67	24	5	180	11	180
Hydropsyche cuanis (Ross)	697	40	632	409	613	3	288	116	387
Hydropsyche simulans (Ross)			54	48	62		3		86
Hydropsyche frisoni (Ross	191	27	880	234	132	8	75	110	183
Cheumatopsyche sp.	14545	13750	13891	5211	2634	24	3822	5929	8950
Potamyia flava (Hagen)	237	56	1568	1420	812	5	1200	1399	10058
Anthripsodes sp.	11	22	8				19	38	5
Hydroptila sp.							5	11	5
Mayatrichia sp.									13
Ithytrichia sp.	22	5					22	19	
Ephemeroptera									
Caenis sp.	874	70	43	207	183		103	108	584
Stenonema sp.	460	5	100	116	5	5	19	22	151
Paraleptophlebia sp.	129	8	16	19	3		3		8
Ameletus sp.	498	11	159	234		11	86	56	557
Isonychia sp.	250	3	110	581		5	40	121	382
Potamanthus sp.					19		3	5	

Table IX. (Cont'd)

Taxa	1972				1973				
	7/6	7/27	8/16	10/26	2/24	6/26	7/31	8/20	9/20
Coleoptera									
Stenelmis sp.	594	915	740	183	1256	441	1286	1071	2136
Stenelmis sexilineatus (Sanderson)								3	
Macronychus glabratus (Say)							5		
Megaloptera									
Corydalus cornutus L.			3						19
Plecoptera									
Neoperla clymene (Newman)	81	3	3	11	19	40	5	16	97
Lepidoptera									
Elophila sp.			8	94	19		3	16	226
Diptera									
Simuliidae									
Simulium vittatum (Say)	818	89	390	565	164	56	5	16	97
Rhagionidae									
Atherix variegata (Walker)								32	5
Empididae	11	3					3		24
Culicidae									
Chaoborus sp.	35	3							

Table IX. (Cont'd)

Taxa	1972 7/6	1972 7/27	1972 8/16	1972 10/26	1973 2/24	1973 6/26	1973 7/31	1973 8/20	1973 9/20
Chironomidae									
Polypedilum sp.	777	135	315	32		13	350	207	465
Chironomus (*Cryptochironomus*) sp.	102	62	5		231	27	89	67	161
Chironomus (*Chironomus*) sp.					22				
Chironomus (*Endochironomus*) sp.					5				
Glypotendipes sp.							3		
Pseudochironomus sp.					35				
Tanytarsus sp.								3	161
Tanypodinae									
Ablabesmyia sp.	126		3	11	46	3	8	8	16
Tanypus sp.		13							
Orthocladinae									
Cricotopus sp.	108		38	380	215	3		16	269
Psectrocladius sp.				40	13				
Nannocladius sp.	24			6	19		11	3	
Corynoneura sp.	130	3	70	67		3	73	13	191
Hemiptera									
Hebridae				3					

Table IX. (Cont'd)

Taxa	1972				1973				
	7/6	7/27	8/16	10/26	2/24	6/26	7/31	8/20	9/20
Collembola									
Isotomidae									
Isotomurus palustris (Muller)						3			
TOTAL TAXA	29	25	27	26	27	24	34	34	36

Table X. Physical conditions during drift sampling.

Sampling Date	Stream Velocity (m/s)	Stream Depth (m)	Stream Width (m)
1 August	0.49	0.15	10.37
2 August	0.77	0.20	10.37
20 August	0.81	0.30	33.50
21 August	1.29	0.30	33.50

Table XI. Annual precipitation record for 1972 and 1973*.

Month	1972	1973
January	0.17	2.77
February	0.41	1.20
March	1.28	9.50
April	6.70	3.75
May	3.30	4.69
June	2.05	3.30
July	8.62	8.44
August	4.26	4.20
September	1.09	15.59
October	1.83	5.46
November	2.95	2.13
December	1.23	2.24
Total	33.89	62.27
Annual Mean (1931-1946)		34.10

* Climatological Data Kansas; U. S. Dept. of Commerce Pub. National Oceanic and Atmospheric Administration; Environmental Data Service; Emporia FAA 86(1)-87(13).