DIURNAL CHARACTERISTICS OF DRIFTING MACROINVERTEBRATES IN THE MISSOURI RIVER, 1976

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ABSTRACT

Estimates of daytime and nighttime macroinvertebrate drift were compared for the same locations in the Missouri River in 1976. Densities of Ephemeroptera, Trichoptera, Chironomidae, miscellaneous aquatic insects, and terrestrial insects were usually higher during the night. Habitats located near the border of the main channel of the river contained significantly more macroinvertebrates during the nighttime than during the daytime. Usually more macroinvertebrates were collected during the night than during the day in the main channel of the river; overall, however, the differences between daytime and nighttime estimates were not significant. Most macroinvertebrate production takes place in *Aufwuchs* communities located in habitats in or near the border of the main channel, and some of the organisms produced later become part of the drifting community.

DIEL VARIATIONS IN INSECT NUMBERS IN THE DRIFT OF THE MISSOURI RIVER

INTRODUCTION

Diel variations in densities of drifting macroinvertebrates in streams have been discussed by Tanaka 1960, Waters 1932, Elliott 1967, Hughes 1970, and others. In the diel patterns described by these authors peak densities usually occurred shortly after sunset or shortly before dawn. Griffith 1974 reported that in small Idaho trout streams, the maximum numbers of various insect orders occurred during the different periods of the night. All of these observations were made in relatively small streams, and diurnal phenomena were much easier to detect than those that may occur in a large lotic system. I found only three papers that yielded information on diel variations in macroinvertebrate drift from the Missouri River: Namminga 1969 reported no significant nocturnal increases in 24-hour drift collections taken near Vermillion, South Dakota; in a follow-up study, however, Schmulbach and Namminga

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1974, and Schmulbach 1974 reported that diel patterns did exist in both aquatic and terrestrial drifting macroinvertebrates in the same general section of the stream. Densities of aquatic species increased after sunset, and maximum numbers probably occurred sometime during the night or before sunrise; decreased numbers occurred during the daytime except for the terrestrial forms, which peaked just after sunrise.

Increased nighttime drift is largely due to the effect of external environmental factors or circadian insect activity rhythms (Waters 1969). Photo-illumination, substrate competition, ambient water conditions, and other factors have been shown to influence distribution and behavior of aquatic insects (Pearson and Franklin 1968).

This paper presents information on diurnal macroinvertebrate activity from four locations, including two habitats, in the Missouri River from the Fort Randall Dam to a point 32 km below Sioux City, Iowa. Previous studies (Namminga 1969; Schmulbach and Namminga 1974; and Schmulbach 1974) were short term and were confined to a relatively short stretch of the river. Data were collected as part of an investigation and evaluation of various habitat types for fish and fish food organisms in the unchannelized and channelized sections of the Missouri River (Kallemeyn and Novotny 1977).

STUDY AREA AND HABITAT DESCRIPTIONS

Much of the natural free-flowing Missouri River has been eliminated by the construction of six main stem dams on the upper river and by channelization of the river from Sioux City, Iowa to the mouth. Although isolated segments of unimpounded and unchannelized river still exist, flow in these areas is controlled by the dams. Two such areas are the 60 km of river between Fort Randall Dam and the headwaters of Lewis and Clark reservoir and the 83 km of river between Gavins Point Dam, the southernmost dam on the river, and Ponca, Nebraska (Fig. 1).

Wide, meandering channels, which contain numerous shifting sandbars and subsidiary channels, characterize the sections of unchannelized Missouri River below Fort Randall and Gavins Point dams. Channel widths in these sections range from 300 to 1500 m below Fort Randall Dam, and average 640 and 760 m below Gavins Point Dam. Depths range up to 8 m but average less than 2 m. Stream gradient in both sections is about 0.2 m/km. Bottom materials consist primarily of sand, except in backwater and marsh areas where silt deposits occur. The channelized river below Sioux City has a mean width of about 240 m, and depths greater than 3 m (Morris et al. 1968). Bottom materials include sand in the channel and silt in quiet areas, and the rock and wood pilings of dikes and revetments.

Water levels in the river below Fort Randall Dam fluctuate considerably because of variable water releases from the twin-peaking power plant. The river stage in the study area fluctuated up to 0.5 m over a 24-hr period, with maximum water releases occurring near 1200 and 1900, and minimum releases at 0600. During the study, daily mean discharges ranged from 872 to 1104 m^3/sec, and averaged 1015 m^3/sec.

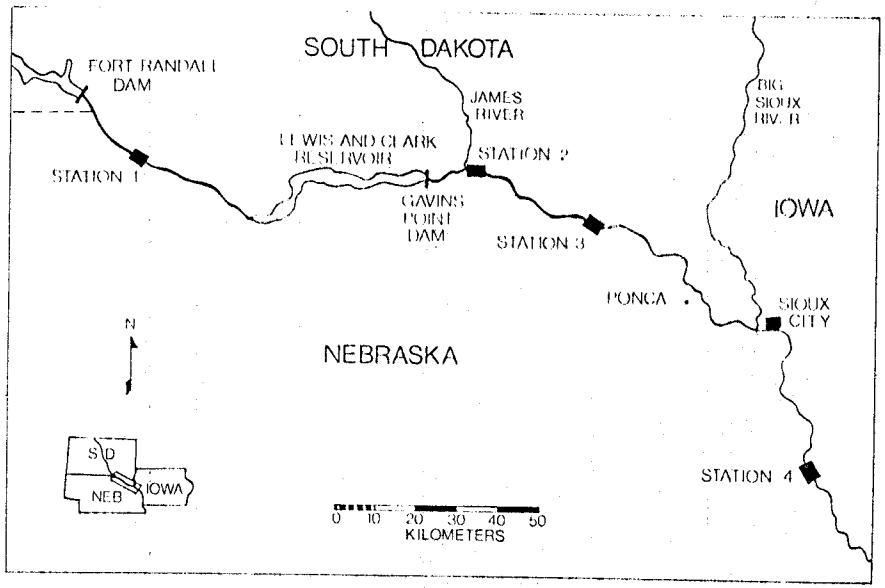

Figure 1. Location of sampling stations (1-4) on the Missouri River

Water releases from Gavins Point Dam vary little during a 24-hr period but there is considerable seasonal variation. Releases average over 900 m^3/sec during the navigation season, which extends from mid-March to mid-November, but are normally less than 575 m^3/sec during the non-navigation season. Daily mean discharges during the study averaged 1024 m^3/sec, and ranged from 985 to 1048 m^3/sec.

Main channel (mc) and main channel border (mcb) areas were the two types of habitats sampled for day-night comparisons of drift abundance. Current velocities were faster in the mc than in the mcb habitat in the unchannelized river (Stations 1-3). Surface flow velocities in the mc generally exceeded 1.0 m/sec; mid-depth and bottom flows generally averaged 84% and 70% of the surface velocity, respectively. Depths ranged from 5.8 m to less than 2.0 m, depending on alterations in the stream bed associated with the constantly shifting river currents.

The mcb habitat in the unchannelized river is defined here as a zone about 10 m wide adjacent to the mc shoreline. These areas were commonly bordered by abrupt, friable banks and contained a great deal of debris, including logs and stumps. Depths and velocities depended on the proximity and approach angle of the main channel. Depths ranged from 0.9 to 4.0 m, and flow velocities from 0.3 to 1.2 m/sec.

The mc in the channelized river is defined by channel improvement structures (dikes and revetments), which insure a mean channel width of about 240 m. Channel depths in this area ranged from 3.6 to 4.8 m and current velocities normally exceeded 1.5 m/sec. The mcb habitat in the channelized river was located along a stabilization revetment composed mostly of rock rubble. Depths in this habitat ranged from 0.9 to 1.8 m; surface velocities averaged 0.6 m/sec and ranged from 0.4 to 1.2 m/sec.

Four locations were sampled in the unchannelized and channelized sections of the Missouri River from Fort Randall Dam to a point 32 km below Sioux City, Iowa (Fig. 1). Station 1 was in the unchannelized river below Fort Randall Dam (river miles [RM] 862-856) and Stations 2 and 3 were in the unchannelized river below Gavins Point Dam at RM 802-797, and RM 781-777. Station 4 was in the channelized river 32 km below Sioux City at RM 709-704.

METHODS

Daytime and nighttime samples were taken from the two habitat types at each station on four occasions from April to November 1976. Daytime samples were taken near noon and nighttime samples 1 to 1.5 hours after sunset. A total of 64 samples (32 daytime and 32 nighttime) were collected.

The macroinvertebrates were collected from the drift with a 0.5 m plankton net with No. 00 mesh (0.752-mm aperture). A flowmeter mounted in the mouth of the net was used to determine sample volume. The sampler was calibrated regularly to avoid errors associated with sand particles, which caused meter wear and eventual malfunction.

All samples from the two habitats were collected 0.5-1.0 m below the surface of the water by extending the net into the current from a stationary position for 10-30 min, depending on flow velocity. An average of 241,000 liters per sample was filtered in the mc habitat, and 170,000 liters per sample in the mcb habitat. All samples were preserved with 10% formalin.

Samples were hand sorted in the laboratory and organisms were identified to the lowest identifiable taxa, and numerical standing crops (No./1000 m^3) calculated.

We used a paired t-test to compare daytime and nighttime estimates.

RESULTS

Insects made up 94% of the macroinvertebrate drift; the rest was composed of arachnids and malacostracans (Table 1). Planktonic Entomostraca (e.g., *Daphnia* sp. and *Leptodora* sp.) were not included in the estimates of macroinvertebrate drift.

Generally, macroinvertebrate drift densities were lowest at Station 1, highest at Station 4, and intermediate at Stations 2 and 3 (Fig. 2 and 3). These trends were noted during both nighttime and daytime estimates in both habitats. The mcb habitat exhibited the greatest nighttime increase.

In the mcb habitat, significantly more macroinvertebrates occurred in the drift at night than in the daytime ($P<.01$). Higher nighttime densities were recorded from all stations on every sampling date (Fig. 2). Drift densities (no/1000 m^3) at all four stations combined averaged 653 during the nighttime, and 256 during the daytime; mean nighttime densities ranged from 201 at Station 1 to 1,352 at Station 4, and mean daytime densities from 102 at Station 1 to 533 at Station 4 (Table 1).

The increase in nighttime densities in the mcb habitat was primarily a result of increased densities (no./1000 m^3) of Ephemeroptera and Trichoptera (Table 1): ephemeropterans increased from an average of 13 during the day to 113 during the nighttime, and trichopterans from an average of 28 during the day to 140 at night. These two orders collectively increased from 16% of the daytime drift to 38% of the nighttime drift. Nighttime density increases also were observed in Chironomidae, other aquatic insects, and terrestrial insects, but they were proportionately smaller than those of Ephemeroptera or Trichoptera.

More insects were collected during the nighttime in 11 of the 16 samples taken from the mc (Fig. 3); however, diurnal differences in abundance were not significant. In the mc habitats of the unchannelized river (Stations 1-3) five of six daytime samples taken in April, May, and June yielded higher drift densities than did nighttime samples on these dates, primarily because of higher daytime densities of chironomid pupae.

Average numbers of insects collected (no./1000 m^3) from all four mc stations were higher during the night (497) than during the day (410). Nighttime estimates ranged from 224 to 966, and daytime densities from 199 to 684 (Table 1). Mean numbers of insects were lower at night than during the day at Stations 2 and 3, but higher at night than during the day at Stations 1 and 4.

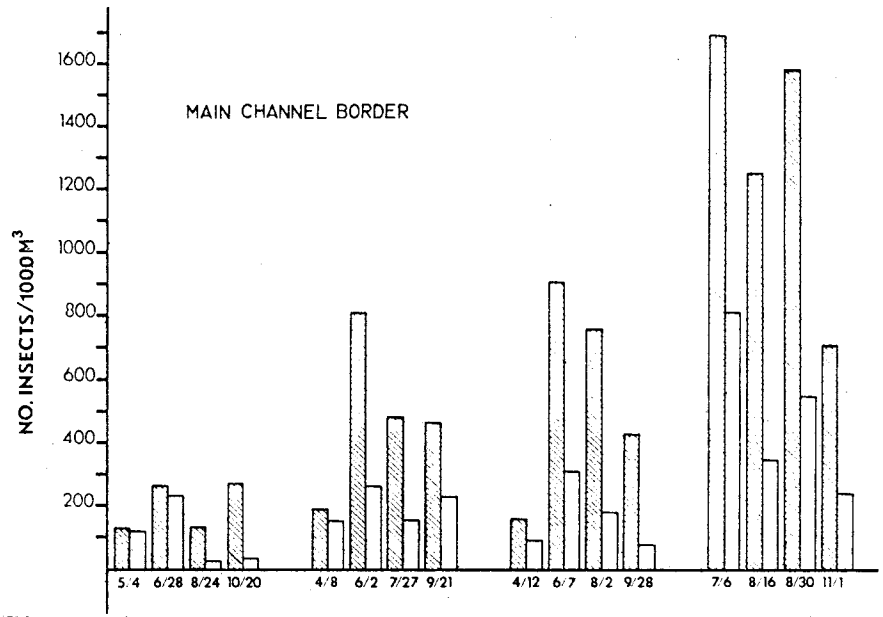

Figure 2. Numbers of insects in nighttime (shaded) and daytime (unshaded) collections, main channel border, Stations 1-4, Missouri River, 1976.

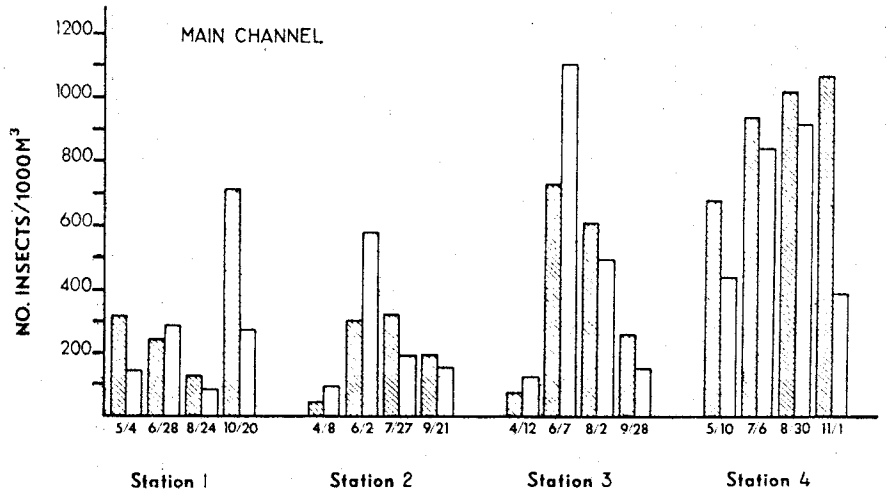

Figure 3. Numbers of insects in nighttime (shaded) and daytime (unshaded) collections, main channel, Stations 1-4, Missouri River, 1976.

TABLE 1

Daytime and Nighttime Estimates of Macroinvertebrate Drift in Mean Numbers/1000 m³ for Samples Collected April-Oct. 1976, Missouri River

Habitat/ Station	Ephemeroptera Night	Ephemeroptera Day	Trichoptera Night	Trichoptera Day	Chironomidae Night	Chironomidae Day	Other aquatic insects Night	Other aquatic insects Day	Terrestrial insects Night	Terrestrial insects Day	Other invertebrates Night	Other invertebrates Day	Total macroinvertebrates Night	Total macroinvertebrates Day
Main channel border														
1	24	2	41	8	95	57	11	3	29	32	0	0	201	102
2	81	11	38	21	154	102	26	16	61	52	59	10	419	212
3	81	7	117	20	144	74	32	22	160	44	106	10	640	177
4	264	31	363	62	381	160	37	15	251	202	55	63	1,352	533
Total	450	51	559	111	774	393	107	56	501	329	220	83	2,612	1,024
Mean	113	13	140	28	194	98	27	14	125	82	55	21	653	256
Percentage*	17	5	21	11	30	38	4	5	19	32	8	8	100	100
Main channel														
1	2	3	38	12	208	153	28	3	76	28	6	0	358	199
2	4	24	30	24	107	143	14	12	65	49	4	8	224	260
3	15	15	37	45	208	292	40	48	111	81	24	16	436	497
4	87	79	254	206	196	170	105	56	264	124	60	49	966	684
Total	108	121	358	287	720	758	188	120	517	282	94	72	1,984	1,640
Mean	27	30	90	72	180	190	47	30	129	71	24	18	497	410
Percentage*	5	7	18	18	36	46	9	7	26	17	5	4		

*Percentages separately computed for daytime and nighttime samples for each taxon.

Densities of Ephemeroptera and Chironomidae decreased in the nighttime in the mc, whereas numbers of Trichoptera, other aquatic insects, and terrestrial insects increased (Table 1). Ephemeroptera and Trichoptera, collectively, made up a similar proportion of both the night and day drift (23-25% of the total numbers). Downstream drift density increases similar to those which occurred in the mcb habitats were noted for all insect groups except the Chironomidae, which displayed no discernible upstream-downstream density trend in the mc habitats.

Terrestrial insects were commonly found in samples taken during the day and at night in both habitats. This insect group was considered to be an accidental component of the drift, primarily because the numbers present depended largely on environmental conditions during the sampling period (e.g., wind and rain). Daytime estimates ranged from 25-42% of the total drift in the mcb habitats to 14-19% in the mc habitats. During the nighttime, terrestrial insects averaged 26% of the drift numbers in the mc habitats, and 19% of the drift in the mcb habitats.

The highest densities of terrestrial insects were found in the nighttime drift (Table 1). This phenomenon was largely due to increased activity of the terrestrial taxa during the crepuscular hours of the day, causing them to become more abundant in the samples taken shortly after sunset. The percentage composition of terrestrial insects decreased during the nighttime in the mcb habitats due to higher abundances of aquatic taxa, but actual terrestrial insect numbers increased more than 30%. Aquatic insect numbers did not increase proportionately in the mc during the nighttime; consequently in this habitat the terrestrial insects made up a higher percentage of the nighttime drift.

Baetis, *Caenis*, and *Hexagenia* were the dominant ephemeropteran genera in both the daytime and the nighttime samples. Other ephemeropteran genera collected were *Anepeorus*, *Baetisca*, *Heptagenia*, *Homoeoneuria*, *Leptophlebia*, *Stenacron*, and *Tricorythodes*.

The trichopteran genera were dominated by *Hydropsyche* and *Potamyia* during both sampling periods. The only other trichopteran genera commonly collected were *Hydroptila* and *Neureclipsis*.

Members of the dipteran family Chironomidae, including adults, pupae, and larvae, were the most frequently collected group of insects. Adults were slightly more common in the nighttime than in the daytime collections (37% vs. 30%). Fewer pupae were collected during the night than during the day; larvae were collected in similar numbers during the two time periods. The numbers of chironomids in each genus were not determined; however, a qualitative list of the Chironomidae genera from daytime and nighttime samples was given by Kallemeyn and Novotny 1977.

Families other than Chironomidae accounted for about 25% of the total dipteran fauna. The most common of these families were Sciaridae, Simuliidae, and Ceratopogonidae.

Most of the terrestrial insects collected were members of the families Sciaridae (Diptera), Formicidae (Hymenoptera), and Aphididae (Homoptera).

DISCUSSION

The production of aquatic macroinvertebrates in the Missouri River occurs primarily in the *Aufwuchs* communities in the nearshore, chute, and backwater areas bordering the main river channel (Modde and Schmulbach 1973; Nord and Schmulbach 1973). Few macroinvertebrates are produced in the mc, where shifting substrates, absence of aquatic vegetation, and swift currents discourage macroinvertebrate habitation (Berner 1951; Wolf et al. 1972). Nearshore areas are most conducive to macroinvertebrate production because of the occasional presence of vegetation and other debris, and the diversity of habitats and substrates in these areas. This was especially true for Station 4, where the rubble substrate along the border of the river provided diverse conditions for macroinvertebrate production. The higher densities in both nighttime and daytime drift at Station 4 was a result of the increased production in the numerous niches available in the rubble substrate.

I concluded that drifting macroinvertebrates in the Missouri River increased significantly during the night. The failure to detect significant increases in insect densities in the main river channel shortly after sunset was probably due to the time lag involved in the emigration of insects from the production areas into the main water mass. Greater abundances of insects in the mcb habitats during the night was to be expected, since they were being produced in or adjacent to the sampling area.

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