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Drift of Ephemeroptera and Plecoptera in Two Colorado Rivers[1]

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Abstract. Mayfly and stonefly drift were studied during the ice-free season in two Colorado mountain rivers. Eleven and 12 species of mayflies and stoneflies, respectively, were collected in 416 samples, taken at eight daily time periods. Drift rates ranged 1-499/100 m^3. *Baetis bicaudatus* and *Baetis tricaudatus* were the most prolific mayfly drifters in all months in both rivers. *B. tricaudatus* exhibited a bigeminus pattern in the Dolores River in August and September, 1975, with high August drift rates of 499/100 m^3 and 158/100 m^3, respectively, during post-sunset and pre-sunrise hours. *Baetis bicaudatus* also exhibited a bigeminus pattern in August and September in both rivers. Larger *Baetis* nymphs drifted more at night than in the three daytime periods in May, June in the Dolores River, and larger *B. bicaudatus* drifted at night in September. These times correspond with months representing larger nymphal sizes and seem to support the hypothesis that larger nymphs drift predominantly at night, after reaching some minimal size threshold that might increase their risk as prey for sight-feeding fishes. *Ephemerella inermis* drifted at densities of 6-9/100^3 in May and July, respectively, in the Dolores River, and *Rhithrogena* sp., *Ephemerella inermis* and *Cinygmula* sp. drifted at peak rates of 11, 9 and 8/100 m^3, respectively in May, June and July in the Dolores River. All other mayfly species drifted infrequently and/or at low rates of less than 2/100 m^3 in both rivers. Stoneflies, except Chloroperlidae, drifted at low densities of less than 2/100 m^3 in both rivers. For most species, these low numbers corresponded with low relative benthic abundance, making it difficult to ascertain propensity to drift. The relatively high benthic abundance of *Claassenia sabulosa* and *Hesperoperla pacifica*, coupled with their near absence in the drift, would suggest a low behavioral drift tendency, consistent with most drift studies that have included Plecoptera.

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Chloroperlid nymphs representing the genera *Suwallia, Sweltza* and *Triznaka,* drifted in the Gunnison River at the relatively high peak densities of 16-26/100 m^3, with a marked nighttime periodicity. Their peaks represented large, pre-emergent sized nymphs, and occurred in May, June and August, 1975, corresponding with emergence of various species throughout the summer.

Behavioral insect drift functions as a population regulating mechanism in stream ecosystems. Overpopulated habitats experience emigration of insects which form a suspended, drifting reserve, able to colonize underpopulated or denuded downstream habitats (Müller 1954; Waters 1961, 1965; Walton et al. 1977; Walton 1978). Such a mechanism presumably maximizes carrying capacity and space utilization (species packing) of streambed along the habitable longitudinal gradient of drifting species, and provides a means of dispersal for preemergent stages. Waters (1965) demonstrated by net blocking a stream that drift of *Baetis* represented a substantial downstream displacement of up to 38 m, and Bird and Hynes (1981) found that drift was far greater than upstream movement or random wandering of insects in Salem Creek, Ontario.

Tanaka (1960) first established that mayfly drift was primarily nocturnal. Subsequent reviews by Chaston (1972), Waters (1972), and Müller (1974) further substantiated diel periodicty in drifting insects, with highest drift rates often occurring just after sunset. Such an adaptation theoretically reduces predation by sight-feeding fishes during this vulnerable time of movement. These reviews have also revealed that the propensity of different developmental stages or sizes to drift is inadequately established for most insects. Anderson (1967), Elliott (1967a) and Waters (1969) reported highest drift rates in smaller sizes of several insect species whereas larger sizes of other species predominated in the drift in these and other studies (Müller 1966; Elliott 1967a,b; Anderson 1967; Ulfstrand 1968).

Our objectives were to determine the following aspects of mayfly and stonefly drift in two Colorado rivers: 1) propensity of various species to drift, 2) drift densities and seasonal/diel drift patterns, 3) sizes of nymphs drifting, and 4) relation of drift to life cycles. Such knowledge can be important in predicting insect population recovery in damaged streams at different seasons of the year, and can be helpful to fishermen who use nymphs and wetflies. Except for Brusven's (1970) seasonally-limited study, little advantage has been taken by investigators of the interpretive dimension to be gained by concurrent drift study on two rivers having similar faunas.

MATERIALS AND METHODS

The comparative value of the now voluminous literature has been hampered by the disparity of samplers used, variations in sampling designs and drift rate expressions, and, in some cases, concentration of effort on one or a few species in small streams during a limited time frame. We attempted to improve sampling and to maximize comparative value of our data by: 1) sampling the entire insect community on two relatively large rivers over the entire ice-free season, 2) increasing efficiency of sampling by using a larger number of samplers at spaced scotophase and adjacent post-dawn and pre-dusk intervals, proposed by Cloud and Stewart (1974a,b) and 3) expressing drift rates as drift density, proposed by Elliott (1970).

All drifting insects were sampled October, 1974, and monthly from May to September, 1975, in the Dolores and Gunnison Rivers, Colorado. This period encompassed recruitment, a portion of the nymphal growth period and emergence of the most mayfly and stonefly taxa (except Capniidae). The Dolores River site, described by Fuller and Stewart (1979), was located near the upstream city limits of Dolores, in Montezuma County, Colorado. The Gunnison River site (Fuller and Stewart 1977) was on private property known as the Lost Canyon Resort, ca. 4.5 km below the confluence of the East and Taylor Rivers in Gunnison County, Colorado.

We used modified Müller samplers, described by Cloud and Stewart (1974a,b). These consisted of: 1) an intake cylinder 10.5 cm dia × 17.5 cm long, 2) a tapering 45 cm-long, 471 μm mesh-opening Nitex bag, and 3) a removable Wisconsin-style plankton bucket with 363 μm mesh-opening netting. The slick, epoxy resin-coated intake cylinder prevented crawling mayflies and stoneflies from escaping the samplers. Samplers were set in pairs on stainless-steel stations (Fig. 1), anchored into the streambed by a single metal rod. Stops on the station rods were positioned so that the bottoms of the sampler intake cylinders rested 10 cm above the substratum, insuring that insects sampled came from the water column. Use of this system and adjustable stops on the rods allows variable vertical positioning and/or stacking of samplers.

Three pairs of 1-h samples were taken on both rivers in October 1974, at the following eight time periods: 1) ending 0.5 h before sunset (PRSS), 2) beginning 0.5 h after sunset (POSS), 3-5) three evenly spaced scotophase samples, 6) ending 0.5 h before sunrise (PRSR), 7) beginning 0.5 h after sunrise (POSR), and 8) 12:00 noon. Each pair of samplers was spaced at 25, 50, and 75% the distance across a transect. Seasonally associated logistic problems in 1975, particularly high turbidity and drifting debris in spring and higher than projected spring-summer discharge, necessitated several adjustments from the October 1974 sampling design on both rivers. These essentially consisted of: 1) reducing sample numbers to four per day in both rivers, 2) reducing sampling time to 0.5 h May-July in the Dolores River because of high turbidity and

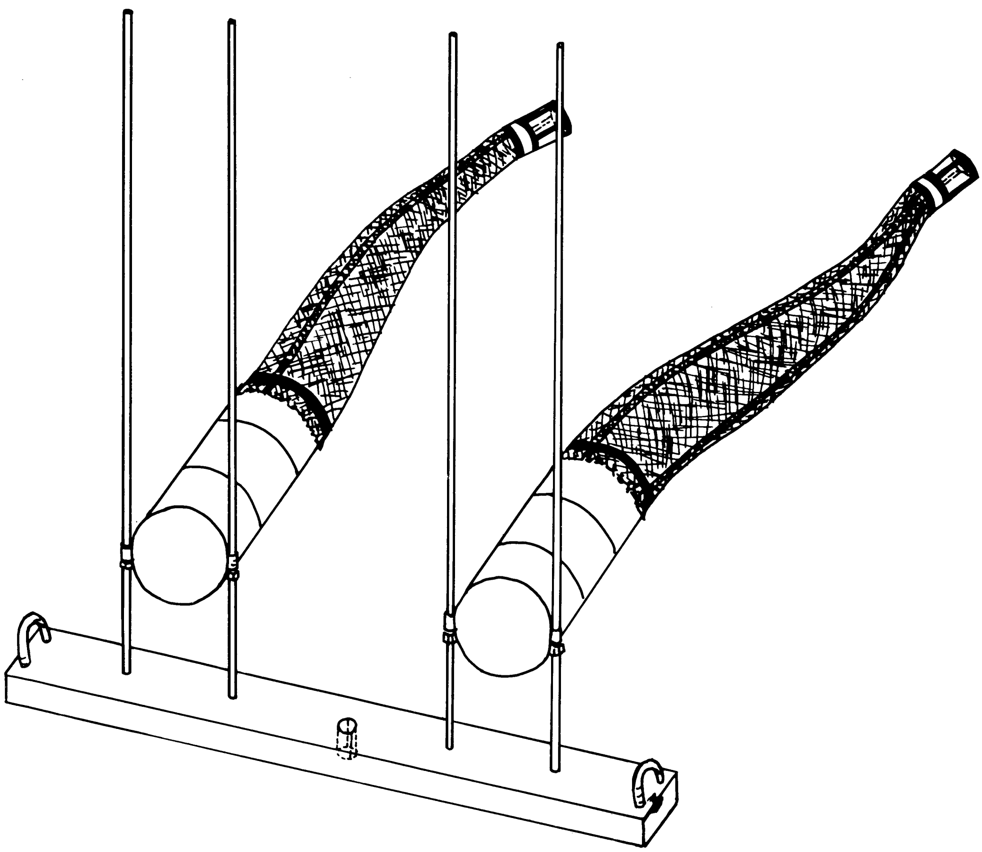

Fig. 1. Paired drift samplers mounted on stainless-steel station.

sampler clogging, and 3) repositioning of the two stations (2 samplers each) as follows: a) Dolores River--Stations were set at 25% and 50% across a transect, except in May, when access to midstream was impossible. Stations that month were set at ca. 20% and 30% distance from the access side; the second station was set 25 m downstream of the first, b) Gunnison River--each of the two stations was set at midstream in each of two channels separated by a small island. Because of swift current, access to these positions required holding to a heavy rope stretched across the channel immediately downstream.

Station water depth, temperature and water discharge through samplers were measured at the beginning of each sampling time, using a meter stick, Kahl Shock-Protected Water Thermometer and Kahl Pigmy Flow Meter, respectively. Insects from drift samples were preserved in 70% isopropanol and later identified to lowest possible taxon, enumerated and maximum head capsule width (hcw) measured with a calibrated ocular micrometer. Numbers drifting were converted to drift density (No/100 m^3 water discharge).

RESULTS AND DISCUSSION

Taxa Drifting — A total of 11 of 12 species of mayflies and stoneflies, respectively, were collected in the 416 drift samples on both rivers. Species in the Dolores River drift were: 1) Ephemeroptera--*Baetis bicaudatus* Dodds, *Baetis tricaudatus* Dodds, *Cinygmula* sp., *Epeorus* (*Iron*) *longimanus* (Eaton), *Ephemerella* (*Drunella*) *grandis* (Eaton), *Ephemerella* (*Ephemerella*) *inermis* Eaton, *Paraleptophlebia* sp., *Rhithrogena* sp. and *Tricorythodes* sp., and 2) Plecoptera--*Claassenia sabulosa* (Banks), *Cultus aestivalis* (Needham & Claassen), *Isogenoides zionensis* (Hanson), *Isoperla fulva* Claassen, *Isoperla quinquepunctata* (Banks), *Pteronarcella badia* (Hagen), *Prostoia besametsa* (Ricker), *Skwala parallela* (Frison) and *Suwallia* complex spp.

Gunnison River drift samples yielded 12 of the same taxa; additional species not represented in the Dolores River were: 1) Ephemeroptera--*Ephemerella* (*Drunella*) *doodsi* Needham, *Ephemerella* (*Ephemerella*) *infrequens* McDunnough and *Isonychia* sp., and 2) Plecoptera--small capniid nymphs, *Hesperoperla pacifica* (Banks) and *Zapada cinctipes* (Banks). Dolores River drifters not represented in the Gunnison River samples were the mayflies *Ephemerella inermis*, *Cinygmula* sp. and *Epeorus longimanus*, and the stoneflies *Isogenoides zionensis*, *Isoperla quinquepunctata* and *Prostoia besametsa*.

During and just subsequent to field sampling, *Ephemerella* species form both rivers were separated to *E. doddsi*, *E. grandis* and *E. inermis*, using Allen and Edmunds (1965). A recent re-examination of the *E. doddsi* component, in light of Johnson (1978), resulted in nymphs from the Gunnison River being assigned to *E. infrequens*, and those from the Dolores River to *E. inermis*. There still appears to be some problem with separation of the nymphs of these two similar species, since our Dolores River nymphs showed the strongly curved claw character of *inermis*, yet the distinct forefemoral subapical spine band of *infrequens*.

Drift Densities and Seasonal/Diel patterns — Nymphs of nine taxa (39% of taxa drifting), and adults of *Baetis* and *Tricorythodes* drifted infrequently and exhibited no distinct patterns (Table 1). Few adults were recovered from the samples. Those of *Baetis*, drifting near sunset in August 1975 (Table 1), corresponded seasonally with expected emergence of the bivoltine *B. bicaudatus*, suggested by nymph size composition data of Allen (1978) in nearby Cement Creek. Adult *Tricorythodes*, which typically emerge during morning hours (Meck 1977) appeared only in noon samples, perhaps as a result of imago "spinner fall".

Except for *Hesperoperla pacifica*, the stoneflies that drifted infrequently and at low rates (Table 1) occurred in relatively low benthic abundance in both rivers (Fuller & Stewart 1977, 1979, concurrent studies), making it unfeasible to estimate their propensity to drift. *Hesperoperla pacifica*, however, occurred in relatively high benthic abundance

TABLE I

Infrequent and low density insect drifters: Dolores and Gunnison Rivers, Colorado, 1974-75.

Species Rivers	Month Daily time periods[a]	Density/100m^3 HCW mm
EPHEMEROPTERA		
Baetis sp. (adult)[b]	Aug/1, 2, 3	4/-; 2/-; 2/-
Gunnison		
Ephemerella sp.	Aug/3	1/1.09
Gunnison		
Isonychia sp.	Aug/5; Sep/8	4/0.86; 19/0.69
Gunnison		
Tricorythodes (adult)[b]	Aug/8	3/1.00
Gunnison		
Tricorythodes sp.	Aug/8	1/1.09
Dolores		
Gunnison	Sep/8	2/0.69
PLECOPTERA		
Capniidae nymphs	May/5	2/0.15
Dolores		
Gunnison	Jun/5, 7	2/0.80; 1/0.90
Cultus aestivalis	Oct/6, 7; May/5; Jul/4	1/0.45; 1/0.40; 2/1.20; 2/2.200
Dolores		
Isogenoides zionensis	Oct/4; Aug/5; Sep/5	1/-; 1/1.47; 2/1.05
Dolores		
Hesperoperla pacifica	Oct/6; May/3, 6, 7	1/5.50; 1/4.60; 1/1.30; 1/1.00
Gunnison		
Prostoia besametsa	Jun/1	3/0.80
Dolores		
Skwala parallela	May/5; Jul/2	2/0.90; 2/0.60
Dolores		
Gunnison	Oct/4, 5, 6	1/2.90; 1/2.85; 2/2.40

[a]Numbers representing time correspond to daily time periods given in Material and Methods.
[b]Indeterminable species due to poor condition.

(Fuller & Stewart 1977), yet only one nymph was recovered in each of four total samples, indicating a low drift propensity.

Baetis sp. nymphs generally drifted at moderate densities of 5-30/100 m^3 during October, 1974 and May-June 1975, in both rivers (Fig. 2). High densities of 70-80/100 m^3 drifted at noon in the Gunnison River, and post-sunset in the dolores River in October 1974. This difference in October periodicity between the two rivers might be attributable to different *Baetis* species drifting; the state of taxonomic knowledge of this genus did not allow separation of these early nymphs (Fig. 3) to species. Densities increased at most time periods in July (Fig. 2) corresponding with recruitment in June-July (Fig. 3) (Pearson & Kramer 1972).

Nymphs of 2- and 3-tailed species were counted separately beginning with August 1975, samples. From July-September there was a distinct diel pattern by all *Baetis*, with peak drift densities of 40-499/100 m^3 occurring during post-sunset hours. This is consistent with high post-sunset drift rates of insects (among which *Baetis* was a predominant species in nearby Cement Creek in 1975-76, Allen 1981). The high post-sunset drift of 3-tailed species in August (Fig. 2) and relatively high densities for both species during JulySeptember, corresponded with the active nymphal growth period. During these last 3 months, a bigeminus pattern was generally displayed by all *Baetis*. Three-tailed species

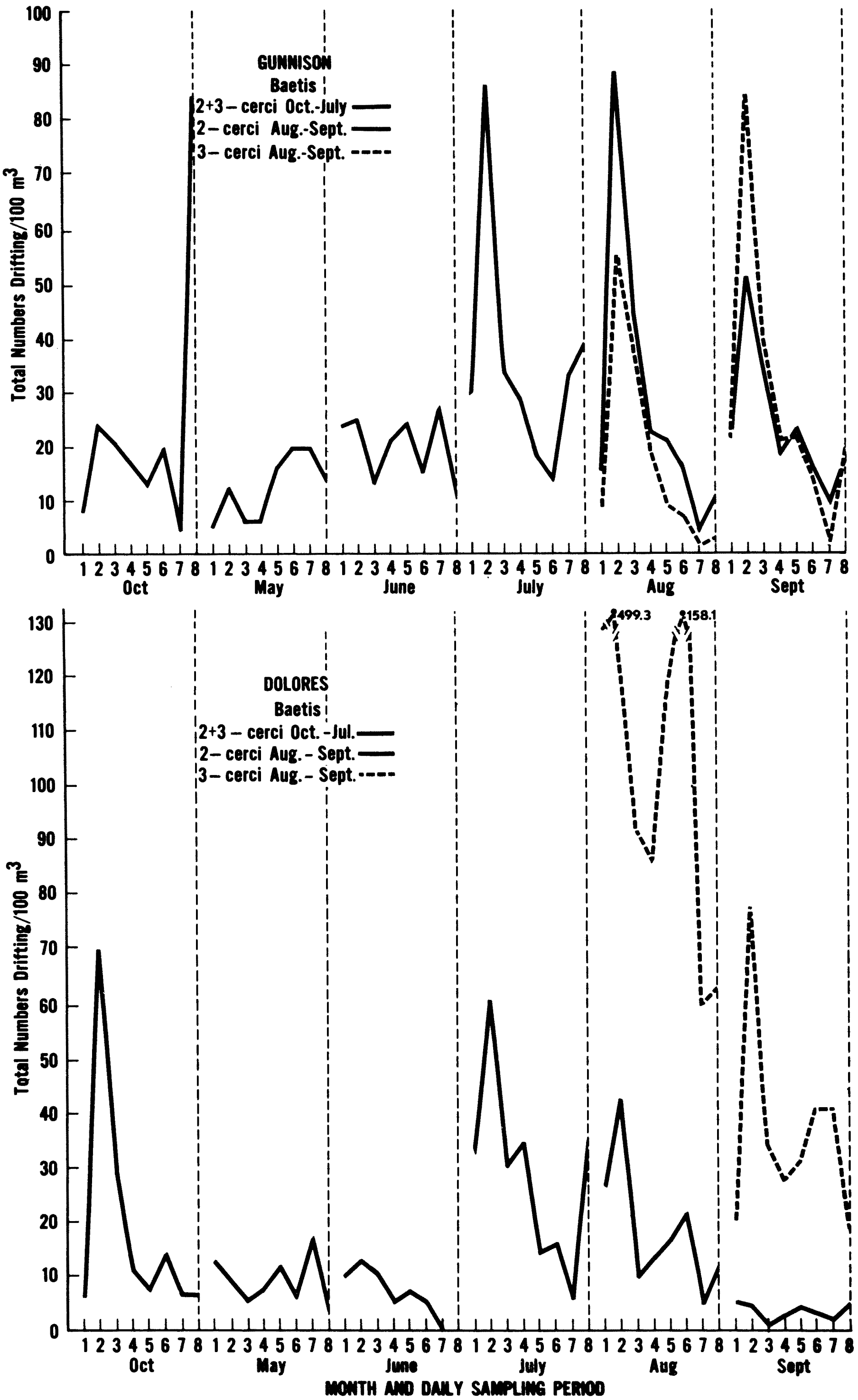

Fig. 2. Drift densities of *Baetis* in the Dolores and Gunnison Rivers, Colorado, October 1974 - September 1975. Daily sampling period numbers are outlined in Materials and Methods.

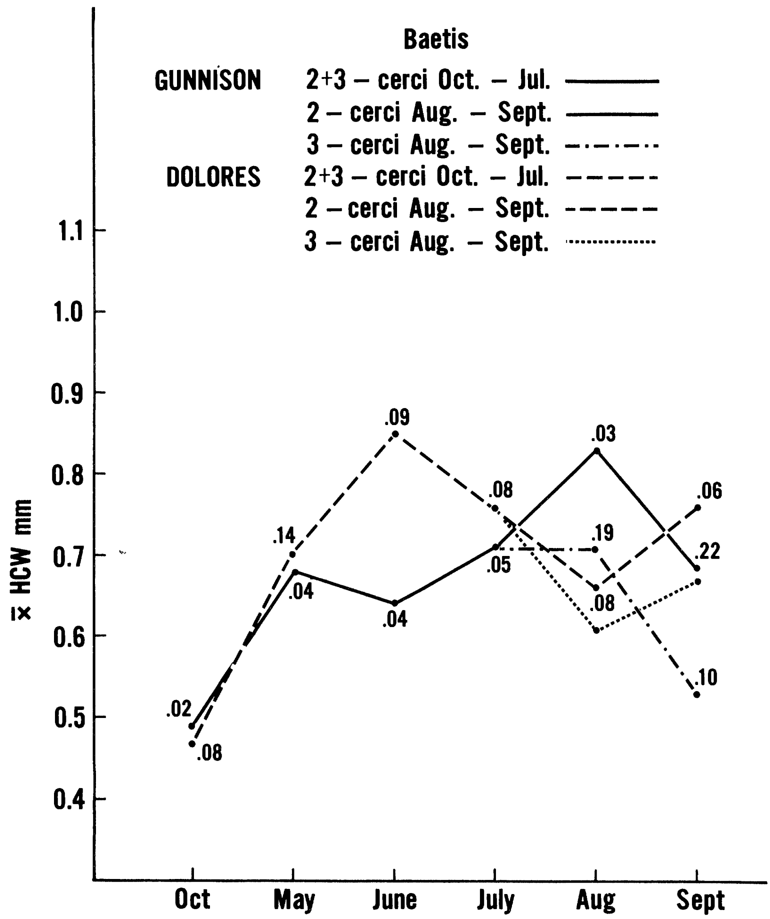

Fig. 3. Mean head capsule widths of drifting *Baetis* in the Dolores and Gunnison Rivers, Colorado, October 1974 - September 1975. Numbers at data points represent ±SD.

drifted at higher densities than 2-tailed ones during the August-September period in both rivers, except in August in the Gunnison River (Fig. 2). This could have resulted from differential abundance and/or temporally separated generations of 2- and 3-tailed species in the two rivers. Since we did not distinguish between 2- and 3-tailed nymphs in quantitative samples (Fuller & Stewart 1977), no comparison can be made between their drift and benthic densities. Similar diel patterns of *Baetis* drift were reported by Pearson and Franklin (1968), Brusven (1970) and Kroger (1974) in western rivers.

The three species of *Ephemerella* drifted at low rates of less than 2/100 m^3 in the Gunnison River (Fig. 4a). The few nymphs of *E. grandis* and *E. infrequens* caught in the drift samplers in May were of pre-emergent size, having hcw of greater than 1.2 mm, coinciding with expected seasonal emergence (Edmunds et al. 1976), and probably represented nymphs caught in the nets during their vertical swim to the surface for transformation. These low drift densities and near absence in the drift during June and July (Fig. 4a) when *E. grandis* and *E. infrequens* benthic densities were ca. 2-5 and 2021/50 cm^2, respectively (Fuller & Stewart 1977), would suggest a low propensity of these *Ephemerella* to drift. Similar low drift rates for *E. grandis* were reported by Brusven (1970) in Gold Center Creek in Idaho. Kroger (1974) sampled in July and August and reported a high drift index for *E. inermis* in July, in the Snake River, Wyoming. This

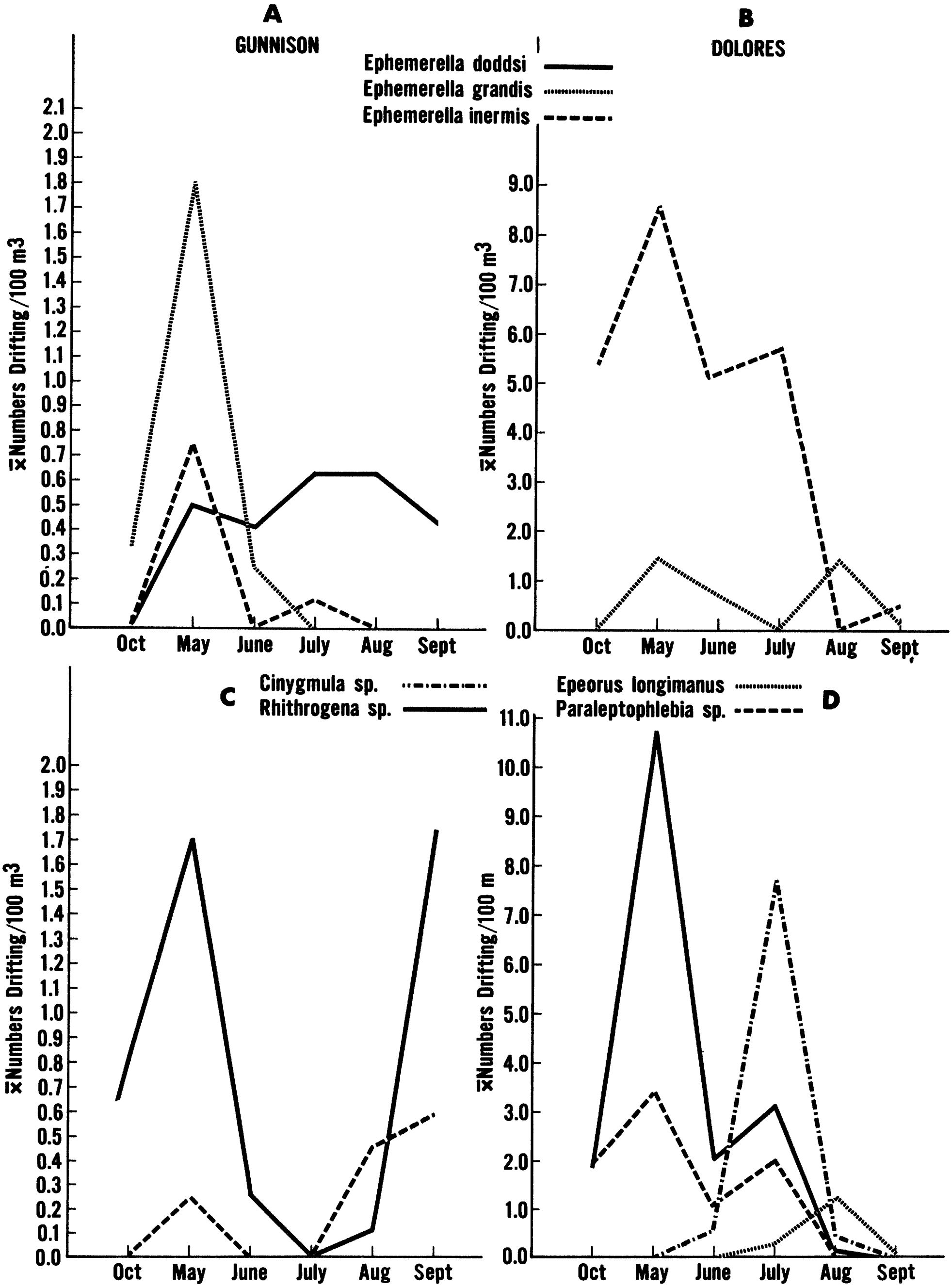

Fig. 4. Drift densities of Ephemerellidae, Heptaginiidae and Leptophlebiidae in the Dolores and Gunnison Rivers, Colorado, October 1974 - September 1975. The dashed line represents *Ephemerella infrequens* in A, and *Ephemerella inermis* in B.

species is closely related to *E. infrequens*, and is usually found in rivers at lower elevations than *infrequens* (Johnson 1978).

A similar pattern of peak May drift of *E. grandis* and *E. inermis* occurred in the Dolores River (Fig. 4). *Ephemerella inermis* was collected in this river at over 4X the densities of *E. infrequens* in the Gunnison River, and at higher densities than *E. grandis*. This is probably a reflection of the relatively higher benthic densities of *E. inermis* in the Dolores River (Fuller & Stewart 1979). *Ephemerella doddsi* drifted at low densities in the Gunnison River (Fig 4a), and was not collected in the Dolores River.

Rhithrogena sp. drifted at low densities of less than 2/100 m^3 in the Gunnison River (Fig. 4c), despite the fact that it was the most abundant heptageniid in the river, having benthic densities of 15-55/50 cm^2 (Fuller & Stewart 1977). *Cinygmula* sp. and *Epeorus longimanus* were both found at lower densities in the benthos (Fuller & Stewart 1977), but were not found in the drift. Allen (1981) found *Cinygmula* and *Rhithrogena* to be the predominant drifters in nearby Cement Creek.

Rhithrogena sp. drifted at higher rates in the Dolores River, peaking in May at 11/100 m^3 (Fig. 4d). This corresponds with its 3.5X greater relative benthic abundance in the Dolores River than in the Gunnison River in May (Fuller & Stewart 1977, 1979) and generally with occurrence of the largest pre-emergent nymphs. Kroger (1974) reported low August drift rates of *Rhithrogena hagenii* in the Snake River. *Epeorus longimanus* drifted only in July-September at very low densities in the Dolores River, and *Cynygmula* sp. peaked at 8/100 m^3 in July.

Paraleptophlebia sp. drifted only occasionally at very low densities in the Gunnison River (Fig. 4c), and at densities of 2-3/100 m^3 in May and July in the Dolores River. (Fig. 4d). Lehmkuhl and Anderson (1972) reported peak drift densities of ca. 55/100 m^3 for *Paraleptophlebia temporalis* in Oak Creek, Oregon, yet *Paraleptophlebia debilis* drifted at very low rates in May and June in that creek.

All stoneflies except Chloroperlidae drifted at low densities of less than 2/100 m^3 in both rivers (Fig. 5). Brusven (1970) also noted that many stoneflies that were abundant in the benthos were poorly represented and in low numbers in the drift. It is questionable whether peaks shown graphically are meaningful at these low levels; the suggested peaks for *Isoperla fulva, Pteronarcella badia* and *Zapada cinctipes* in the Gunnison River (Fig. 6a) correspond with their expected emergence, and they occurred at very low benthic densities (Fuller & Stewart 1977). The two suggested peaks for *Isoperla fulva* in the Dolores River (Fig. 6b) are probably artifacts, resulting from such low densities and/or difficulty in identifying early instars of newly recruited nymphs in October. The suggested May peak for *P. badia* in the Dolores River corresponds with expected emergence. Large perlids in these rivers, such as *Claassenia* and *Hesperoperla* would not be expected to display appreciable catastrophic drift due to their clinging and swimming ability in relatively strong currents. This might also be true for *Isoperla* and other perlodids, and heptageniid mayflies previously discussed. Detritivores such as *Zapada* and *Pteronarcella* are cryptic, reside in slow currents and have strong clinging ability, enabling them to resist accidental dislodgement into, and retention in, the water column for any appreciable time or distance. This clinging ability of stoneflies and the fact that our samples rested 10 cm above the substratum and had slick intake cylinders to which stoneflies and mayflies could not cling, would indicate that numbers sampled are probably an accurate reflection of a real propensity to drift, considering upstream species abundance (Waters 1969; Lehmkuhl & Anderson 1972).

Three major drift peaks were evident in May, June and August 1975 for Chloroperlidae nymphs in the Gunnison River. This is in spite of the fact that nymphs of these species, representing the genera *Suwallia, Sweltza* and *Triznaka* were indistinguishable at the time

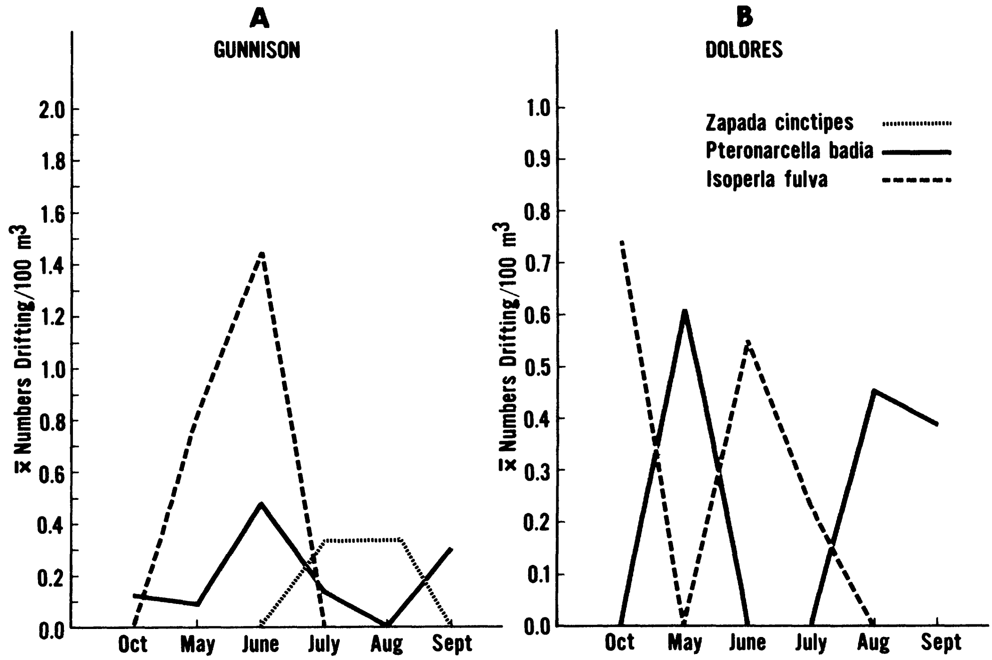

Fig. 5. Drift densities of *Zapada cinctipes, Pteronarcella badia* and *Isoperla fulva* in the Dolores and Gunnison Rivers, Colorado, October 1974 - September 1975.

of sample sorting. These peaks correspond to the relative benthic abundance data of Fuller and Stewart (1977). The peaks probably represent a correlation between relatively high drift rates and emergence of species in these genera. Drift densities of 16-26/100 m^3 during these peaks are relatively high for stoneflies, and a marked nocturnal periodicity is indicated, when compared with noon, late afternoon and early morning densities (Fig. 6). The much lower drift densities of chloroperlids in the Dolores River (Fig. 6) were expected, since their benthic densities were lower than in the Gunnison River during the study (Fuller & Stewart 1977, 1979). Higher densities of up to 8/100 m^3 were evident in May in the Dolores River drift (Fig. 6).

Sizes of Nymphs Drifting — Propensity of *Baetis* sp. to drift increased with seasonal size increase in both rivers from October, 1974, to June-July 1975 (Fig. 3). Largest hcw in May, June preceeded emergence of winter generations. Another peak in hcw of both species occurred in August in the Gunnison River, and in the Dolores River in September. These data generally correspond with the life cycle of *B. bicaudatus*, discussed by Pearson and Kramer (1972). Hunt (1965), Anderson and Lehmkuhl (1968), Waters (1972) and Allan (1978) have advanced the hypothesis that larger taxa or growth stages are more subject to predation by sight-feeding predators, and therefore may have adapted to nocturnal drift patterns. A corollary of this would assume that those species with propensities for diurnal drifting would do so in predominantly small size classes. Allan (1978) showed that nocturnal drift exceeded diurnal drift in *Baetis bicaudatus* in nearby Cement Creek, Colorado. There, *B. bicaudatus* is bivoltine; thus, a spectrum of size classes is available to drift during mid-late summer. He found that small nymphs of *B. bicaudatus* were disproportionately more abundant in the daytime drift, compared to nighttime, especially in July and September.

The disparity in total daytime vs. nighttime samples in this study, and low numbers of some species drifting, do not enable us to adequately compare sizes between day and night drifters. However, there is some indication that larger *Baetis* drifted at some nighttime

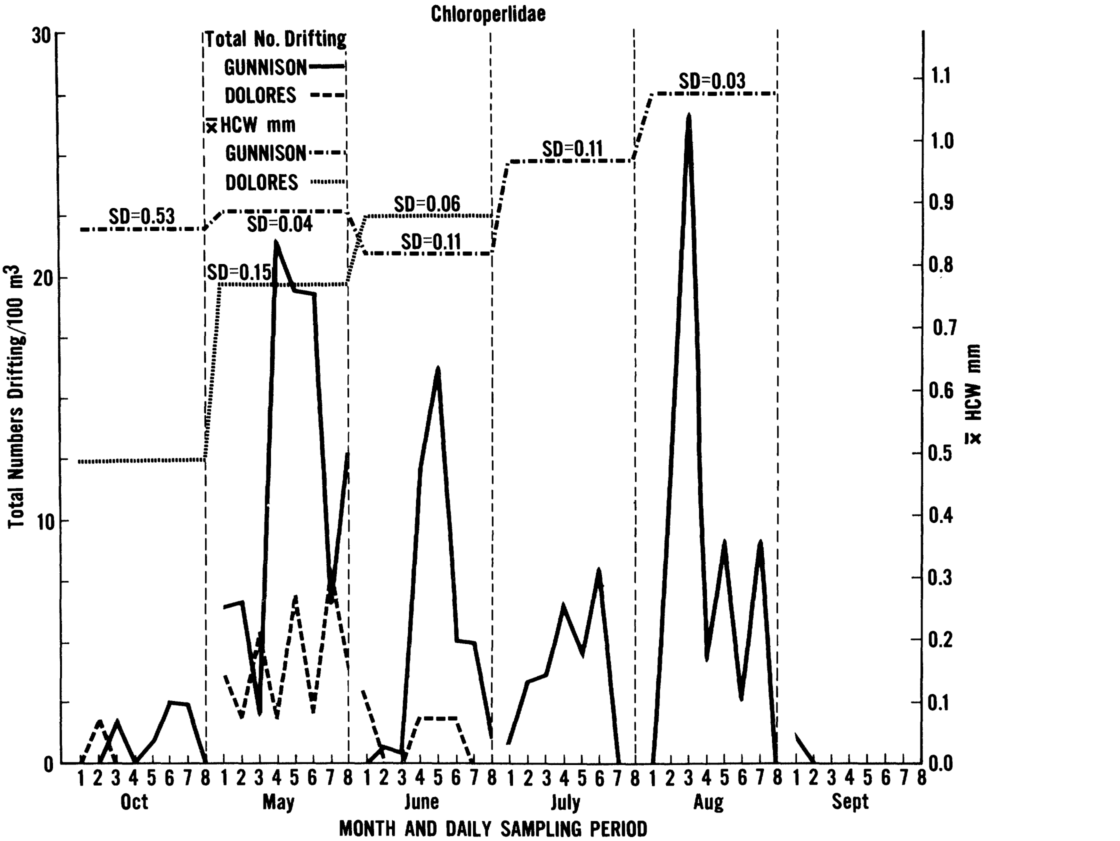

Fig. 6. Drift densities and mean head capsule widths of drifting Chloroperlidae larvae in the Dolores and Gunnison Rivers, Colorado, October 1974 - September 1975. Daily sampling period numbers are outlined in Materials and Methods.

period(s) rather than during adjacent pre-sunset, post-dawn or noon periods, and that there was considerable variation in sizes drifting at different nighttime periods (Fig. 7). These differences in the Gunnison River in October 1974, and May-July, 1975, were generally insignificant in light of large standard deviations, except in August 1975, when larger 3-tailed species drifted during post-sunset hours (Fig. 7). This could mean that for 3-tailed univoltine *Baetis* species, the pressure of sight-feeding by fishes on sizes of nymphs drifting may be important only after large numbers in the population reach some minimum size threshold (Fig. 3).

In the Dolores River, larger *Baetis* nymphs drifted at night than in the daytime periods sampled in May and June, for pooled 2- and 3-tailed species, and in September for 2-tailed species (Fig. 7b). These times correspond well with months when large numbers of the bivoltine 2-tailed *Baetis* (Allan 1978) reached larger nymphal sizes (Fig. 3), further suggesting the possibility that larger nymphs drift predominantly at night after reaching some minimal size threshold that might increase their risk or vulnerability to sightfeeding fishes. If food habits and food electivity may be influenced in some way by stage of development (Fuller & Stewart 1977, 1979), then it seems plausible to us that developmental stage could also influence the propensity of different sizes of a species to drift behaviorally during different diel periods.

Drift densities of other mayflies and stoneflies in the two rivers were too low to discern any differences in sizes of individuals drifting at the different daytime or nighttime

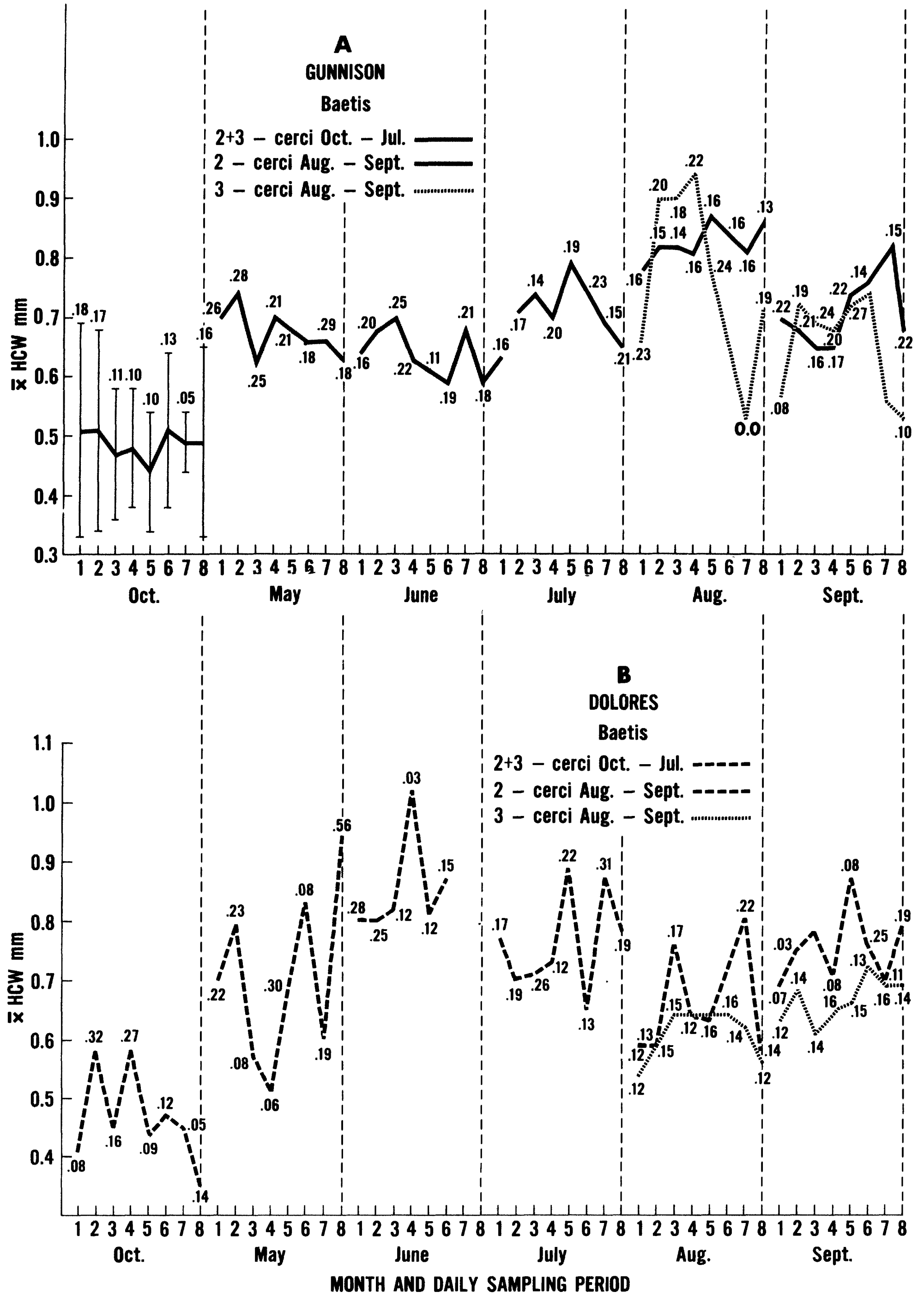

Fig. 7. Mean head capsule widths of drifting *Baetis* at different daily time periods in the Dolores and Gunnison Rivers, Colorado, October 1974 - September 1975. Daily sampling period numbers are outlined in Materials and Methods and numbers at data points represent ±SD.

periods. The mean hcw of the mayflies *Epeorus longimanus* (1.45 mm August, September 1975) and *Cinygmula* sp. (1.21 mm, July) in the Dolores River, and *Rhithrogena* sp. (2.60 mm, May) in the Gunnison River, corresponded with peak drift densities in those months and emergence, suggesting that these species drift at greatest densities during preemergent instars. However, the *Rhithrogena* drifting in the Dolores River peaked in May, with mean hcw of 1.59 mm, before attaining pre-emergent size in June and July at 2.20 and 1.80 mm mean hcw, respectively.

Pooled Chloroperlidae species generally showed a progression of hcw from October 1974 - August 1975 in the Gunnison River, and October-June in the Dolores River (Fig. 6). The relatively larger numbers drifting during May, June and August in the Gunnison River were large nymphs, suggesting a relationship between drift rates and emergence of probably three or more different species.

Water Temperature There was considerable daily temperature fluctuation in both rivers on each sampling date (Fig. 8). Lows and highs generally occurred at sunrise and pre-sunset, respectively, with a gradual decline throughout the night (Fig. 8). This is an expected pattern during ice-free months in wide, open-canopied western rivers that receive solor radiation by day and experience heat dissipation during cool nights. In October, 1974, the daily temperature difference was 8.5 °C in the Dolores River (Fig. 8).

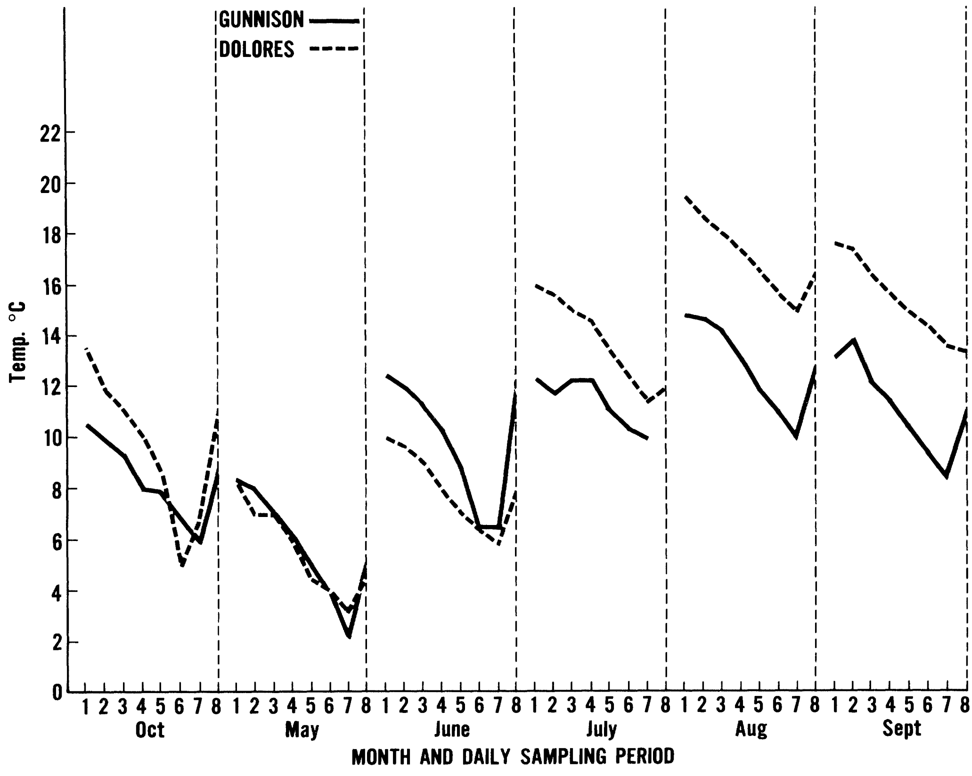

Fig. 8. Water temperatures on sampling dates in the Dolores and Gunnison Rivers, Colorado, October 1974 September 1975.

Comparison of Figures 2, 6, 7, and 8 indicates no clear correlation of peak drift densities or sizes of insects drifting, with thermal patterns.

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