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SEASONAL FLUCTUATIONS OF MACROINVERTEBRATE DRIFT IN A SOUTH CAROLINA PIEDMONT STREAM

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Abstract

The seasonal fluctuations of larval macroinvertebrate drift, exuvial drift and larval benthic density were quantitatively examined over a 1-year period in a fourth order, spring-fed stream in the Piedmont area of South Carolina. The drift was dominated by the mayfly *Baetis* spp. and by two species of blackfly *(Prosimulium mixtum* and *Simulium jenningsi).* Peak drift densities were noted during early spring and especially late summer. Strong correlations were noted between larval drift densities and exuvial drift, indicating a relationship between drift and seasonal growth and emergence patterns. Seasonal trends in drift and benthic densities, though less strongly correlated, were also generally similar.

Introduction

Investigations of macroinvertebrate drift have, in general, emphasized community productivity (e.g. Needham, 1928; Hynes, 1961; Waters, 1962a, 1965, 1969; Pearson & Kramer, 1972) or community dynamics (e.g. Clifford, 1966; Elliott, 1967, 1969, 1971; Kroger, 1974). Superimposed upon these two concepts are investigations of drift as an active versus a passive phenomenon controlled by endogenous, exogenous or composite rhythms (Elliott, 1965; Waters, 1965; Chaston, 1968; Larimore, 1972). Excellent reviews of the many factors that influence these rhythms have been presented by Hynes (1970), Waters (1972) and Müller (1974).

The exact influence of benthic density on drift density is as yet unknown, there being evidence for both a density independent and a density dependent relationship. However, Waters (1972) notes that direct relationships between benthic and drift densities have generally not been found.

The composition of macroinvertebrate drift, with respect to both species and number of individuals, has frequently been observed to exhibit seasonal fluctuations and a diel periodicity. These fluctuations may be closely related to prepupation and emergence activities (Waters, 1969; Reissen & Prins, 1972; Cloud & Stewart, 1974; Kroger, 1974). Müller (1974) cited examples of drift being related to breeding activity. Larger organisms (Anderson, 1967) and later instars (Waters, 1969) have been noted as more frequent components of macroinvertebrate drift. In addition, several investigators have reported periods of maximum drift coinciding with periods of maximum growth (Elliott, 1967; Cloud & Stewart, 1974; Otto, 1974). These observations suggest a close relationship between the various stages in the life cycles of macroinvertebrates and their presence in stream drift.

The emphasis of this presentation is on the seasonal fluctuations of the drift of macroinvertebrates in a small, spring-fed stream in the Piedmont area of South Carolina. The absence of precipitation during the monthly sampling periods permitted the examination of these fluctuations without the complications that arise from catastrophic drift.

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Methods

Site Description

This study was conducted on Long Branch Creek, a soft-water, fourth order, spring-fed stream in York County, South Carolina, in the 'Piedmont' province. The stream flows through an area of mixed alluvial deposits that support an immature flood plain forest dominated by *Liriodendron tulipifera* L., *Fagus grandifolia* Ehrh., *Acer rubrum* L., and *Cornus florida* L. A 1 to 2-meter zone along the steep mud banks of the stream is composed of *Kalmia latifolia* L. and *Leucothe editorum* Fern & Schub.

The stream bed was approximately 5 meters wide with a cobble-gravel substrate. During the entire sampling period (April 1975-February 1976) pH ranged from 6.5 to 6.9, alkalinity ranged from 8 to 25 mg/l, temperature ranged from 5 to 17 degrees C, and daytime dissolved oxygen levels were generally at saturation. Stream depth averaged 0.3 meters in the reaches with pools attaining depths up to 1.5 meters. Flow, measured with a Pygmy Gurly meter, ranged from 0.43 m^3 sec^{-1} in February to 1.15 m^3 sec^{-1} in May, but averaged 0.62 m^3 sec^{-1} throughout most of the sampling periods.

Two sampling stations, 50 meters apart, were established in the stream. Three rectangular drift nets (pore size 363 microns) were set in a transect across the stream at each of the stations during each sampling period. The nets were placed on the stream bottom immediately below a riffle area and emptied four times over a 24-hour period. Backwashing of the nets was not a problem. Samples were collected at the predetermined intervals of 'day,' 'dusk,' 'dark,' and 'dawn.' The 'dusk' and 'dawn' intervals each ran 4 hours during the periods of sunset and sunrise, respectively. The 'day' and 'night' intervals each included approximately 6 hours between the 'dusk' and 'dawn' intervals. Samples were collected 10 times over a 12-month period. Stream current velocity and depth were recorded for each drift net during the diel collection period. No samples were taken during or immediately following a period of heavy rainfall that could have induced catastrophic drift. Water depth never exceeded the tops of the drift nets; hence the entire water column above the substrate was sampled.

Twelve benthic samples were taken with a standard Square-foot Surber Sampler at monthly intervals corresponding to the drift sample collections. Estimates of benthic macroinvertebrate density and community composition were made from these samples.

All macroinvertebrates and exuviae were removed from the drift and Surber nets and preserved in 70 percent ethyl alcohol. The number of individuals and exuviae collected with the drift nets are presented as an average of six nets per unit volume of water sampled. The numbers of individuals collected with the Surber Sampler are presented as an average of 12 samples per square meter.

Results and discussion

Seasonal Fluctuations In Total Drift

Estimates of macroinvertebrate and exuvial drift densities, collected over a 24-hour period, and estimates of benthic community density are presented on a monthly basis in Figure 1. Drift densities of larval organisms were relatively constant throughout the year. Peaks were noted during August to October and in February. The drift densities ranged from 20 individuals per 100 m^3 in January to 160 individuals per 100 m^3 in February.

Peaks in larval drift density during similar time periods have been noted in other studies of South Carolina streams and rivers. Wingo & Coleman (1977) found that peaks in drift occurred during the fall and spring in the Broad River, a much larger body of water than Long Branch Creek. Two general peaks in biomass drift occurred during March through May and from August to October in a stream similar to Long Branch Creek (Reissen & Prins, 1972). The seasonal drift patterns observed in that study and in Long Branch Creek were quite similar, the variations noted possibly being due to the different methods of expressing the data. Unfortunately, it was not possible to recalculate their results as number of organisms per unit volume of water.

The majority of the drift studies conducted in more northerly areas of the temperate zone indicate that maximum drift density occurs during the summer months (Waters, 1969). The studies noted for South Carolina, a more southerly area of the temperate zone, indicate that maximum drift density occurs during the spring and fall. An investigation of macroinvertebrate drift in subtropical Florida indicated peaks in drift density during the winter and early spring (Cowell & Carew, 1976). These peaks in drift density generally correspond to periods of rapid growth, prepupation events and emergence activities for the given areas. A direct relationship between these activities and seasonal fluctuations in drift density often becomes apparent when variations in drift due to events such as rainfall and moon phase are eliminated. The

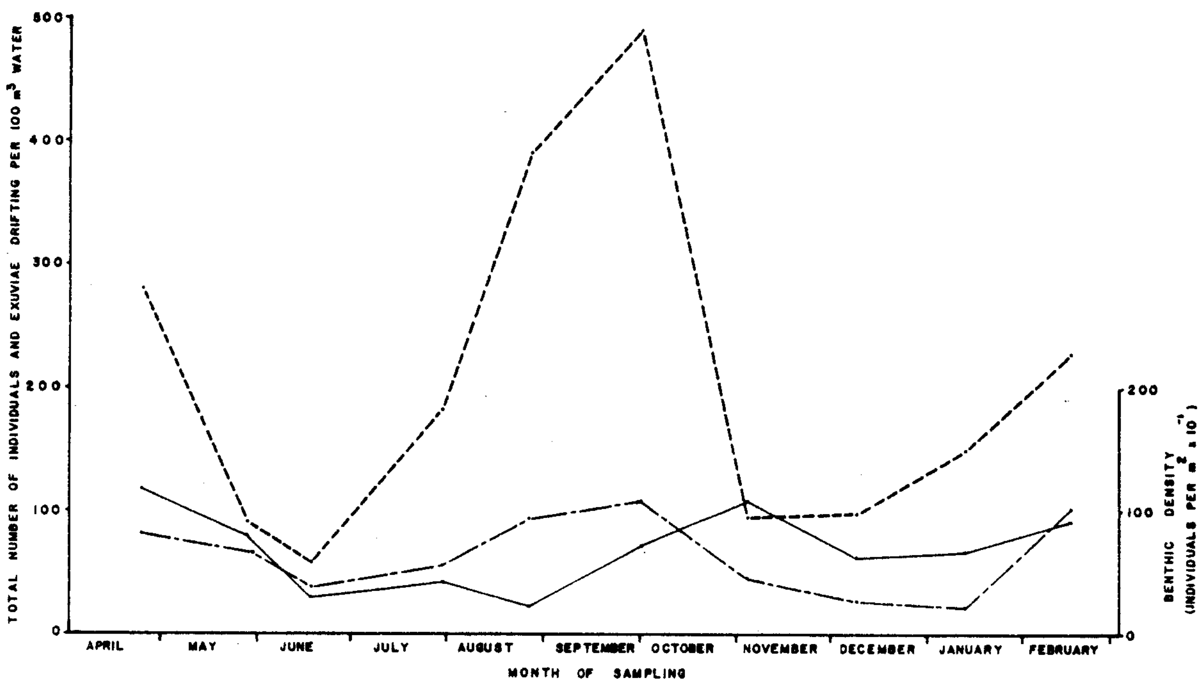

Fig. 1. Seasonal Fluctuations of the Drift and Benthic Densities of the Benthic Macroinvertebrate Community.

Drifting Larvae
Drifting Exuviae
Benthic Density

existence of this relationship has been postulated by other investigators (Waters, 1969; Reissen & Prins, 1972; Cloud & Stewart, 1974; Kroger, 1974; Otto, 1974, 1976; Cowell & Carew, 1976). The observation that no distinct seasonal pattern in drift density occurs in tropical areas (Bishop, 1973; Hynes, 1975), where growth and emergence patterns are subject to less marked seasonal changes, lends further support to this hypothesis.

Exuvial drift densities were frequently considerably higher than the larval drift densities. The abundance of exuviae in the drift has been previously reported. Ide (1942), for example, noted that exuviae comprised 56 percent of the stream drift by volume. Our data indicate distinct seasonal pulses in exuvial drift densities, ranging from a low in June of 50 exuviae per 100 m^3 to a late September high of 490 exuviae per 100 m^3. Peaks in exuviae occurred in late summer (August-September) and in winter-early spring (February through April). These seasonal fluctuations corresponded to the fluctuations observed in larval drift density. Hynes (1975) also noted high numbers of exuviae during peaks of larval drift.

The seasonal trends in drift density also appear to approximate benthic density, with the exception of the November data. The inverse relationship observed during November is attributable to an increase in the benthic density of two Ephemeroptera, specifically *Stenonema annexum* and *S. rubrum*. However, larval drift density was more closely correlated with the number of exuviae collected ($r = 0.62$) than with larval benthic density ($r = 0.24$). If periods of rapid larval growth and adult emergence are reflected by seasonal variations in the number of exuviae present in a stream, then our data further support the hypothesis that larval drift increases during periods of rapid growth and emergence.

The February peak in larval drift is of further interest, not only because it corresponded to peaks in benthic and exuvial drift density, but because it may reflect the absence of the depressent effect of moonlight on macroinvertebrate activity (Anderson, 1966). The effect of moonlight on macroinvertebrate activity can best be assessed in streams flowing through decidious forests in temperate regions, during the winter months when the forest canopy is open. February was the only winter month that samples were collected in the absence of moonlight. A comparison of the February samples with those collected during other winter months when there was moonlight may at least partially reflect the absence of the depressant effect of moonlight. This speculation merely emphasizes that macroinvertebrate drift is influenced by a myriad of interactive factors, most of which cannot presently be accurately measured or indeed have yet to be recognized.

Fluctuations In The Drift of Predominant Orders and Taxa

The Diptera and Ephemeroptera were, on a percentage basis, the most important orders of drifting organisms collected. The fluctuations in the seasonal pattern of total drift (Fig. 1) were primarily the result of variations in the drift of organisms in these two orders. The seasonal drift patterns and estimates of benthic densities of the predominant insect orders are presented in Figure 2. These data, and general observations on the diel periodicity of drift, are discussed below.

Diptera

The Diptera were the most abundant group collected in the drift samples. Two seasonal pulses in larval drift were observed, a winter-early spring peak extending from February through May, and a summer-fall peak extending from July through September. There were two corresponding peaks in the drift density of exuviae, the maximum occurring in late September. The densities of drift-

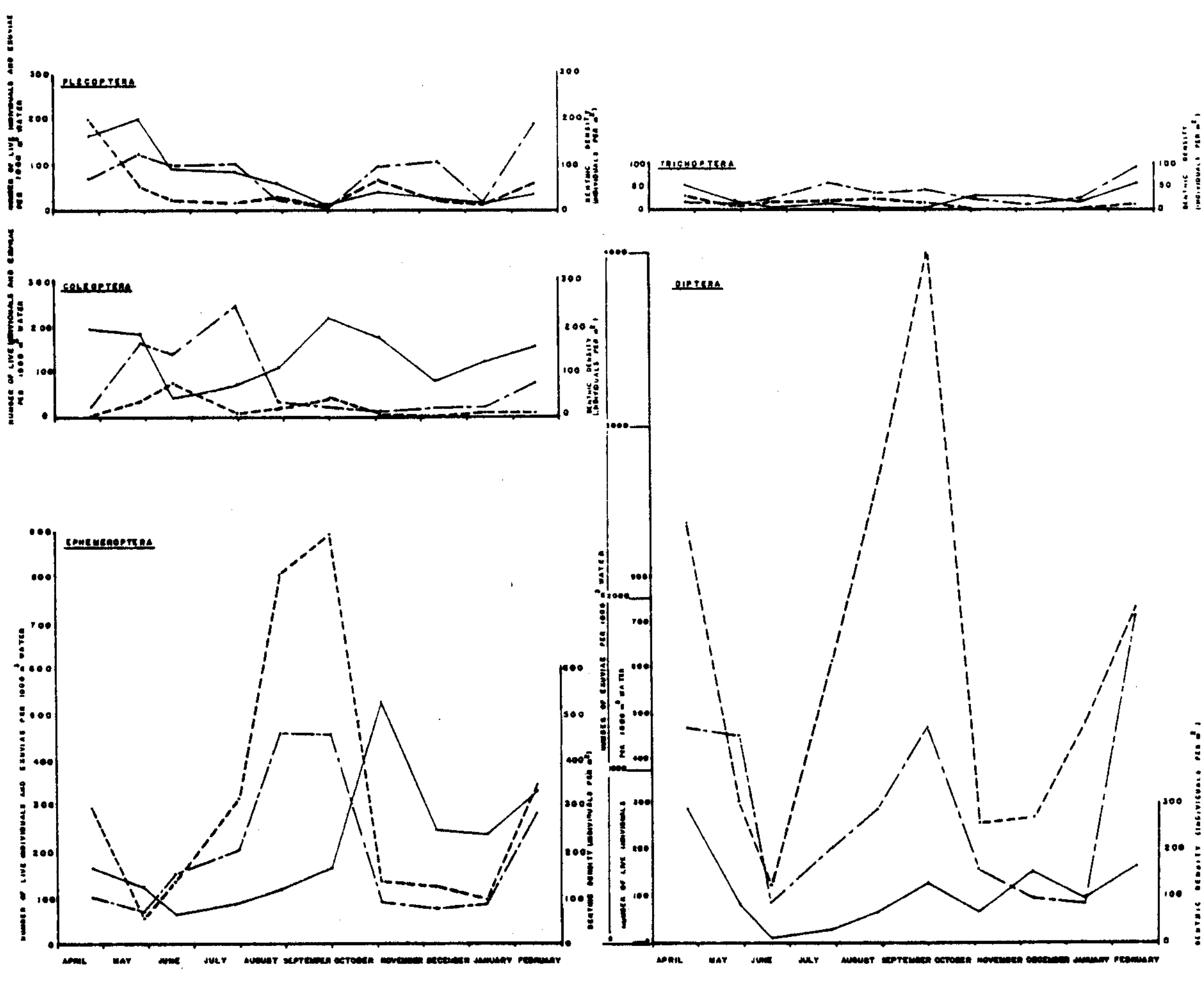

Fig. 2. Seasonal Fluctuations of the Drift and Benthic Densities of the Dominant Orders.
Drifting Larvae ————————————
Drifting Exuviae — — — — — — — — — —
Benthic Density ————————————

ing larvae were only moderately correlated with the number of exuviae (r = 0.55) and with benthic density (r = 0.50).

Individuals of *Dixa* sp. and two species of Simuliidae dominated the dipteran drift. The importance of the Simuliidae as a component of macroinvertebrate drift has been noted by other investigators (Dendy, 1944; Waters, 1969, 1972; Hynes, 1970; Reissen & Prins, 1972; Cowell & Carew, 1976). Two peaks in Simuliidae drift density, corresponding to the presence of two species, were observed (Fig. 3). The February through May peak was due primarily to *Prosimulium mixtum,* drifting at a density of over 300 individuals per 1000 m^3 of water. A lower peak, due primarily to *Simulium jenningsi,* was observed during a period extending from July to October.

A surprisingly high number of *Dixa* sp. were collected in the drift samples. Two peaks in drift density were observed, one in the summer and one in the winter (Fig. 3). It is unknown if these peaks represent bivoltinism or bimodal activity patterns of a single species, or if two species of this genus were present. Waters (1962b) observed a significant number of *Dixa* in drift samples, noting that their habits of moving about at the water's edge and in the surface film makes them highly susceptible to downstream movement. Benthic densities were low and fluctuated only slightly. However, use of a Surber sampler probably was inadequate for estimating benthic densities of *Dixa* given their preferred habitats. Elliott & Tullett (1977) found that most of the drifting *Dixa* larvae were fourth (final) instars. Seasonal peaks occurred when adults and pupae were present and when the larvae were searching for suitable prepupation sites.

Individuals in the family Chironomidae have been noted as an important and frequently abundant component of dipteran drift (Waters, 1969). Many species of this family were collected in our samples over the year, but only a few taxa were numerically important. Peaks in drift density were observed during August through September and again during February through April. These

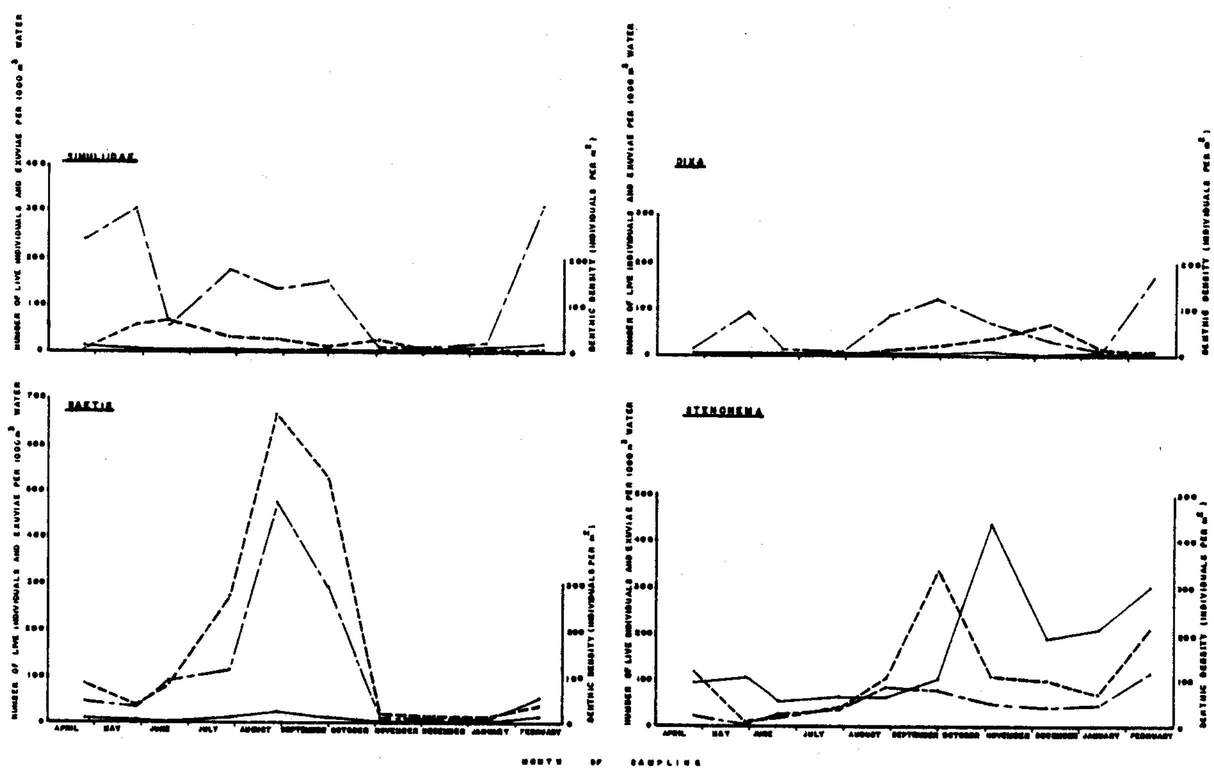

Fig. 3. Seasonal Fluctuations of the Drift and Benthic Densities of the Four Major Taxa.
Drifting Larvae ————————
Drifting Exuviae – – – – – – – –
Benthic Density ————————

peaks in the drift of the larvae corresponded to peak periods of emergence. Several species of *Eukiefferiella* were the most common drifting midge larvae, maximum density occurring in September (65 individuals per 1000 m^3). The winter drift peak was dominated by *Tanytarsus* spp.

Some question exists as to which dipterans exhibit diel drift periodicities. Anderson & Lehmkuhl (1968) observed a general absence of dipteran drift periodicity. The Simuliidae have been found to be predominately active at night with respect to drift (Waters, 1969), but Clifford (1972), Reissen & Prins (1972) and Hynes (1975) found no distinct differences between day and night drift for this family. The Chironomidae usually do not exhibit diel periodicities in drift activity (Waters, 1969; Clifford, 1972; Kroger, 1974). In this study, however, a distinct, nocturnal drift periodicity was found for the Simuliidae, Dixidae and Chironomidae, the periodicity of the latter, however, being the least pronounced.

Ephemeroptera

The mayflies exhibited a marked increase in drift density from a May minimum (48 nymphs per 1000 m^3) to an August and September maximum (456 and 452 nymphs per 1000 m^3, respectively) (Fig. 2). A second, lesser peak in drift occurred during February. The drift density of the exuviae followed a similar trend; the correlation between the drift density of nymphs and exuviae was strong ($r = 0.96$). Benthic density did not fluctuate with drift density ($r = -0.27$), exhibiting a summer low and a winter high, noting again the November peak due mainly to species of *Stenonema*.

Nymphs of the genera *Baetis* and *Stenonema* were the most abundant Ephemeroptera collected in the drift. Individuals of many species of *Baetis* have often been shown to be an important component of macroinvertebrate drift (Dendy, 1941; Waters, 1964; Bishop & Hynes, 1969; Clifford, 1972; Bishop, 1973; Cowell & Carew, 1976). In this study *Baetis* accounted for 51 percent of the total number of mayflies collected. Peak densities of drifting *Baetis* spp. nymphs and exuviae occurred during August (Fig. 3). Waters (1962b) noted that *B. vagans* exhibited maximum drift densities in August, with lesser peaks during February and May. In Florida, drift peaks of *B. intercalaris* occurred at 2 to 3-month intervals, possibly reflecting activity of different cohorts (Cowell & Carew, 1976). In Long Branch Creek the period of maximum drift corresponded with the maximum density of the benthic population. Seasonal trends in the drift density of *Baetis* were correlated with the number of exuviae ($r = 0.99$) and benthic density ($k = 0.81$). Other researchers have also found drift and benthic density of *Baetis* fluctuating together (Reissen & Prins, 1972; Cowell & Carew, 1976).

Individuals of the various species of *Stenonema* exhibited a summer and a winter peak in drift density (Fig. 3). The summer peak was due primarily to *Stenonema (Stenacron) interpunctatum*. The winter peak resulted from increases in the drift of *S. rubrum* and *S. annexum*. Cowell & Carew (1976) found *S. (S.) interpunctatum* drift peaks coinciding with *Baetis* spp. peaks and noted emergences in March, April and September. They also found a positive relationship between the benthic density of *Stenonema* and drift peaks.

Other mayflies were also present in the drift, but in generally low numbers. Nymphs of the genus *Ephemerella*, primarily *E. temporalis*, were found to drift throughout the year; the maximum drift density occurred during February (33 individuals per 1000 m^3). Nymphs of *Isonychia* spp. and *Habrophlebia vibrans* were also present in all of the monthly drift samples. Peaks in the drift density of *H. vibrans* occurred during June and February, both at 39 individuals per 1000 m^3. *Isonychia* spp. nymphs reached their maximum during the late summer. A few nymphs of *Baetisca carolina*, *Hexagenia munda* and *Ephemera blanda* were present in the summer drift collections. Nymphs of *Leptophlebia* spp. were found only from November through February.

Day time drift densities were relatively constant throughout the year, ranging from 2 to 28 individuals per 1000 m^3 of water, and represented only a minor contribution to the overall increase in the total daily drift observed during the summer. The summer increase, therefore, represented a much higher number of individuals drifting during the hours of darkness. No trends in the diel periodicity of exuviae was observed; there were frequently no significant differences between their densities at different times of the day.

Coleoptera

Drift activity of larval Coleoptera occurred primarily in the summer, peak activity being noted from May through July. Maximum drift of 242 individuals per 1000 m^3 occurred in July. The peak in drift density coincided with a decrease in the benthic population density. The peak in larval drift corresponded to a peak in exuviae drift density. Following the July peak, the drift density declined and the benthic density increased. The most numerous larvae were *Promoresia tardella*, *Ectoparia nervosa* and

Psephenus herricki. The majority of the Coleoptera in the drift samples were collected during the hours of darkness; hence, drift activity was decidedly nocturnal.

Plecoptera

Seasonal fluctuations in the drift of stoneflies was especially affected by life history patterns of the dominant species. A weak relationship was found between benthic density and drift activity ($r = 0.33$). Drift was almost exclusively nocturnal, a pattern noted for stoneflies by most observers (Waters, 1969).

During the spring and early summer months *Peltoperla* sp. and *Leutra* spp. were the dominant drifting nymphs. Maximum drift density of *Peltoperla* occurred in June (70 individuals per 1000 m^3). Thereafter, very few specimens of this genus were present in the drift. The drift density of *Peltoperla* exuviae peaked in the April collections, reflecting a period of rapid growth prior to emergence. *Leuctra* spp. exhibited drift density peaks during May, July and November, the latter month being the period of maximum density (89 individuals per 100 m^3). Reissen & Prins (1972) found March, May and September peaks for *Leuctra,* the latter being associated with emergence.

The December peak in drift density was due to the abrupt appearance of *Braychyptera (Strophopteryx) fasciatus,* the only month that this species was present in the drift collections. The observation that the Brachypterinae tend to resist drifting (Madsen, 1969) indicates that the drift peak for this species was due to movement prior to emergence.

Nemoura nigritta was present in the drift samples collected from December through April. The highest drift density was observed in February (138 individuals per 1000 m^3). Individuals of *Hastaperla* and *Acroneuria* (including *A. abnormis, A. georgiana* and *A. (Eccoptura) xanthenes)* were sporadically present in the drift throughout the year. *Paraperla* spp. and *Isoperla* spp. were collected as drift in low numbers only during April and May.

Trichoptera

The caddisflies generally drifted in low numbers. Although 17 taxa of Trichoptera were collected in the drift samples, only *Cheumatopsyche* spp. occurred in all of the monthly drift samples in numbers large enough to be discussed with any confidence. The total caddisfly drift (Fig. 2) was due mainly to this genus, except that during July *Diplectrona modesta* was common. The February peak was composed of *Cheumatopsyche* spp., *Lepidostoma* spp., *Lype* sp. and *Polycentropus* sp. February was the only month during which the latter three genera were common in the drift samples. As in this study, maximum drift of *Cheumatopsyche* spp. has usually been found to occur during the summer months and is probably associated with prepupation activity (Cloud & Stewart, 1974; Cowell & Carew, 1976). The relatively few exuviae that were collected in the drift showed a peak that coincided with the summer larval drift maximum. Drift activity exhibited a low correlation ($r = 0.33$) with benthic density. The Trichoptera were predominantly nocturnal with respect to drift activity.

Summary

The aquatic insect fauna in a fourth order, spring-fed stream, in the 'Piedmont' province of South Carolina, was quantitatively sampled from April 1975 through February 1976. Water temperature ranged from 5 degrees C to 17 degrees C, pH varied from 6.5 to 6.9, alkalinity ranged from 8 to 25 mg/l, and day time dissolved oxygen levels were generally at saturation. Flow ranged from 0.43 m^3 sec^{-1} in February to 1.15 m^3 sec^{-1} in May, but averaged 0.62 m^3 sec^{-1} during most of the sampling periods.

Emphasis in this study was placed on an examination of the seasonal periodicity of larval and exuvial drift and larval benthic density. Concurrent sampling with drift nets (24 hr.) and a standard Surber Sampler permitted an examination of the hypothesized relationships among larval drift, larval growth (as reflected by exuvial drift) and larval benthic density. The absence of rainfall during the sampling periods resulted in data sets that were not complicated by catastrophic drift.

Larval drift densities were relatively constant throughout the year, ranging from 20 to 160 individuals per 100 m^3 water. Peaks were noted during early spring and late summer. Seasonal fluctuations in the drift were primarily due to variations in the drift of Ephemeroptera and Diptera, especially *Baetis* spp. and the blackflies *Prosimulium mixtum* and *Simulium jenningsi.*

Exuvial drift densities were usually considerably higher than larval drift densities, ranging up to a late September high of 490 exuviae per 100 m^3 water. Seasonal fluctuations in the abundance of exuviae in the drift were strongly correlated with the fluctuations observed in larval drift density, indicating that a relationship exists between drift and seasonal growth and emergence patterns. Trends in

seasonal drift and benthic densities were also generally similar, although less strongly correlated than were drift and exuvial densities.

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