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Insect Drift in Condor Creek, Australian Capital Territory

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Abstract

Samples of benthos and drift were taken in the same locality in March, April, June and July 1978. Most species appeared in both benthos and drift. The benthos was dominated by *Atalophlebioides* sp. (Ephemeroptera) and *Helicopsyche* sp. (Trichoptera) in April and June, plus Glossosomatinae (Trichoptera) in July. The principal taxa occurring in the drift were Leptoceridae sp. 1 (27%), *Atalophlebioides* sp. (15%), Chironomidae pupae (8%), Leptoceridae sp. 2 (6%) and Chironomidae larvae (5·4%). A major spate in May caused changes in the proportions of the benthic and drifting fauna, probably due to the differential effect of scouring on different behavioural strategies.

Drift rate varied temporally (nocturnal maximum) and with creek discharge. High numbers of caseless larvae of some Trichoptera in the nocturnal drift are believed to be indicative of case-building activity. Incidental evidence is provided to support the hypothesis of previous authors that moonlight depresses drift rates. Mean diel drift rates for 24 taxa are given. Ephemeroptera and Trichoptera were more prevalent at night and Chironomidae pupae during the day. The Ephemeroptera larvae drifting during the day were, on average, smaller than those drifting at night.

Introduction

Downstream drift of insects in lotic systems is a well-documented and ubiquitous event (e.g. Elliott 1967; Bishop and Hynes 1969; Waters 1972; Muller 1974), however, its full significance in their life histories and behavioural strategies remains unclear and many features require resolution.

Little work on drift has been done in Australian streams (see Morrissy 1967; Cadwallader and Eden 1977; Suter and Williams 1977). The present paper documents an investigation of drift in a small mountain stream in the Australian Capital Territory. The aim was to determine composition and magnitude of drift and its relationship to the benthic fauna, and to describe certain features of diel periodicity.

Materials and Methods

The investigation was based on Condor Creek, a small tributary of the Cotter River, A.C.T. It is fed by a number of small semipermanent creeks over an area of 100 ha, at an elevation of 1036–1066 m. Creek width ranges from 2·0 m across riffle areas to 5·0 m across pools during non-flood periods. Due to rapid runoff, spates and subsequent scouring occur quickly. Stream bottom type is fairly constant; the predominant type is large boulders and stones. Areas of sheet rock break the surface in places and produce narrow channels with rapid flow. Small areas of pebbles and gravel are moderately common.

The sampling site was midway along a 75-m straight run between two riffle areas, about 6 km from the creek source. The stream bottom at this location consisted of cobbles and pebbles interspersed with a few large boulders [particle size according to Cummins (1962)].

The surface and tunnel samplers were constructed after Elliott (1967), enabling both surface and deeper water to be sampled. Nets were emptied every hour over a 24-h period. The sampling efficiency of both types of drift nets was tested (Elliott 1970) and found to not decrease significantly over 24 h. Samples were taken on 24 and 25 March, 24 and 25 April, and 9 and 10 June 1978, each sampling period starting at 1200 h. Bottom samples were taken with a Surber sampler (Surber 1937) which sampled an area of 900 cm^2. Five equally spaced bottom samples were taken in a 45° diagonal transect from bank to bank 1·0 m upstream from the sampling site. Benthos samples were taken at 1500 h on 25 April, 10 June, and 1 July 1978. Both the drift and bottom samples were stored in 80% (v/v) alcohol and hand-sorted in the laboratory prior to further analysis. Water velocity, air and water temperatures, and illumination were measured every hour concurrently with drift sampling (Table 1). Velocity was measured at a depth of 5 cm using a digital meter (digital flow meter—General Oceanics Inc., Florida, U.S.A.). Temperatures were measured with a maximum/minimum mercury thermometer. Illumination was measured at the water surface using a digital photometer (J16 digital photometer with J6501 probe—Tektronix Inc., Oregon, U.S.A.).

Table 1. Physical characteristics of the study site on Condor Creek, A.C.T., at sampling times from January to July 1978

Sampling date	Velocity ($cm\ s^{-1}$)	Width (cm)	Depth (cm)	Discharge ($l\ h^{-1}$)	Water Temp. (°C)	Benthos density (No. m^{-2})	Total monthly rainfall (mm)
—.i.1978	—	—	—	—	—	—	151·2
—.ii.1978	—	—	—	—	—	—	0
24–25.iii.1978	26±4·06	365·0	29·85±5·49	$8\cdot17\times10^5$	14·0–17·0	—	116·6
24–25.iv.1978	16±2·17	365·75	19·80±4·46	$3\cdot34\times10^5$	9·8–11·2	617·0	59·7
22–23.v.1978	>100	>600	>150	$>70\times10^5$	7·9–9·0	—	163·0
9–10.vi.1978	60±4·61	365·75	27·8±4·83	$17\cdot6\times10^5$	6·0–7·5	378·7	21·7
1.vii.1978	97±8·97	365·75	31·5±6·5	$19\cdot0\times10^5$	5·0–6·2	970·5	88·4

Results

Drift Samples

Composition

Table 2 shows the principal taxa present in the drift when sampled in March, April and June 1978. *Atalophlebioides* sp. was the dominant mayfly in all three months. The other common mayfly, *Atalophlebia australis*, was most prominent in March when it comprised 8·2% of the total. Other Ephemeroptera were poorly represented. The trichopteron Leptoceridae sp. 1 was the most abundant insect in the drift. Of particular interest with regard to this species and *Anisocentropus* sp. is the variation between the numbers of cased or caseless individuals on the different sampling dates (Table 3). The Glossosomatinae were a very minor component with the greatest number occurring in the June sample; individuals in all samples were caseless, as found also by Waters (1962). The Tanypodinae and Orthocladiinae were the dominant dipteran groups. In both subfamilies there was a trend for the numbers of individuals to increase from March to April and decline in June. Paralleling the increase of larvae from March to April was an increase in pupal numbers. Pupal numbers, however, increased further during June. The major component within the Coleoptera was the larval and adult stages of Helminthidae. A gradual increase in larval numbers occurred in the drift over the three months, while adult numbers remained relatively constant.

Relative composition of drift and bottom fauna

Table 2 compares drift and bottom fauna samples taken at the same time in April and June. The percentage composition of drift and bottom fauna varied, due mainly to large differences in numbers of individuals present. There were marked differences,

Table 2. Composition of bottom and drift samples from Condor Creek, A.C.T., on 24–25 March, 24–25 April, 9–10 June and 1 July 1978
Composition of bottom samples is given as density

Taxon[A]	24–25.iii.1978		24–25.iv.1978				9–10.vi.1978				1.vii.1978	
	Drift		Bottom		Drift		Bottom		Drift		Bottom	
	(No.)	(%)	(No. m^{-2})	(% m^{-2})	(No.)	(%)	(No. m^{-2})	(% m^{-2})	(No.)	(%)	(No. m^{-2})	(% m^{-2})
Ephemeroptera												
Atalophlebioides sp.	125	12·9	220	35	169	15·0	94·7	24	190	18·1	193·3	19·7
Atalophlebia australis	80	8·2	11	1·8	17	1·58	18·9	4·8	36	3·4	26·5	2·7
Tasmanocoenis sp.	22	2·2	30	4·8	5	0·4	11·4	2·9	28	2·7	56·8	5·8
Coloburiscoides spp.	8	0·8	11	1·8	22	2·0	17·4	4·4	26	2·5	3·8	0·4
Jappa sp.	22	2·2	0	0	6	0·5	0	0	14	1·3	3·8	0·4
Centroptilum spp.	3	0·3	4	0·6	16	1·5	2·6	0·6	1	0·1	0	0
Atalomicria sp.	10	1·0	0	0	2	0·2	0	0	3	0·3	3·8	0·4
Baetidae	18	1·8	0	0	15	1·4	0	0	14	1·4	3·8	0·4
Trichoptera												
Anisocentropus sp.	70	7·1	11·4	1·8	62	5·7	16·2	4·1	28	2·7	83·5	8·5
Hydroptila spp.	4	0·4	7·6	1·2	5	0·4	4·2	1·1	8	0·8	7·6	0·8
Helicopsyche sp.	5	0·5	94·7	15	14	1·3	66·3	16·8	1	0·1	204·7	20·8
Hydropsychinae	9	0·9	15·2	2·4	13	1·2	14·2	3·6	15	1·4	26·5	2·7
Hydrobiosinae	22	2·2	7·6	1·2	24	2·2	5·7	1·4	20	1·9	7·6	0·8
Glossosomatinae	8	0·8	22·7	3·6	11	1·0	24·2	6·1	17	1·6	200·9	20·4
Leptoceridae sp. 1	282	28·8	22·7	3·6	273	25·3	22·7	5·7	293	27·9	83·4	8·5
Leptoceridae sp. 2	81	8·2	34·1	5·4	39	3·6	10·6	2·7	62	5·9	18·9	1·9
Diptera												
Simulium sp.	22	2·2	11·4	1·8	43	4·0	7·2	1·8	8	0·8	7·6	0·8
Tanypodinae	57	5·8	34·1	5·4	68	6·3	29	7·3	53	5·0	7·6	0·8
Orthocladiinae	31	3·2	15·2	2·4	121	11·3	6·8	1·7	15	1·4	3·8	0·4
Chironomidae (pupae)	29	3·0	0	0	79	7·3	0	0	144	13·7	0	0
Coleoptera												
Helminthidae	12	1·2	18·9	3·0	17	1·6	3·8	1·0	19	1·8	3·8	0·4
Helminthidae (adults)	17	1·7	0	0	23	2·1	0	0	14	1·3	0	0
Helodidae	0	0	15·2	2·4	0	0	3·8	1·0	0	0	0	0
Gyrinidae	4	0·4	0	0	2	0·1	0	0	3	0·3	0	0
Psephenidae	9	0·9	7·6	1·2	2	0·1	7·6	1·9	2	0·2	7·6	0·8
Others	32	3·3	36	5·6	23	2·2	28	7·1	36	3·4	25	2·6

[A]Insect larvae unless otherwise indicated.

however, in the occurrence of Leptoceridae sp. 1; *Jappa* sp., Baetidae, Chironomidae pupae and Helminthidae adults occurred in the drift and were absent from benthic samples; and *Helicopsyche* sp. was present in the bottom samples but absent from the drift.

Diel fluctuations in drift numbers

Fig. 1 shows drift rates over the 24-h period sampled in each month and the total number of insects caught. More insects were collected at night than in the day, clear support for the findings of others (e.g. Elliott 1967) and reinforcing the hypothesis that drift is controlled extensively by light.

Table 3. Numbers of cased or caseless individuals of *Anisocentropus* sp. and Leptoceridae sp. 1 in March, April and June drift samples

Sampling date	Species	No. cased	No. caseless	χ^2	P
24–25.iii.1978	Leptoceridae sp. 1	200	82	49·37	<0·001
	Anisocentropus sp.	13	57	27·65	<0·001
24–25.iv.1978	Leptoceridae sp. 1	135	138	0·03	n.s.[A]
	Anisocentropus sp.	7	55	37·16	<0·001
9–10.vi.1978	Leptoceridae sp. 1	123	170	7·54	<0·006
	Anisocentropus sp.	5	24	12·93	<0·001

[A]n.s., not significant.

In relation to the night-time drift activity, the March data show the previously reported (Waters 1962; Elliott 1967) post-sunset, midnight and predawn peaks, whereas those for April show only a post-sunset peak. An explanation may be provided by the phase of the moon. In March a total lunar eclipse early in the night was followed by very low cloud cover so that little light reached the creek. In April, however, the full moon rose at 1844 h and could have suppressed drifting activity thereafter as suggested by Waters (1962), Anderson (1966), Elliott (1967), and Bishop and Hynes (1969).

Diel fluctuations of drift in various insect groups

The consistency of timing of the post-sunset peak of activity (between 1800–2000 h) over the three periods of observation, independent of changes in the time of sunset, suggest that valid comparison might be possible when hourly activities are pooled over the three months.

Diel fluctuations in drift rates for individual taxa are shown in Fig. 2 (see figure caption for details). As the figure indicates, the five mayfly species were all more prevalent in the drift at night. *Atalophlebioides* sp. showed more day drifting than the others, while *Coloburiscoides* spp. showed a drift activity almost completely nocturnal. With regard to the Trichoptera, *Anisocentropus* sp. was collected throughout the 24-h period, although cased individuals were mainly caught at night. The two subfamilies of non-case builders, Hydrobiosinae and Hydropsychinae, displayed maximum drift at night, although low numbers of Hydrobiosinae did occur throughout the 24-h period. Leptoceridae sp. 1 also showed maximum drift numbers during the night, irrespective of whether cased or caseless individuals were present, whereas there was a marked difference in the drift activity of cased and caseless individuals of Leptoceridae sp. 2.

Both the Orthocladiinae and Tanypodinae showed similar drift numbers throughout the 24-h period, although slightly higher values were recorded for 2-hourly periods during the night. Chironomid pupae appeared to reach maximum drift numbers 2–4 h after dawn. In this group, more individuals were collected throughout the day than the night. Of the Helminthidae, adults appeared in the drift throughout the 24-h period, but larvae were mainly restricted to the night. However, adults and larvae were collected in such low numbers that no firm statements can be made.

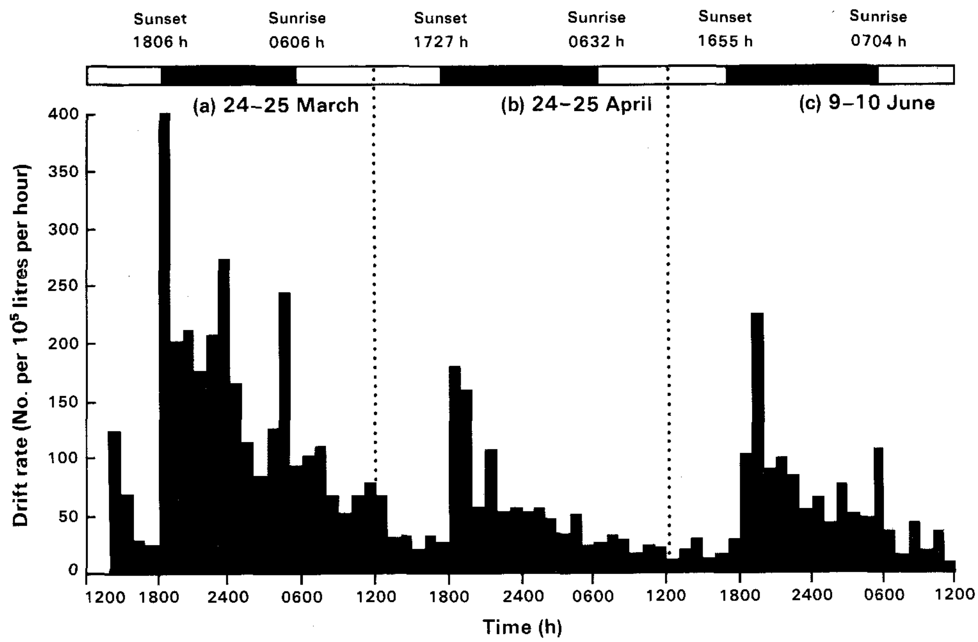

Fig. 1. Diel periodicity of drift rate over 24-h period (1200–1200 h) on 24–25 March (*a*), 24–25 April (*b*) and 9–10 June (*c*) 1978 in Condor Creek, A.C.T. Total number drifting were (*a*) day 738, night 2315; (*b*) day 386, night 905; (*c*) day 231, night 1137. Observed rate has been converted to a standard drift rate per 10^5 litres of water filtered for each month.

Differences in the distribution of size classes of Atalophlebioides *sp. in the drift and bottom samples*

If a uniform distribution of particular size classes exist in both benthos and drift, the percentage of each size class should not be different for day and night drifters. Table 4 summarizes differences in the percentage of each size class of *Atalophlebioides* sp. in the April and June samples of benthos, total drift, and day and night drift. Measurements given refer to head width between inner lateral ridges of the orbit.

Discussion

Bottom Samples

Heavy rain fell in May (Table 1) when 100 mm fell in less than 48 h. May had the highest monthly rainfall record in over 12 months and increased total creek discharge by a factor of 20. It seems likely that this increase was the main factor in the fluctuations of benthic density. The scouring effect on the bottom fauna can be seen from the June benthos density value taken 10 days after the rain: the population

Fig. 2

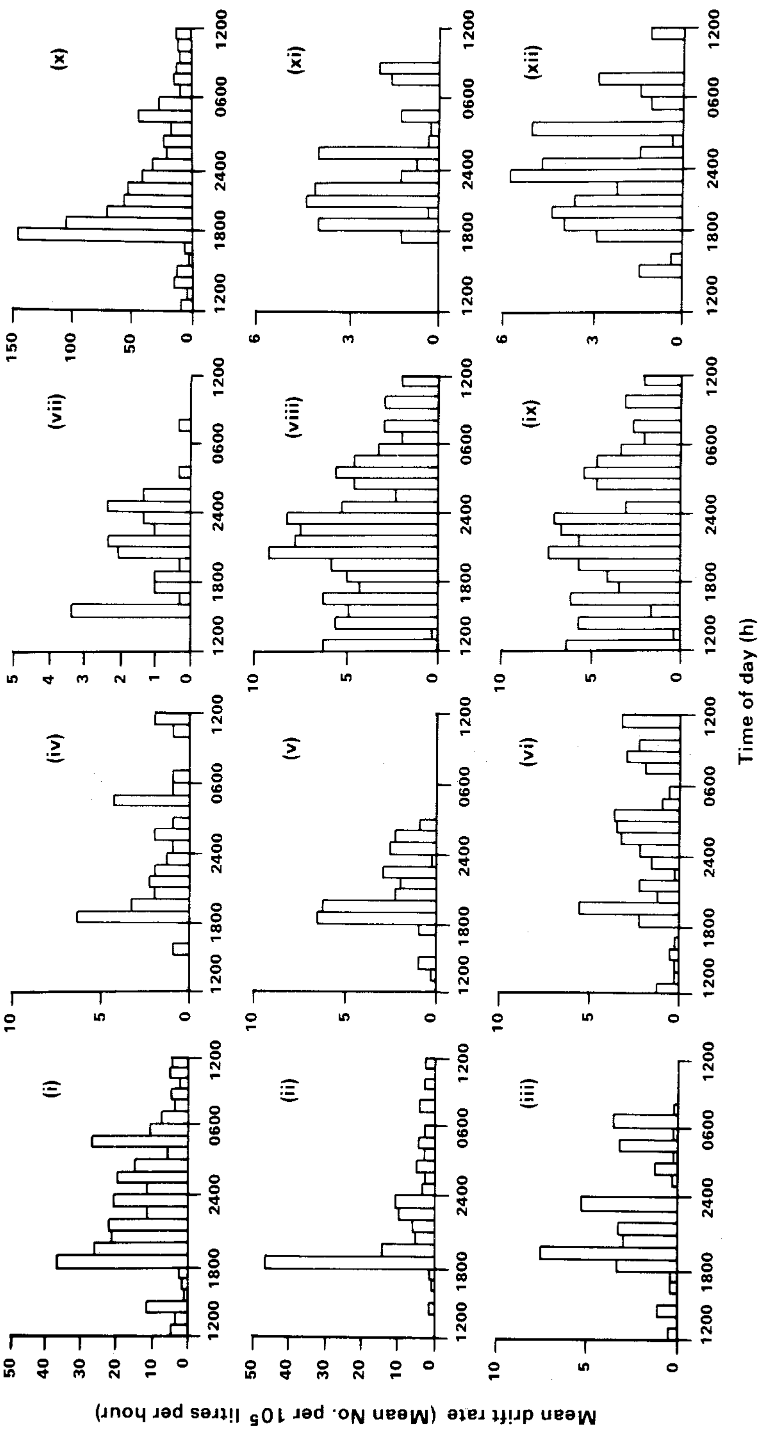
(i)
(ii)
(iii)
(iv)
(v)
(vi)
(vii)
(viii)
(ix)
(x)
(xi)
(xii)
Mean drift rate (Mean No. per 10^5 litres per hour)
Time of day (h)

Fig. 2 (contd)

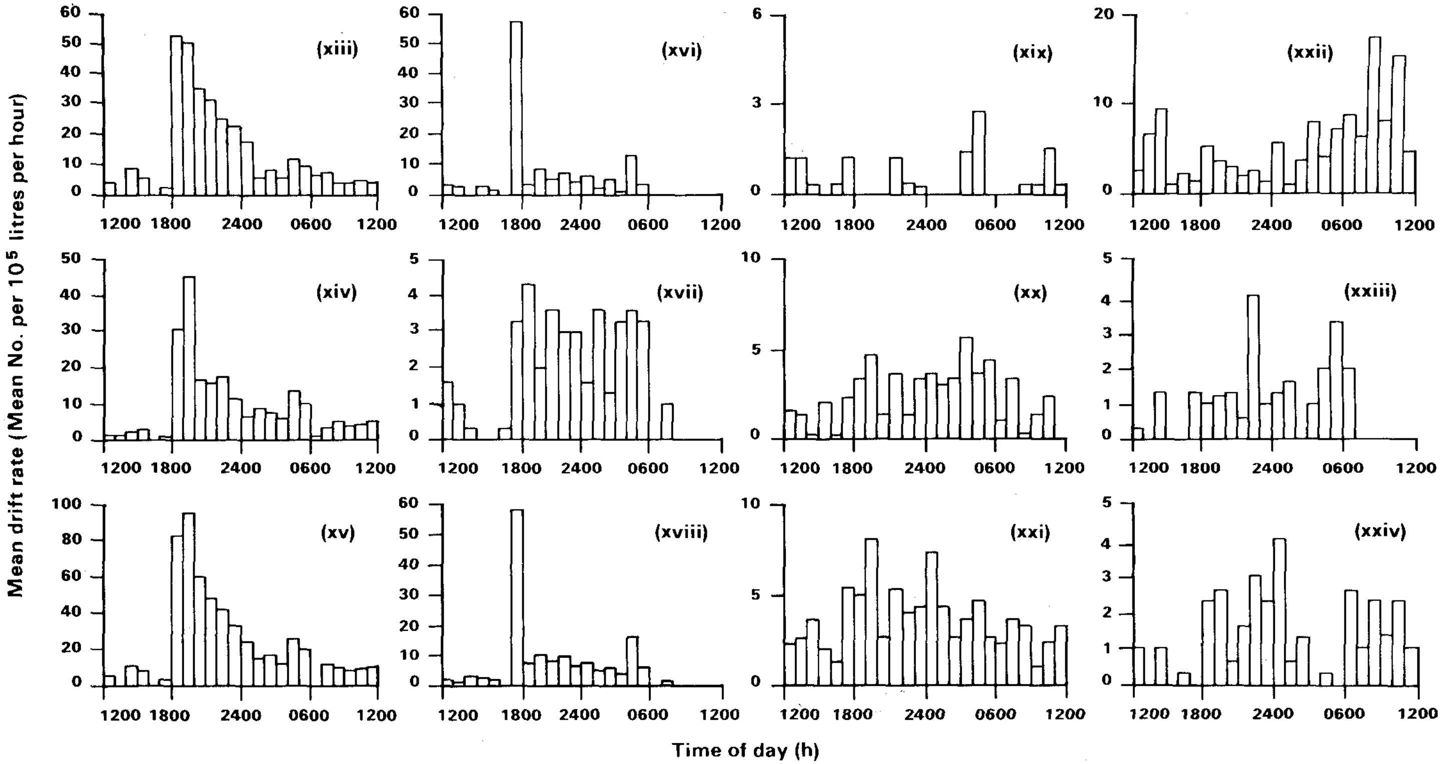

Fig. 2. Diel periodicity of drift rate in Condor Creek for various taxa. (i) *Atalophlebioides* sp.; (ii) *Atalophlebia australis*; (iii) *Tasmanocoenis* sp.; (iv) *Jappa* sp.; (v) *Coloburiscoides* spp.; (vi) *Simulium* sp.; (vii) *Anisocentropus* sp. (+case); (viii) *Anisocentropus* sp. (−case); (ix) *Anisocentropus* sp. (total); (x) Leptoceridae (sp. 1 +sp. 2); (xi) Hydropsychidae; (xii) Hydrobiosinae; (xiii) Leptoceridae sp. 1 (+case); (xiv) Leptoceridae sp. 1 (−case); (xv) Leptoceridae sp. 1 (total); (xvi) Leptoceridae sp. 2 (+case); (xvii) Leptoceridae sp. 2 (−case); (xviii) Leptoceridae sp. 2 (total); (xix) Helicopsyche sp.; (xx) Tanypodinae; (xxi) Orthocladiinae; (xxii) Chironomidae pupae; (xxiii) Helminthidae larvae; (xxiv) Helminthidae adults. Value in each hourly class interval is the mean of the values obtained on 24–25 March, 24–25 April and 9–10 June 1978 after conversion to a standard number drifting per 10^5 litres of water filtered. Before pooling data, the variance between the three sets of data was tested using Bartlett's test and was found to be homogeneous ($P < 0 \cdot 5$).

density was reduced by at least 40% of the April sample. However, it then increased by 157% within 20 days. McLay (1968) reported similar recolonization following a major flood of the Kakanui River, New Zealand.

Not all species were similarly affected or reacted in a similar fashion. At least some differences can be reasonably explained. Observations throughout 1978 suggested that *A. australis* prefers larger rocks than *Atalophlebioides* sp. and will cling to the undersurface of such rocks even when these are partially buried. That its numbers and its proportion of the total population were greater after the flood suggests that this behaviour is beneficial. Conversely the reduction in the number of *Tasmanocoenis* sp. is probably caused by the burrowing of this species into fine gravel, which offers little protection against any rapid flow. The increase in the numbers of some Trichoptera groups, *Anisocentropus* sp., and Leptoceridae sp. 1 may indicate that they have taken evasive action against the water by burrowing or concentrating in less turbulent areas of the creek. However, detailed studies on trichopteran behaviour are necessary before firm statements can be made.

Table 4. Proportion of particular size classes of *Atalophlebioides* sp. occurring in benthos, and in either day or night drift compared with their proportion in the total drift over a 24-h period

Sampling period was from 1200 to 1200 h during the dates indicated. Measurement given is the head width between inner lateral ridges of both orbits

Size class (mm)	Benthos (%) 24–25 iv.1978	Benthos (%) 9–10 vi.1978	Total drift (%) 24–25 iv.1978	Total drift (%) 9–10 vi.1978	Day drift (%) 24–25 iv.1978	Day drift (%) 9–10 vi.1978	Night drift (%) 24–25 iv.1978	Night drift (%) 9–10 vi.1978
≤0·29	15·3		26·6	4·2	44·8[A]	16·4[D]	21·3	2·0
0·30–0·39	44·0		28·4	11·6	24·2	13·9	23·3	7·9
0·40–0·49	15·3		10·0	14·8	6·9	14·4	10·5	12·1
0·50–0·59	13·5		19·6	15·9	17·2	16·3	18·0	15·4
0·60–0·69	11·9		15·4	20·1	6·9[B]	19·1	27·8[C]	16·6
≥0·70				33·4		19·9[E]		46·0[F]
Sample size	220		169	190	51	35	118	155

[A] $\chi^2 = 12{\cdot}1$, $P < 0{\cdot}001$. [B] $\chi^2 = 4{\cdot}7$, $P < 0{\cdot}05$. [C] $\chi^2 = 10{\cdot}0$, $P < 0{\cdot}001$. [D] $\chi^2 = 31{\cdot}0$, $P < 0{\cdot}001$. [E] $\chi^2 = 5{\cdot}5$, $P < 0{\cdot}05$. [F] $\chi^2 = 4{\cdot}8$, $P < 0{\cdot}05$.

Drift Samples

The high numbers of caseless trichopteran larvae sampled from the drift during the three sampling dates are believed to reflect an association between case-building activity and drift. Gallepp (1974) recorded corresponding peaks of case-building activity and associated drift in *Brachycentrus americanus* during the daylight hours. Case-building activity occurred very little during the night. In the present study, however, the greater numbers of caseless *Anisocentropus* sp. and Leptoceridae sp. 1 were sampled in the drift after sunset, which would be consistent with the possibility of nocturnal case-building activity.

McLay (1968) suggested that occurrence in the drift is initially determined by the numbers of each species present in the benthos, and that exceptions to this can be accounted for by considering behavioural differences and also mechanical influences such as the occurrence of lumps of algae detached from the substrate, which contain variable numbers of animals. This latter suggestion may explain the results obtained for the Orthocladiinae. Numbers of this group were collected in clumps of algae that had probably been dislodged and floated downstream. Mundie (1956), Williams and Davies (1957) and Morgan and Waddell (1961) have all reported the emergence of Chironomidae to take place in the early hours of the morning. The high numbers of pupae sampled in the drift during the day in the present study may reflect various changes in behavioural activity of the pupae before the emergence period.

Anderson (1967) reported a greater daytime drift of early instar *Amiocentrus aspilus* (Ross) larvae compared with the nocturnal numbers of the larger larvae. He suggested that there is a high level of constant and behavioural drift (using the terms of Waters 1965) of the small caddis larvae during the day, but that selective predation by nocturnal carnivores reduces the numbers in the drift at night.

In the present study there were significantly greater numbers of small nymphs of *Atalophlebioides* sp. (Table 4) occurring in the day drift in both April and June compared with the total drift. Furthermore, the largest size class occurred in significantly greater numbers in the night drift. The data in Table 4 suggest that different size classes of *Atalophlebioides* sp. are active at different times of the day. It is possible that this activity is reflected in the drift sample. The most probable activity is feeding, although high densities of animals per stone in the benthos may increase activity and override the normal negative phototaxis (Bailey 1981).

Elliott (1967) reported increased drifting of mayfly nymphs at times of rapid growth and suggested that this may be due to increased competition between nymphs for food and space. The high levels of drift numbers of the smaller size classes during the day in the present study may support this. However, until detailed studies are conducted on growth times and development in *Atalophlebioides* sp., no correlation between drift numbers and growth can be assessed.

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