MACROINVERTEBRATE STREAM DRIFT – AN AUSTRALIAN EXAMPLE

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Abstract. The flow of organisms in lotic environments is known as Macroinvertebrate Stream Drift: a phenomenon that has long fascinated freshwater ecologists. Stream-dwelling organisms are often transported downstream in the water column in substantial numbers. Because they have limited swimming ability and the movement is apparently passive, the process is referred to as drift. This study assesses drift fauna in a lotic environment upstream from the Australian inland city of Wagga Wagga, looking at the abundance and diversity of invertebrates over sampling times spanning daytime, dusk and nighttime. Not only did the abundance of individual macroinvertebrates increase from daytime to nighttime, but the diversity of taxa also increased. Although not as sharp as the increase in individual numbers, the diversity of taxa however did more than double from the dusk sampling period to the first night sampling period.
Keywords: *lotic; macroinvertebrate; drift; taxa.*

Introduction

Numerous studies worldwide have reported that many benthic invertebrates (especially immature mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera) and some true two-winged flies (Diptera)) temporarily enter the water column as drift [2]. While accidental and catastrophic drift (e.g.- during floods) certainly occur, the greater numbers of drifting invertebrates and algae collected at night as opposed to during the day suggests an element of behavioural drift, that is, an adaptation of invertebrates to life in running waters [16]. Numbers appear to peak soon after dusk and decline with a smaller peak prior to dawn (the *bigeminus* pattern), although patterns can alter between different groups of invertebrate taxa and among streams. Light level appears to be the primary cue to behavioural drift [4].

There is no definitive answer to the question of why drift occurs, but several reasons have been proposed. In the past, many researchers have assumed that drift is the major dispersal route used by new colonists following the removal or destruction of macroinvertebrates that follows a catastrophic event. More recent research suggests that floods do not turn over entire stream-beds and local redistribution of invertebrate numbers from undisturbed patches of the stream-bed also occurs [5]. Other suggestions as to the reasons for drift include: foraging activity; parasitism; and responses to pollutants and human activities [4]. This latter suggestion appears to be a useful biomonitoring tool because quantitative samples can be passively collected and expressed as density or rate [3]. As previously stated, light appears to be a time signal for behavioural drift. Muller [11] manipulated the light-dark cycle in the field by means of light and opaque plastic. He found that two species of *Baetis* (mayflies) showed the following patterns:

- Continuous light resulted in no drift and no rhythm.
- Natural drift persisted for 8 days in total darkness.

Muller [11] also discovered correlations between the onset of drift and darkness, which provided a number of estimates below which drift commences that are usually between 0.1 and 1 lux. A level of 5 lux was found to prevent nocturnal drift completely while levels of 1 and 2 lux reduced the nocturnal peak by 5-10 folds. Bright moonlight (approx. 0.2 lux) did not appear to reduce drift.

The aim of this exercise was to design and undertake a study of drift fauna in a lotic environment, looking at the abundance and diversity of invertebrates over sampling times that spanned daytime, dusk and nighttime.

Materials and methods

This exercise was carried out on the Murrumbidgee River at Oura Beach, upstream from the New South Wales inland city of Wagga Wagga, on March 1st 2002. The sampling area was that of a narrow riparian zone on a sandy and cobbled point bar bend in the river, surrounded by farmland.

The drift fauna was sampled using modified surber nets (50cm x 50cm with 250 micron mesh) attached to the streambed. The fauna was sampled over five separate sampling periods, each period lasting ten minutes. Four replicates were carried out during each ten minute sampling period, and river flow was tested at each replicate location. Two sampling periods were carried out in late afternoon prior to sunset (6.30pm and 7.00pm). At dusk, (8.00pm) another ten minute sampling period was carried out, and two more were carried out during nighttime (8.30pm and 9.00pm). At the end of each sampling period, the netted samples were back washed into a sorting tray, and approximately 15 minutes was spent live sorting the specimens with the aid of forceps and pipettes. The collected invertebrates were then placed in labeled bottles containing 70% alcohol.

On returning to the laboratory, the collected samples were identified. The content of each sample bottle was emptied into a Petri dish and with the aid of forceps and dissection needles, the specimens were grouped into groups of like individuals. Using relevant literature [16], the macroinvertebrate samples were keyed out to family level. The numbers of individuals in each family were counted and recorded.

Statistical analysis was carried out on the number of individuals and the number of taxa. Homogeneity of variances was tested, with analysis of variance (ANOVA) only proceeding once homogeneity between variances ($p>0.05$) was established. Where variances were found not to be homogenous ($p<0.05$), transformations of the data (log(n)) were carried out until either no significant difference between variables was established, or until confidence was established that the means of the groups were statistically significant.

Results

Figure 1 shows that the number of individuals collected from this exercise greatly increased as daylight gave way to night. Individual numbers maintained a steady average from the starting time of 6.30pm until approximately 8.30pm, when macroinvertebrate numbers jumped sharply as full darkness enveloped the sampling area. In fact, the average number of individuals collected during the first nighttime sample (8.30pm) had more than quadrupled when compared to the numbers collected during the dusk sampling period. All four replicates undertaken during the final two sampling periods (8.30pm & 9.00pm) resulted in far greater numbers of samples being collected than the previous sampling periods carried out during daylight and at dusk.

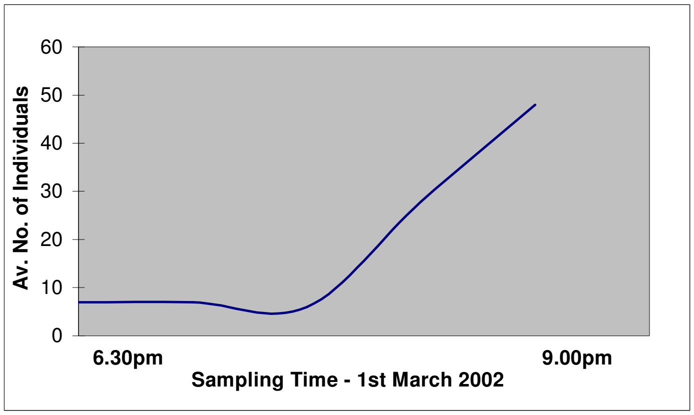

Figure 1. *Average Number of Individuals vs. Sampling*

Not only did the abundance of individual macroinvertebrates increase from daytime to nighttime, but the diversity of taxa also increased. Although not as sharp as the increase in individual numbers, the diversity of taxa however did more than double from the dusk sampling period to the first night sampling period at 8.30pm. In the following sampling period held at 9.00pm, the number of taxa again increased, albeit by only a small amount *(Figure 2).*

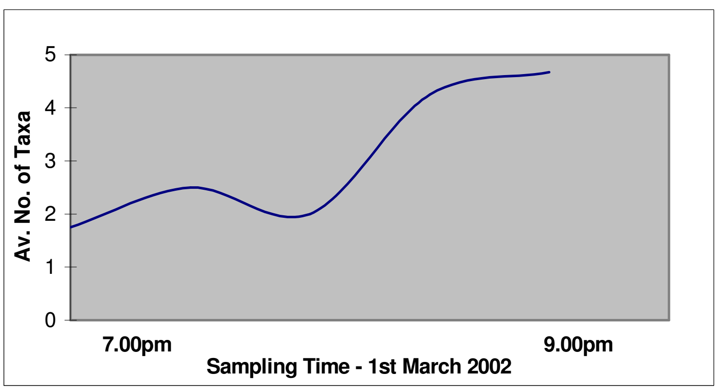

Figure 2. *Average Number of Taxa vs. Sampling Time*

Another interesting feature of the study was what type of taxa was present in the river at the different times of sampling. Not only did the diversity of species increase, but also numbers of certain species dramatically increased during the nighttime sampling as opposed to the daytime and dusk sampling.

A classification system based on Hawking and Smith [7] was incorporated and classified the macroinvertebrates into categories based on their feeding mechanism. These categories included: shredders, collectors, scrapers and predators. As can be seen in *(Figure 3),* species classified as 'predators' (*Hydrachnidae*) were only present during

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the daytime sampling. Taxa classified as 'shredders' (*Leptoceridae*), displayed a dramatic decrease in numbers from daytime to dusk and a further drop again to night sampling, with only 13 individuals collected at night as opposed to 58 during daytime sampling. The two remaining functional feeding groups, 'collectors' (*Hydropsychidae, Economidae, Chironomidae & Colobruscoides*) and 'scrapers,' (*Baetidae, Coroxidae, Gryptopterygidae & Elmidae* larvae) included taxa whose numbers increased dramatically at nighttime, although not a single collector species was collected during dusk sampling *(Figure 3).* Taxa belonging to the scrapers feeding group increased their collected numbers from only 3 during daytime sampling, to 17 at dusk, and 170 at night. It was also interesting to note that not all taxa collected displayed nocturnal peaks in abundance. For example, the *Chironomidaes* and *Hydrachnidae* were not present in collections post daytime sampling.

One final point to re-emphasize is the dramatic increase in individual numbers collected from daytime to nighttime. A total of 70 individuals were caught across all four replicates of daytime sampling compared to a nighttime sampling haul of 255 individuals.

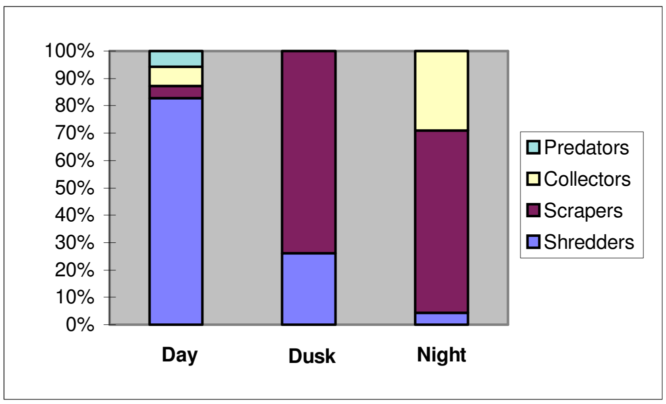

Figure 3. *Percentage of Functional Feeding Groups vs. Time of Sampling March 1st 2002*

Discussion

There are obvious differences in the numbers of individuals and types of families collected across the different sampling times. The number of drifting animals is definitely greater by night than by day, often many times greater. So, why does drift occur and why do most drift fauna display a nocturnal peak in abundance and diversity? Waters [15] proposed a classification scheme to explain why organisms may appear in the water column.

- Behavioural Drift – exhibits a consistent pattern, usually with a pronounced peak at night.
- Constant Drift – continuous background of low numbers, most easily detected during the day.
- Catastrophic Drift – effects of floods and other major adverse events. Catastrophic drift may also provide a useful index of human disturbance.

From knowledge known about the sampling area on the Murrumbidgee River on March 1st 2002, there were no major adverse events that took place in the weeks or months preceding the sampling date that may have influenced the results obtained. In many ways, behavioural drift is the most interesting form and was the basis of this exercise, as it implies that drift is acting as an evolved strategy and that drift has an ecological purpose.

It was the discovery by Tanaka [13] of nocturnal periodicity that stimulated research into invertebrate stream drift after previous studies had concluded that the phenomenon was mainly due to the 'colonisation cycle hypothesis.' This hypothesis, proposed by Muller [10], stated that compensatory upstream flight by adult insects was necessary to maintain populations. That is, insects fly upstream and colonisation occurs from upstream to downstream. However, Elliot [6] found no evidence of upstream flight in *Ephemoptera* or *Plecoptera*. He also found that *Trichoptera* moved downstream when the wind was strongly downstream and upstream when the wind was weak. Subsequent studies have shown that upstream flight is common in many freshwater insects, although it is often weak and variable. Whatever the cause of drift, the continual downstream loss of invertebrates appears to be adequately compensated by a combination of excessive production and limited upstream migration [4]. On the subject of excess production, Waters [14] suggested that drift represented exactly that, removing animals from the benthos and making them available to higher trophic levels, especially drift feeding fishes. This theory appears to be very logical. In terms of modern genetics, individuals of a population tend to produce more offspring than can survive and reproduce in a given environment. In time, its individuals must compete for resources. Darwin was able to explain natural selection after correlating this understanding of inheritance with certain features of populations and the environment [12].

This hypothesis of excess production therefore suggests that drift is disadvantageous and that it only occurs when there is an excess number of individuals above the carrying capacity. It follows that drift should have a curvilinear relationship with benthic density, although Hildebrand [8] found a simple linear relationship in his stream examinations.

With regard to the question of why is behavioural drift mainly a nocturnal exercise, it could be suggested that there has been an adaptive response by drift fauna to deal with the problems associated with predators that use vision to locate prey. This was tested by Allan [1]. He found that Brook Trout fed on only large *Baetis* and showed the greatest size selectivity during daylight hours. Allan predicted that the risk of drifting during the day would therefore be greater for bigger *Baetis.* He found that nocturnal drift was relatively bigger in the larger size classes of mayfly. This size-dependent version of the predation risk hypothesis may explain why smaller invertebrates such as water mites and chironomids don't show nocturnal periodicity, as shown in this exercise on the Murrumbidgee River. McIntosh *et al*. [9] looked at the effect of fish odour on the behaviour of *Baetis bicaudatus* from a fishless stream and a trout stream in four large tanks supplied with water from the fishless stream. Drift was measured day and night for 3 days. Trout odour was added to two of the tanks to test for the effects of predator presence. This resulted in more mayflies from the trout stream being observed in the water column during the night than the day, but the magnitude of night drift was less for the fish odour treatments than the odour free ones. McIntosh *et al.* concluded that sensitivity to fish odour may allow mayflies to alter their behaviour with respect to predation risk.

The patterns displayed by the functional feeding groups as classified by Hawking & Smith [7] also require an attempted explanation. Each of the four groups classified and used in this exercise (shredders, collectors, scrapers and predators) have been organised in a manner that associates each group with a broad food category: shredders – vascular plant tissue; collectors – detrital particles; scrapers – attached algae; predators – live prey. The dramatic increase in abundance of both scrapers and collectors may suggest either an increase in the abundance of food available at night for these two groups, or a decrease in the pressures exerted by predators that use vision, as mentioned above. This point is more likely and reinforced by the observed presence of predators during daytime sampling only. The fact that numbers of shredders decreased from day to night (58 to 11 individuals of *Leptoceridae*), in direct contradiction to the major trend, and that shredders are associated with plant tissue, may suggest a link with plant photosynthesis, or to be more precise, the lack of plant photosynthesis at night. Is it possible that the shredders of the exercise are in some way dependent upon the proceeds of photosynthesis? The answer is outside the realms of this particular exercise, and should be left to a possible future study on the issue.

Drift fauna are made up primarily of benthic organisms and spend very little time in the water column. Any member of the benthic fauna can be captured in the drift for one reason or another although it seems that some taxa are particularly common.

The findings of this report are in total agreement with those of Muller [10], who noted that the majority of taxa captured in drift exercises were: 'Ephemoptera' (2 Families – *Baetidae & Colobruscoides* collected in this exercise), 'Diptera' (1 Family – *Chironomida*), 'Plecoptera' (1 Family – *Gryptopterygidae*) and 'Trichoptera' (3 Families – *Leptoceridae, Hydropsychidae & Economidae*).

It can be concluded that three taxa from this exercise displayed definite behavioural drift *(Hydropsychidae, Baetidae & Corixidae)* and a fourth (*Colobruscoiodes)* displayed drift to a lesser degree. Although the results of this study clearly show an almost across the board display of behavioural drift with regard to abundance and diversity of fauna over time, drift remains an intriguing phenomenon the world over.

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