Notes on invertebrate drift: A pilot study

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INTRODUCTION

Needham (1928) first noted the 'drift' of aquatic insects when examining the importance of terrestrial insects as trout food. When using a fine copper wire-meshed net to collect benthos in streams near Ithaca, NY he discovered large numbers of aquatic insects present his samples. Drift attracted more attention from researchers in the 1950's after Muller quantified drift and compared drift with benthos densities (Brittain and Eikeland 1988). Waters' (1962) discovery of the diel periodicity of drift also helped initiate interest in insect drift. Since then, numerous papers have addressed various aspects of drift including which invertebrates drift and in what numbers, why invertebrates drift and what factors affect the drift of aquatic invertebrates.

Hildebrand (1974) gives a clear definition of drift, being "the downstream displacement of animals normally inhabiting eroding substrates…" Drift has been found to be caused and influenced by a number of factors both abiotic and biotic. Abiotic factors (e.g. ice, chemicals, etc.) influencing drift are often described as 'catastrophic' (Anderson and Lehmkuhl 1967). Biotic factors are generally thought to be related to behavior, where the animals actually 'choose' to drift (active drift). Invertebrate drift is usually thought to be taxa specific, though catastrophic drift can affect any taxon (Brittain and Eikeland 1988). Taxa that regularly occur in the active drift include: Ephemeroptera, Plecoptera, Trichoptera, Simulidae (Diptera), and Amphipoda (especially *Gammarus* spp.). Drifting insects are often a very important food supply for certain fish taxa (e.g. Salmonids).This paper briefly covers some of the factors that influences drift and tests the hypothesis that moonlight depresses drift in caddisflies (Trichoptera).

Abiotic Factors that Influence Drift

The abiotic factors that influence drift are generally thought to be catastrophic. Theses factors make a certain habitat unsuitable for typical life (e.g. frozen stream) and may result in invertebrates drifting not by 'choice'. The insects must move simply because they will not survive if they don't. Some of these factors include high discharge or drought (Anderson and Lehmkul 1996), ice (Brittain and Eikeland 1988), pesticides (Davies and Cook 1993; Schulz and Liess 1999), oil spills (Miller et. al. 1986), poor water quality (e.g. low dissolved oxygen, low pH, thermal pollution (high temperature), etc.) (Brittain and Eikeland 1988), etc. The above factors may simply make life unsuitable or they may result in the death of the animals, either of which will result in drift.

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Biotic Factors that Influence Drift

There are several biotic factors that influence drift in invertebrates. First, there is always some background drift (constant drift), which is the result of invertebrates accidentally loosing contact with the substrate, thus entering the drift. Constant drift is not generally taxa specific, and explains why researchers encounter ‘non-drift’ taxa when sampling drift. Other biotic factors that influence drift include competition for food resources (Hildebrand 1974), piscine predator avoidance (Flecker 1992; Lagarrigue et. al. 2002), invertebrate predator avoidance (Peckarsky 1979; 1980) and dispersal (Allan 1995). Piscine predation is especially important because it is thought to be the reason why most drifting invertebrates exhibit a diel periodicity in their drifting activity (Muller 1974; Flecker 1992; Lagarrigue et. al. 2002).

The Diel Periodicity of Drifting Invertebrates

Most (but not all) drifting insects exhibit some sort of diel periodicity in their drifting activities. The taxon that typically defies the diel periodicity concept is the Chironomidae (Allan 1995). Most active drifting occurs at night with peaks just after sunset (‘bigeminus’ pattern) or rarely the peak is before dawn (‘alternans’ pattern) (Muller 1954). Allan (1995) noted that the difference in drift densities may be orders of magnitude greater at night.

Diurnal periodicity is generally thought to be an evolutionary adaptation to minimize contact with visually oriented drift feeding fishes (Allan 1995; Flecker 1992) with light levels controlling the periodicity (Chaston 1969). Insects ‘choose’ to drift at night because there is less of a chance of them getting preyed on by drift feeding fish (e.g. trout). This diurnal periodicity is so strong that invertebrates often retain their drifting patterns when fish are experimentally excluded (Flecker 1992). It is interesting to note that the same taxa that drifted in the presence of piscine predators did not show a diurnal periodicity in drift patterns in nearby streams that have never had drift feeding fishes, thus, indicating the behavioral adaptation to predation (Flecker 1992).

The Drift Paradox

In a widely cited paper, Muller (1954) noted an apparent paradox in the downstream movements of insects, suggesting that with the large numbers drifting downstream, one would expect to see a depopulation of upstream reaches. However, this was never observed. He proposed that upstream flights of adult aquatic insects compensated for the downstream movements of the larval forms, thus resolving the apparent paradox. Waters (1972) proposed the ‘excess production hypothesis’, which suggested that the production of insect progeny was in excess of the stream’s carrying capacity, compensating for the drift (i.e. these drifting insects are ‘extras’). The true explanation is probably a combination of both colonization hypothesis and the excess production hypothesis, and perhaps some other factors. Researchers continue to look for answers (e.g. Hershey et. al. 1993).

The Effect of Moonlight on Drift in Trichoptera

BACKGROUND

Allan (1995) and Brittain and Eikeland (1988) noted that moonlight depresses drift in invertebrates; however, they also note that research has suggested that moonlight has no influence on drift.This study was conducted to test the hypothesis that moonlight depresses drift in caddisflies.

METHODS

This study was conducted on the East Branch of the Otego Creek ((a.k.a the Fly) N42° 39.867' W075° 02.981), in Hartwick, Otsego County, New York. Methods for measuring drift were adapted from Smock (1996). Drift was sampled with a pair of rectangular 0.09 m^2 300μm mesh drift nets on one clear, full-moon night (8-9 December 2003), and on one night where moonlight was totally precluded by cloud cover (10-11 December 2003). The nets were set in the stream at the head of a pool/riffle tail in approximately 0.5 m of water such that the top edge of the net was level with the air/water interface. The nets were set from 1600-0800 hours on both sampling dates and the collection bottles were emptied every 4 hours (e.g. 2000, 2400, 0400, 0800 hours). All vertebrate bycatch was released.

Stream velocity was measured with a digital flowmeter (m/s) when the net was initially set. Stream velocity was measured at three points in transect across the opening of the nets. The mean velocity was recorded. If the water level changed in relation to the top edge of the net (indicating a change in discharge) stream velocity was again measured and the mean velocity was recorded (before and after the 4h sampling period).

Drift samples were preserved in 70% ethanol stained with Rose-Bengal and stored in plastic bags. Samples were sorted by taxa, counted, and recorded. Any caddis cases that were not obviously occupied were examined with a dissecting microscope to determine if there was a caddis in the case. Empty cases were not included in the caddis count; however, head/thorax fragments were included in the count (though it wasn't clear whether the head/thorax fragments were molts or the result of mechanical damage to the caddis).

Drift density (# caddis drifting / 100 m^3) was calculated using the following equation (Smock, 1996): **Drift Density = (N) (100) / (t) (W) (H) (V) (3600 s/h);** Where: N = number caddis, t = time net set (h), W = net width, H = net height, V = mean velocity and 3600 converts hours to seconds.

Drift density data were analyzed using UNIANOVA (SPSS® Student Version 10.0.5), with assumptions checked using a Kolomogorov-Smirnoff test, histogram, and scatterplot. All data were analyzed at the 95% confidence interval.

RESULTS

Table 1 summarizes moonlight conditions, sample sizes, mean stream velocities, number of caddisflies caught and mean caddisfly densities during the two nights of sampling. In order to test the null hypothesis that moonlight has no effect on the drift of caddisflies, an UNIANOVA test was run. The results of the UNIANOVA (P = 0.056) indicate there is enough evidence to reject the null hypothesis, thus, moonlight does affect (depresses) drift in caddisflies. Assumptions were checked via K-S test (P = 0.115), histogram, and Levene's test (P = 0.057); the assumptions were not violated. All but 2 (of 152) caddis were from the family Limnephilidae, the 2 other caddis were from the family Hydropsychidae. Caddis were not keyed beyond family because of difficulties due primarily to the small size of some of the caddis as well as differing case morphologies of the different instars. Most caddis had vacated their cases when exposed to the preservative, so the 'ownership' of the cases was questionable anyway.

Other taxa represented in the drift samples included: Collembola (in very high numbers), Chironomids (Diptera), some Plecopterans, some Sialids (Neuroptera: Sialidae), and a variety of Ephemeropterans (sometimes in large numbers). Most insects present in the drift were early instar, and thus were very small.

Moonlight	**N**	**Mean V (m/s)**	**Mean # Caddis**	**Mean Caddis Density (# /100 m^3)**
Yes	62	0.22	7.75 (3 - 14)	2.53 (1.06 - 3.71)
No	90	0.18	11.25 (3 - 28)	4.6 (1.52 - 8.60)

Table 1. Summary of the data related to the effect of moonlight on the drift of caddis in Otego Creek.

DISCUSSION

As noted, this study indicates that moonlight does in fact reduce drift by caddisflies. It cannot, however, be assumed that it was only moonlight that depressed drift. While these data show that moonlight is significantly negatively correlated with drift, there are a number of factors that could have been important related to the drift of caddis on the two nights examined.

Weather probably influenced the results somewhat. The weather on the first night (moonlit) consisted of very cold (~ -18° C) temperatures and very few clouds, whereas the non-moonlit night (cloudy) had temperatures slightly above 0° C, with rain. Discharge (though not calculated) increased noticeably on the later night. This was not reflected in the mean velocity measurements because the beginning of the sampling period had relatively low velocity. The water level was approximately 10-15 cm higher at 0800 hours compared to when the net was set at 1600 hours the previous evening. This increase in discharge could also influence the increased drift on the non-moonlit night.

Another factor to consider includes problems associated with the construction of the nets. The nets were constructed so that the bottle could be attached with a standard hose clamp. This arrangement caused a buildup of organic materials (and insects) just ahead of the bottle. This buildup of materials was difficult to rinse back into bottle (particularly on the colder, moonlit night). This problem may have led to an underestimation of the magnitude of caddis drift (especially on the later night). This problem could be solved with the substitution of the collection bottle with a dolphin bottle or by changing the anchor system so that the net could easily be removed from the water to empty the bottle.

Another important factor that deserves consideration is the relatively small sample size (N = 152) represented by these data. In order to fully determine whether moonlight influences drift in caddisflies, many more nights need to be sampled over a range of seasonal and climatic conditions. Overall, this study provides a sound background for future study.

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