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A preliminary investigation of seasonal differences in leaf decomposition patterns in Australian streams

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Introduction

Terrestrial leaves which fall into streams form an important food component for the stream invertebrate community. In addition they may be decomposed through the activity of microorganisms and physical processes. As a result, investigators of the patterns and rates of decay of leaves placed into streams usually invoke differences in invertebrate shredder abundances, levels of microbial activity or stream discharge (and thus turbulence) to explain differences in the patterns and rates of breakdown between summer and winter. Most such investigations compare results from a single summer with those from a single winter (e.g. Bunn 1988), and a plausible narrative can then be constructed using the differences listed above to explain any pattern which may be found.

In this paper we report preliminary results from a study of leaf breakdown in two Australian streams. In each stream two leaf species were investigated with experiments being carried out in two summers and two winters. This allowed us to evaluate whether the differences between summer and winter results were consistent from year to year.

Methods

The study sites were selected on two pristine streams, Rooty Break Creek (a third order stream) and Far Creek (a fourth order stream) which were both at an altitude of approximately 1000 m on the Errinundra Plateau in Eastern Victoria, Australia (Fig. 1). Rooty Break Creek flows through closed canopy rainforest, dominated by sassafras (*Atherosperma moschatum*) and black olive-berry (*Elaeocarpus holopetalus*), with occasional large shining gum (*Eucalyptus nitens*) and abundant tree ferns (mainly *Cyathea australis*). The water temperature

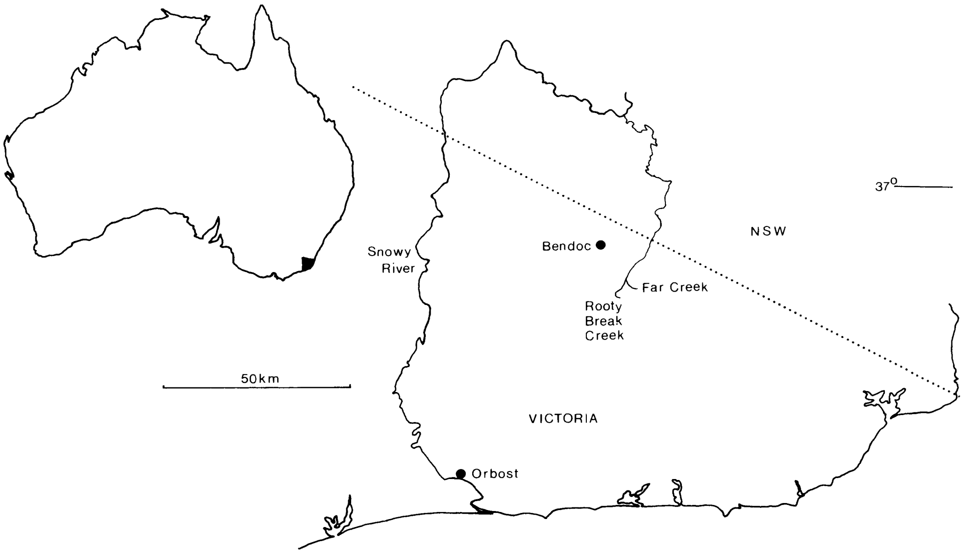

Fig. 1. The location of the study streams, in Southeastern Australia. The location of latitude 37 ° South is indicated in the right hand side of the figure.

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ranges from 2 to 13.5 °C. Far Creek flows through open *Eucalyptus fastigata* forest with a fringing vegetation of *Leptospermum* sp. and *Telopea oreades*. Water temperature ranges from 3.5 – 12 °C. Experiments were commenced in January (summer) and in June or July (winter) in 1986 and 1987. Freshly picked leaves of *E. nitens* and *A. moschatum* were air dried, weighed and then made into packs using plastic buttoneers, 5 g packs for the *E. nitens* and 3 g packs for the *A. moschatum*. All leaves used in these experiments were picked in November 1985. The packs were attached to terra-cotta capping bricks with sewing elastic, two or three packs per brick, and placed in the stream. Samples of at least three packs were withdrawn at various time intervals, with the first sample withdrawn after 48 h so losses due to leaching and leaf crumbling during transport to the site, could be accounted for. In the laboratory the leaves were washed and associated invertebrates picked off and preserved. The leaves were again air dried and weighed.

The proportion of the initial weight remaining was plotted against time in days, and against degree-days to examine the pattern of leaf breakdown, and curves fitted to the data to test the most appropriate form of equation to describe the pattern. Equations were fitted to the data points using the SYSTAT statistics package on an 80386 PC. In each case both straight lines and negative exponentials were fitted to the proportion of the weight remaining vs. days elapsed and vs. degree days elapsed. In each case the value of k, in the negative exponential equation:

$$\log_e x = -ky$$

where x = the proportion of initial weight remaining, and y = a function of time elapsed (either in days or degree days) was calculated to allow comparison of breakdown rates with literature values (Petersen & Cummins 1974, Webster & Benfield 1986, O'Keefe & Lake 1987). For all curve and equation fitting exercises the equations were fitted to the total data set, rather than to mean values at each sampling time, and the standard error was calculated for k where the negative exponential expression was fitted. Stream temperatures were recorded on maximum-minimum thermometers and degree days calculated by multiplying the number of days elapsed by the average of maximum and minimum temperatures.

Table 1. Squared multiple r values for the best fit linear and negative exponential functions for the 8 sets of experimental results for *Eucalyptus nitens* leaves. The letters S and W denote summer and winter experiments, 86 and 87 denote the years 1986 and 1987.

				Negative exponential	
		Linear days	Deg. days	Days	Deg. days
Rooty Break	S 86	0.852	0.906	0.923	0.951
Creek	W 86	0.913	0.879	0.969	0.968
	S 87	0.891	0.925	0.933	0.933
	W 87	0.939	0.906	0.975	0.973
Far Creek	S 86	0.948	0.970	0.939	0.918
	W 86	0.952	0.951	0.957	0.964
	S 87	0.878	0.910	0.915	0.919
	W 87	0.935	0.931	0.827	0.828

Table 2. Squared multiple r values for the best fit linear and negative exponential functions for the 8 sets of experimental results for *Atherosperma moschatum* leaves. The letters S and W denote summer and winter experiments, 86 and 87 denote the years 1986 and 1987.

		Linear days	Deg. days	Negativ exponential	
				Days	Deg. days
Rooty Break	S 86	0.903	0.910	0.836	0.855
Creek	W 86	0.881	0.839	0.961	0.941
	S 87	0.544	0.595	0.795	0.840
	W 87	0.859	0.780	0.978	0.958
Far Creek	S 86	0.968	0.969	0.835	0.810
	W 86	0.891	0.892	0.785	0.792
	S 87	0.862	0.867	0.937	0.935
	W 87	0.817	0.810	0.947	0.943

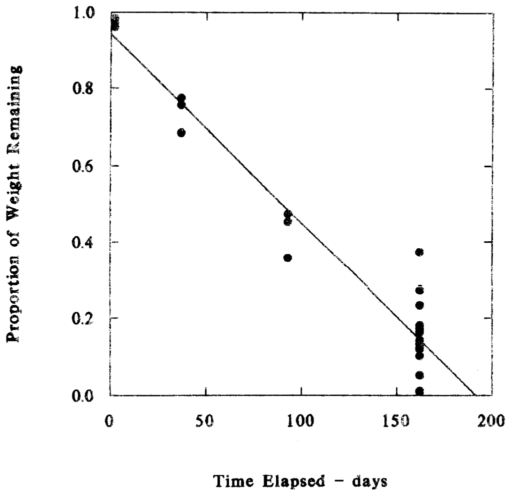

Fig. 2. A plot of the proportion of leaf pack weight remaining vs. time for *Eucalyptus nitens* leaves in Far Creek during winter 1987. A straight line provided the best fit to the data in this case.

Results and interpretation

Patterns of decomposition

The standard error of the proportion of weight remaining in each set of samples was almost always small indicating that the sporadic loss of large chunks of leaf from the packs due to physical breakdown was a rare event. The multiple squared r values demonstrated that in every case the negative exponential curve provided a good fit to the data for both *E. nitens* and *A. moschatum* (Tables 1 and 2). In only 2 out of 8 cases a straight line fitted

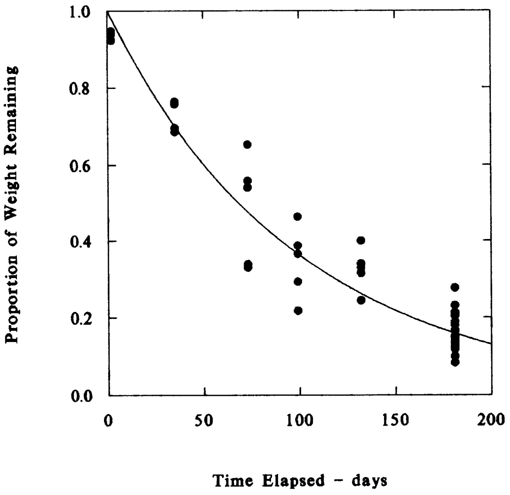

Fig. 3. A plot of the proportion of leaf pack weight remaining vs. time for *Eucalyptus nitens* leaves in Rooty Break Creek during winter 1986. A negative exponential provided the best fit to the data in this case.

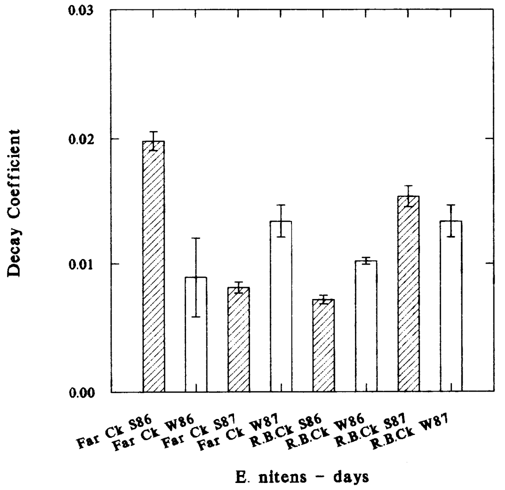

Fig. 4. The values and standard errors for the decay coefficient, k, determined in all the experiments with *E. nitens*. The summer values are shaded. The time scale is in days.

the data better than a negative exponential for *E. nitens* using a "days" time scale. For *A. moschatum* the negative exponential was a better fit to the data than a straight line on both time scales in 5 out of 8 cases.

Visual inspection of the curves (eg. Figs. 2–3) showed no evidence of the two stage breakdown process postulated by Blackburn & Petr (1979), in Cement Creek, a somewhat similar, but more turbulent stream close to Melbourne. Values obtained for k for *E. nitens* places it in the medium to fast breakdown range of Petersen & Cummins (1974) with values measured ranging widely (from 0.0072–0.019). Most values determined for *A. moschatum* fell within the medium range, defined by Petersen & Cummins as $0.01 > k > 0.005$, but 2 values fell below this range and one fell above it. The range of k values for *A. moschatum* was also wide, 0.0044–0.0122.

Seasonal differences

Comparing the k values for *E. nitens* in each of the four seasons in the two streams (Fig. 4) it is evident that there is no consistent pattern between the seasons. Values for the two winter experiments fell between those for the two summer experiments in both Far Creek and Rooty Break Creek. In addition, the 1986 summer experiment produced the highest k value for Far Creek, whereas it produced the lowest value for Rooty Break. Since the two sites are only 3 km apart with similar aspects to their catchments it is unlikely that flood events of sufficient size to significantly affect the results would occur in one stream and not the other.

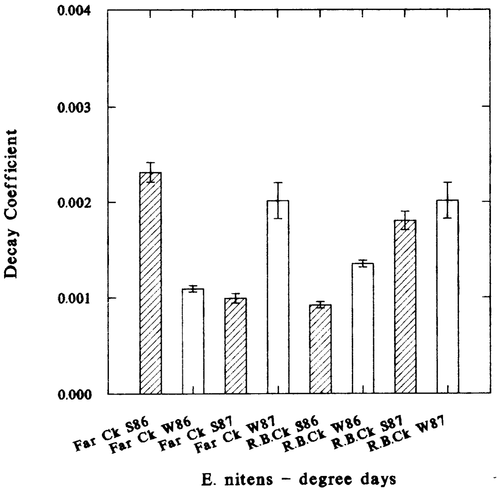

Fig. 5. The values and standard errors for the decay coefficient, k, determined in all the experiments with *E. nitens*. The summer values are shaded. The time scale is in degree days.

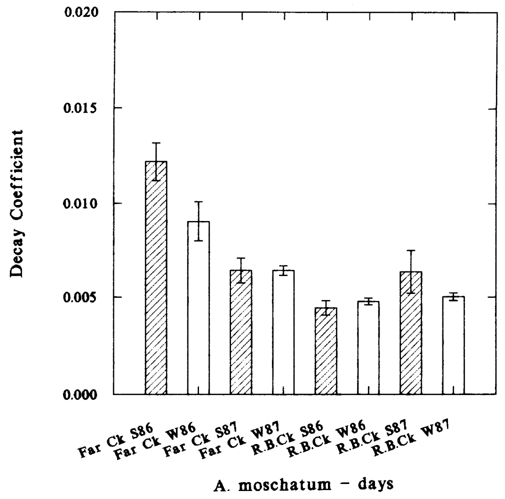

Fig. 6. The values and standard errors for the decay coefficient, k, determined in all the experiments with *A. moschatum*. The summer values are shaded. The time scale is in days.

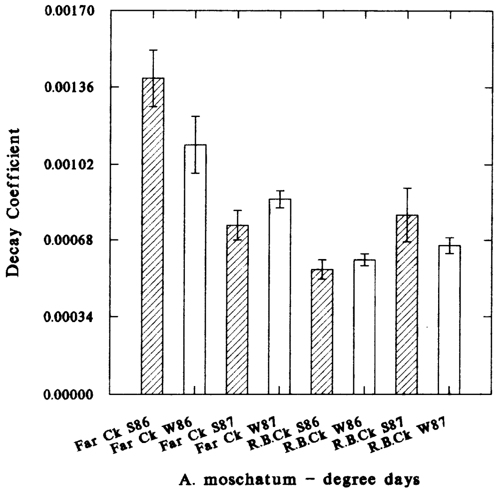

Fig. 7. The values and standard errors for the decay coefficient, k, determined in all the experiments with *A. moschatum*. The summer values are shaded. The time scale is in degree days.

When k values are calculated based on elapsed time in degree days (Fig. 5), to allow for temperature differences between the seasons, it makes little difference to the outcome, indicating that the differences between summer 86 and winter 86 in Far Creek are not primarily related to temperature.

If the same analysis is carried out for *A. moschatum* a similar pattern emerges. The highest k value for Far Creek occurred in summer 86 (Fig. 6), while the summer 87 value was not significantly different from winter 87. Interestingly the seasonal patterns of k values were very similar for the two leaf species (compare Figs. 4 and 6), the only difference within any stream being for winter 87. This suggests that there were definite causal factors determining the patterns, rather than just "noise" in the system. As for *E. nitens*, using degree days to determine the k value for *A. moschatum* (Fig. 7) did not reduce between-season variations, demonstrating again that temperature alone is not a major factor.

Most terrestrial leaf material falls into Australian streams during summer (O'Keefe & Lake 1987, Campbell & James unpubl. data). One can speculate either that this should be the time of most rapid breakdown, because this should be the time of highest shredder density, or that it may be a time when breakdown rates are reduced because there is a surfeit of food available. The relationship between the two may vary from year to year, depending on the secular variations in the amount of leaf fall, shredder biomass and the frequency and timing of small spates which may flush out organic debris.

Conclusions

Leaves of both *A. moschatum* and *E. nitens* can be placed into the medium breakdown rate categories of Petersen & Cummins (1974), although both displayed a wide range of breakdown speeds. There were no consistent differences in breakdown rate between summer and winter, but the seasonal response patterns of the two leaf species were very similar. This indicates definite strong causal factors are likely to be influencing the patterns, rather than system "noise" which would work independently on the two species.

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