Limnologica **24** (3)
(1994) 291 – 293

LIMNOLOGICA

Department of Ecology and Evolutionary Biology,
Monash University, Clayton 3168, Australia

Ecology of Australian Detritus-based Streams – a Note in Response to Graça

IAN C. CAMPBELL

Key words: Leaf Processing; *Eucalyptus*; Aquatic Hyphomycetes, Australia

Summary

A number of the claims made by GRAÇA (1993) concerning the processing of litter in Australian streams are either incorrect or speculative. Contrary to the statements by GRAÇA (1993) there has not been replacement of eucalypt forest by oaks in Australia. Non-leaf components normally comprise 40 – 50% of eucalypt forest litter with a higher proportion of bark in the litter being the major difference between eucalypt and deciduous forest litter. Aquatic hyphomycetes are abundant and diverse on the leaves of at least some eucalypt species in Australian streams. Whether they play as significant a role in Australia as has been suggested for Northern Hemisphere streams is not clear, but there is not evidence that they have been broadly replaced by actinomycetes on eucalypt leaves. In spite of the characteristics, such as thick wax layers and allelochemicals, which have been said to make them unpalatable to shredding invertebrates, leaves from a number of *Eucalyptus* species, including, *E. globulus*, are processed at medium to fast rates in Australian steams.

1. Introduction

GRAÇA (1993) recently reviewed the literature on the pathways by which terrestrial litter is thought to be processed in detritus-based stream systems, concluding that we lack the information in a number of key areas to allow predictions to be made about the effects on streams of afforestation of drainage basins with exotic species. His review was valuable and thought provoking, particularly in its drawing attention to the Northern Hemisphere temperate bias of much of the research and his questioning of its applicability to other regions. This is a point which has been repeatedly made by Southern Hemisphere limnologists (e.g. see WINTERBOURN et al. 1981, LAKE et al. 1985, WILLIAMS 1988). However in his final remarks he made a number of generalisations regarding Australian stream ecology which indicate that he also has failed to adequately consider the Australian literature.

2. Litterfall and Australian Forests

The data on litterfall in Australian eucalypt forests may not be voluminous, but is not as scanty as the three references cited by GRAÇA (1993) would suggest. CAMPBELL et al. (1992) cited 9 studies apart from their own data for two further sites and additional studies have been published by HUTSON & VEITCH (1985) and POLGLASE & ATTIWILL (1992). Based on this data it appears that there is greater litterfall in temperate eucalypt forests than in Northern Hemisphere forests (CAMPBELL & FUCHSHUBER submitted). Whether or not terrestrial litter is the major energy source for Australian eucalypt forest streams is not yet certain. PIDGEON (1978) found that a woodland stream in northern New South Wales was predominantly autotrophic, and LAKE (1982) suggested that this may be the case for many Australian streams due to absence of dense tree canopies overlaying the stream channel. However unpublished data indicate that primary production in southeastern Australian eucalypt forest streams is low, possibly due to low nutrient levels (S. TREADWELL, pers. comm.).

The replacement of *Eucalyptus* sp. by oak in Australia has not caused a serious impact on Australian streams. Oaks are grown as ornamental trees in Australian gardens, not as plantation species since native eucalypts are harvested as a source of hardwood. Oak leaves were used in one study of litter processing in an Australian stream (BLACKBURN & PETR 1979) to provide a basis for comparison with published Northern Hemisphere data, not because oaks have particular ecological significance in Australia (PETR, pers. comm.). Plantations of pines, mainly *Pinus radiata* in southeastern Australia, are extensive (e.g. ROUTLEY & ROUTLEY 1974) and have probably had a significant impact on streams although the data of O'KEEFE & LAKE (1987) remain the only published study.

The study of BLACKBURN (1976) which formed the basis of speculation on compositional differences between litter accession to Australian eucalypt forest streams and Northern Hemisphere deciduous forest streams (e.g. see LAKE 1982) was an inadequate data set since it included only 4 months litter collection and excluded the summer period, known to be the season of peak leaf fall. Since those studies were published more adequate data on most litter components have become available. The amount of branch fall in most forests is not well documented, since techniques used to estimate litterfall usually utilize small quadrats which are not suitable for assessing the fall of large woody material. However the proportion of small wood (<2 cm diameter), bark and reproductive structures in eucalypt and northern hemisphere deciduous forests were compared by CAMPBELL et al. (1992). The accession of bark is higher, and of leaf litter is lower, in eucalypt forests than in deciduous forests, but it is not clear that the other components differ significantly. Leaves usually comprise 50–60% of Australian eucalypt forest litter compared with 70–80% for Northern Hemisphere deciduous forests (CAMPBELL et al. 1992).

There is no evidence to demonstrate that eucalypt litter is richer in polyphenols and poorer in nitrogen than litter from other forest types. Neither MACAULEY & FOX (1980) nor PRESSLAND (1982), the two supporting references cited by GRAÇA (1993) make any such claim. In the absence of any comparative data these comments must be treated as speculative.

3. Role of Aquatic Hyphomycetes in Australia

Similarly GRAÇA's comment that "aquatic actinomycetes appear to be more important in the decomposition of Eucalyptus detritus than aquatic hyphomycetes" which is referenced to COWLING & WADE (1963) does not appear to be an accurate reference. COWLING & WADE (1963) make no reference to actinomycetes, and, although they note that two of 36 samples of dicotyledonous leaves they examined lacked aquatic hyphomycetes and they note that "these two samples consisted of undecomposed eucalypt leaves which we have since found bear a poor aquatic hyphomycete flora" their study was hardly comprehensive. BUNN (1986) found that actinomycetes were more abundant than hyphomycetes on *Eucalyptus marginata* leaves in Western Australian streams, and this was presumably the source of the information in GRAÇA (1993), although he did not cite BUNN's work. However there is a substantial amount of more recent work by THOMAS et al. (1989, 1991, 1992a & b) which demonstrates an Australian aquatic hyphomycete flora which is rich in species, with the greatest number of species occurring on *Eucalyptus viminalis* leaves. Whether the aquatic hyphomycetes are more or less ecologically significant in Australia than elsewhere has not yet been demonstrated. One other unpublished study has suggested that bacteria may also play an important role in decomposition of litter in Australian streams (BARMUTA, 1978).

4. Processing of *Eucalyptus globulus* leaves

Finally, in citing the reference to the slow processing rate of *Eucalyptus globulus* given by O'KEEFE & LAKE (1987), GRAÇA (1993) fails to note that the data for this species were derived from studies carried out outside Australia in streams where eucalypts were not part of the local native vegetation. As yet there are no published data on the processing of *E. globulus* in Australian streams although we have measured an exponential processing rate (k) value of 0.0092 in Rooty Break Creek, a cool temperate rainforest stream in Victoria (CAMPBELL & FUCHSHUBER, submitted) indicating that it falls into the upper end of the medium rate processing category of PETERSEN & CUMMINS (1974). Eucalypt species display a wide range of processing rates in Australian stream with some species, such as *E. marginata* being processed extremely slowly (BUNN 1988) while others, such as *E. nitens* being processed quite rapidly (CAMPBELL et al. 1991).Thus the thick cuticles and high oil contents per se do not appear to greatly impair shredders in Australian streams. However, like any exotic species, the planting of extensive areas of eucalypts in areas where they are not native will surely have severe impacts on the native biota.

5. Conclusions

Australian stream ecologists welcome interest in our streams by researchers elsewhere. But while Australia may be physically inaccessable to other stream workers, the Australian ecological literature is not. The remoteness of Australia should not be used as an excuse for inadequate consultation of its literature.

6. Acknowledgements

Thanks to SIMON TREADWELL, Water Studies Centre, Monash University for access to unpublished data on stream metabolism.

References

BARMUTA, L. A. (1978): The decomposition of *Eucalyptus obliqua* leaf packs in small stream ecosystems. B. Sc. (hons) Thesis, Zoology Department, University of Adelaide.

BLACKBURN, W. M. (1976): A study of forest litter in relation to a mountain stream ecosystem in Victoria. B. Sc. (hons) Thesis, Zoology Department, Monash University.

BLACKBURN, W. M. & PETR, T. (1979): Forest litter decomposition and benthos in a mountain stream in Victoria, Australia. Arch. Hydrobiol. **86**: 453–498.

BUNN, S. E. (1986): Origin and fate of organic matter in Australian upland streams. In DEDEKKER, P. & WILLIAMS, W. D. (eds), Limnology in Australia. CSIRO, Melbourne.

– (1988): Processing of leaf litter in two northern jarrah forest streams, Western Australia. I. Seasonal differences. Hydrobiologia **162**: 196–210.

CAMPBELL, I. C., CUMMINS, K. W. & JAMES, K. R. (1991): A preliminary investigation of seasonal differences in leaf decomposition patterns in Australian streams. Ver. Internat. Verein. Limnol. **24**: 2071–2075.

CAMPBELL, I. C. & FUCHSHUBER, L. (submitted): Amount, composition and seasonality of litter accession to an Australian cool temperate rainforest stream, and possible consequences for the stream invertebrate fauna. Arch. Hydrobiol.

CAMPBELL, I. C., JAMES, K. R., HART, B. T. & DEVEREAUX, A. (1992): Allochthonous coarse particulate organic material in forest and pasture reaches of two south-eastern Australian streams. I. Litter accession. Freshwat. Biol. **27**: 341–352.

COWLING, S. W. & WADE, J. S. (1963): Aquatic hyphomycetes in Australia. Aust. J. Sci. **26**: 122–123.

GRAÇA, M. A. S. (1993): Patterns and processes in detritus-based stream ecosystems. Limnologica **23**: 107–114.

HUTSON, B. R. & VEITCH, L. G. (1985): Relationship between litterfall rate, litter mass and decomposition rate in *Eucalyptus* forests in southeastern Australia. Aust. J. Ecol. **10**: 443–450.

LAKE, P. S. (1982): Ecology of macroinvertebrates of Australian upland streams – a review of current knowledge. Bull. Aust. Soc. Limnol. **8**: 1–15.

LAKE, P. S., BARMUTA, L. A., BOULTON, A. J., CAMPBELL, I. C. & STCLAIR, R. (1985): Australian streams and Northern Hemisphere stream ecology: comparisons and problems. In: DODSON, J. R. & WESTOBY, M. (eds), Are Australian Ecosystems Different? Proc. Ecol. Soc. Aust. **14**: 61–82.

MACAULEY, B. J. & FOX, L. R. (1980): Variations in total phenols and condensed tannins in Eucalyptus: leaf phenology and insect grazing. Aust. J. Ecol. **5**: 341–352.

O'KEEFE, M. A. & LAKE, P. S. (1987): The decomposition of pine, eucalypt and *Acacia* litter in a small upland Victorian stream. Bull. Aust. Soc. Limnol. **11**: 15–32.

PETERSEN, R. C. & CUMMINS, K. W. (1974): Leaf processing in a woodland stream. Freshwat. Biol. **4**: 343–368.

PIDGEON, R. W. J. (1978): Energy flow in a small stream community: an evaluation of the effects of different riparian vegetation. PhD Thesis, University of New England.

POLGLASE, P. J. & ATTIWILL, P. M. (1992): Nitrogen and phosphorus cycling in relation to stand age of *Eucalyptus regnans* F. MUELL. Plant Soil **142**: 157–166.

PRESSLAND, A. J. (1982): Litter production and decomposition from an overstorey of *Eucalyptus* spp. on two catchments in the New England region of New South Wales. Aust. J. Ecol. **7**: 171–180.

ROUTLEY, R. & ROUTLEY, V. (1974): The Fight for the Forests. 2nd ed. Research School of Social Sciences, Australian National University, Canberra.

THOMAS, K., CHILVERS, G. A. & NORRIS, R. H. (1989): Seasonal occurrence of conidia of aquatic hyphomycetes (Fungi) in Lees Creek, Australian Capital Territory. Aust. J. Mar. Freshwat. Res. **40**: 11–23.

– (1991): A dynamic model of fungal spora in a freshwater stream. Mycol. Res. **95**: 184–188.

– (1992a): Aquatic hyphomycetes from different substrates: Substrate preference and seasonal occurrence. Aust. J. Mar. Freshwat. Res. **43**: 491–509.

– (1992b): Colonization and persistence of aquatic hyphomycetes on *Eucalyptus viminalis* bark and twigs in an Australian stream. Nova Hedwigia **55**: 407–418.

WILLIAMS, W. D. (1988): Limnological imbalances: an antipodean viewpoint. Freshwat. Biol. **20**: 407–411.

WINTERBOURN, M. J., ROUNICK, J. S. & COWIE, B. (1981): Are New Zealand stream ecosystems really different? N.Z.J. Mar. Freshwat. Res. **15**: 321–328.

Received: 14. 12. 1993

Address for correspondence: Dr. I. C. CAMPBELL, Department of Ecology and Evolutionary Biology, Monash University, Clayton 3168, Australia.