Verh. Internat. Verein. Limnol. | 22 | 2141—2147 | Stuttgart, März 1985

The macroinvertebrate community of stones in an Australian upland stream

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With 6 figures and 1 table in the text

The assemblage of macroinvertebrates dwelling on stones in upland streams is capable of being sampled without contamination by animals from other substrates or from the drift (Doeg & Lake 1981) and consists of a unit consistently sampleable from stream to stream (Stout & Vandermeer 1975). A further advantage of the fauna of stones as a unit of study is that stones are very amenable to manipulation for experimental purposes (Fox 1977).

The first aim of this study was to examine the composition (and its temporal changes) of the fauna living on stones in a typical upland temperate Australian stream. This fauna was also investigated to determine the representation within it of the different macroinvertebrate functional feeding groups (sensu Cummins & Klug 1979) and how this representation changes with time.

It has been claimed that the fauna of Australasian streams is less diverse than that of comparable northern hemisphere streams (e.g. Williams & Wan 1972; Winterbourn 1978, 1980) and thus a further aim was to compare the species richness of the stone fauna of the studied stream with that reported from streams elsewhere. The temporal changes in species richness and some other properties of community structure (e.g. species abundance and certain heterogeneity indices) were also investigated to determine how such parameters varied with flooding and a period of low flow (drought), both of which are known to adversely affect stream faunas (Hynes 1970).

Study site

The Acheron River rises on the Great Dividing Range, Victoria, and drains north into the Goulburn River, a tributary of the Murray River. The study site (145°45′ E, 37°39′ S) was located 75 km north-east of Melbourne at an altitude of 670 m. At this point the river is a second order stream with an average width of 4 m. The site was 70 m long and consisted of two riffles separated by a short boulder-strewn section. the substratum of the sampled riffles was dominated by stones (Phi scale −6, −7, viz. Cummins 1962) with some pebbles, gravel and coarse sand. The vegetation of the catchment around the site consists of wet sclerophyll forest dominated by *Eucalyptus regnans* with patches of *Nothofagus cunninghamii* in the gullies. Immediately alongside the stream, and forming a complete canopy over it, where *N. cunninghamii*, *Acacia melanoxylon* and *Dicksonia antarctica*.

Rainfall data were obtained for Narbethong (18 km from the study site) and discharge data were obtained for Taggerty (49 km downstream from the study site).

Methods

Stones were sampled 10 times between February 1979 and March 1980 at approximately regular intervals. On each occasion 15 randomly selected rocks were sampled using the method of Doeg & Lake (1981). Prior to the sampling of each stone, its depth below the water surface was recorded and the current velocity 10 cm lateral to it was measured. Water temperature, conductivity and pH were routinely determined using a "Hydrolab" multi-parameter probe.

0368-0770/85/0022-2141 $ 1.75

Results and discussion

The conductivity of the stream was low, varying from a K_{18} of 22.2 $\mu S \cdot cm^{-1}$ in July 1979 to 31.8 $\mu S \cdot cm^{-1}$ in March 1980, a time of very low flow. The stream was slightly alkaline, having a pH range of 7.5—7.6 in winter and 7.8—8.0 in summer. The maximum and minimum water temperatures recorded were 5.8 °C (in July 1979) and 13.5 °C (in February 1979), respectively. Peak rainfall occurred in late winter and early spring while the period January to March 1980 was very dry (Fig. 1). Generally, stream discharge volumes coincided with rainfall (Fig. 1).

The depth in the stream of the stones sampled did not vary significantly ($p < 0.05$) and all parts of the study site were accessible throughout the study. However, current velocity did vary significantly: mean velocities of 96 and 79 $cm \cdot s^{-1}$ were recorded in July and August 1979, respectively, whereas mean velocities of only 36 and 39 $cm \cdot s^{-1}$ were recorded for January and March 1980. Evidently, the considerable variations which may occur in discharge in small streams such as the Acheron are reflected in the current velocity rather than in the depth. The total area of the stones sampled per sampling occasion did not vary significantly and hence the changes in species abundance and species richness which were found cannot be attributed to changes in area sampled.

A total of 9518 animals, comprising 55 taxa, were collected and identified. Insects formed the major portion of the fauna (95 %) with the best represented orders being the Plecoptera (16 spp.), Trichoptera (14 spp.) and Diptera (12 spp.). The most common taxa were *Agapetus* sp. (Glossosomatidae), *Atalonella* sp. (Leptophlebiidae), *Riekoperla williamsi* (Gripopterygidae), *Paramoera fontana* (Amphipoda, Eusiridae) and *Baetis* sp. (Baetidae) (Table 1).

With respect to the changes in their abundance with time, the more common taxa can be allocated to four groups, each exhibiting a different trend: (i) ten taxa (*Atalonella* sp., *Baetis* sp., *Dinotoperla arenaria*, *Simsonia* sp., *Kingolus* sp., *Cricotopus* sp., Orthocladiinae sp. A, Diamesinae sp., *Austrosimulium* sp. and *Paramoera fontana*) occurred at maximum abundance in early- to mid-summer; (ii) three taxa (*Riethia* sp., *Austropsyche victoriana* and *Eusthenioptsis venosa*) peaked in abundance in autumn; (iii) eight taxa (*Riekoperla williamsi*, *Riekoperla rugosa*, *Illiesoperla australis*, *Eunotoperla kershawi*, *Trinotoperla irrorata*,

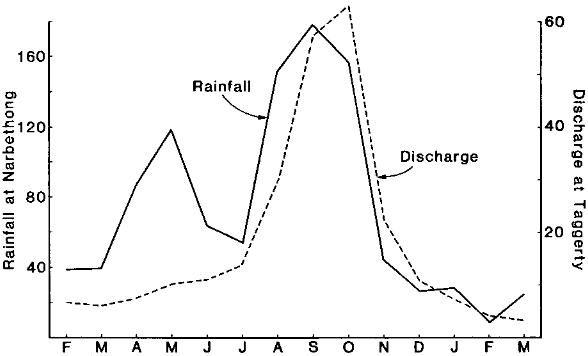

Fig. 1. Variation in rainfall and discharge in the Acheron River during the study period. Rainfall in mm. Discharge in $ml \cdot day^{-1}$.

Table 1. Composition of the fauna on the stones of the Acheron River. The figures in parentheses indicate the percentage abundances of the more common taxa. Rare taxa (total abundance <0.1 %) are not shown.

A: Common taxa (total abundance >1.0 %)		B: Uncommon taxa (total abundance >0.1 % but <1.0 %)
ANNELIDA		ARTHROPODA
Oligochaeta		Insecta
Tubificidae sp.	(1.32)	Ephemeroptera
ARTHROPODA		*Coloburiscoides munionga*
Crustacea		Plecoptera
Amphipoda		*Eustheniopsis venosa*
Paramoera fontana	(7.88)	*Eunotoperla kershawi*
Insecta		*Illiesoperla australis*
Ephemeroptera		*Trinotoperla irrorata*
Atalonella sp.	(17.30)	*Neboissoperla alpina*
Baetis sp.	(5.48)	*Leptoperla bifida*
Plecoptera		*Dinotoperla arenaria*
Riekoperla williamsi	(14.55)	*Riekoperla tuberculata*
Riekoperla rugosa	(1.49)	*Austrocercella* sp.
Trichoptera		Trichoptera
Agapetus sp.	(18.92)	*Austrheithrus* sp.
Alloecella grisea	(2.22)	*Ecnomus* sp.
Austropsyche victoriana	(4.77)	*Ethochorema* sp.
Hydrobiosella sp.	(1.11)	*Ulmerochorema* sp.
Coleoptera		Hydrobiosidae sp.
Simsonia sp.	(1.87)	Coleoptera
Diptera		*Kingolus* sp.
Eukiefferiella	(4.14)	Diptera
Orthocladiinae sp. A	(1.44)	*Cricotopus* sp.
Diamesinae sp.	(5.04)	*Coelopynia* sp.
Riethia sp.	(1.95)	*Edwardsina australiensis*
Austrosimulium sp.	(2.99)	

Agapetus sp., *Edwardsina australiensis* and *Coelopynia* sp.) peaked in winter; and (iv) at least six species (*Coloburiscoides munionga, Alloecella grisea, Ulmerochorema* sp., Hydrobiosidae sp. A., *Eukiefferiella* sp. and Tubificidae sp.) occurred in fairly constant numbers over the sampling period.

Comparison of the number of species found on the stones of the Acheron River with numbers found elsewhere is difficult because of the great variations in sampling effort and efficiency between different studies. However, the number of taxa (species) collected in this study (55) does appear to compare favourably with the 59, 52, 50, 37, and 31 taxa collected respectively by Minshall (1981), Towns (1979), Badcock (1953), Hynes (1961) and Knott et al. (1978) from similar stony temperate streams. In fact, the stone fauna of the Acheron is almost as rich as the tropical stream stone fauna reported by Stout & Vandermeer (1975). There is no evidence, therefore, that the stone fauna of the Acheron River, and that of comparable upland Australian streams, is depauperate. This appears to apply for perennial upland Australian streams in general (Lake 1982).

No other studies have appeared which have specifically considered the functional feeding groups of the stone fauna in streams. Consequently, it is interesting to note that the seasonal dynamics of these groups are different from those hitherto reported from

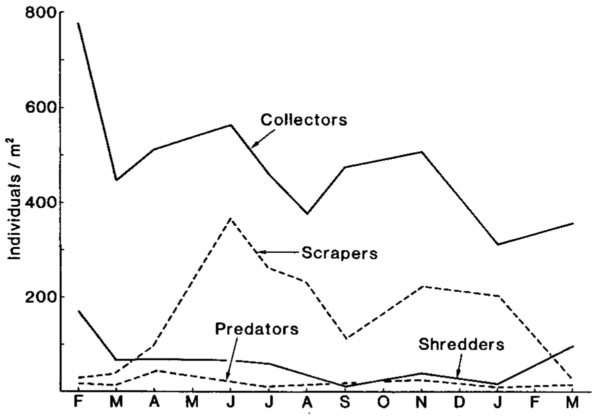

Fig. 2. Densities of the different functional feeding groups present on stones in the Acheron River during the study period.

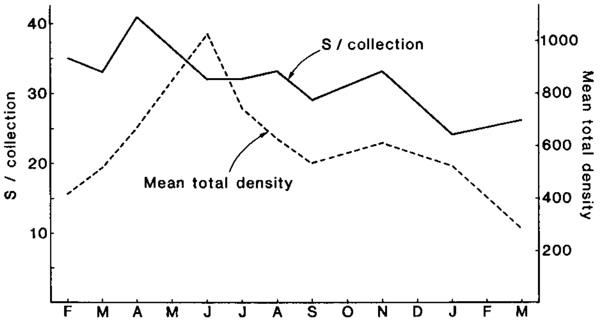

Fig. 3. Variation in number of taxa at each collection and mean total density during the study period.

streams elsewhere. Collectors, principally collector-gatherers rather than collector-filterers, clearly comprise the dominant group at all sampling times, although no clear trends were evident with respect to changes in their density with time (Fig. 2). Shredders occurred at lowest densities in spring—early summer and attained peak densities in late summer—autumn. This peak in density may be due to the summer peak in litter fall of the catchment's eucalypt forest (LAKE 1982) and to the low current velocities in late summer which may allow leaf and bark packs to form around the stones. Scrapers, notably the glossosomatid *Agapetus* sp., peaked in abundance in winter (maximum density 306 animals · m^{-2} in June 1979). This result is somewhat surprising as periphyton production would be expected to be low in winter because of the reduced light availability. However, other factors such as nutrient availability and disturbance by flooding may possibly be of greater importance in controlling periphyton production (ROUNICK & GREGORY 1981).

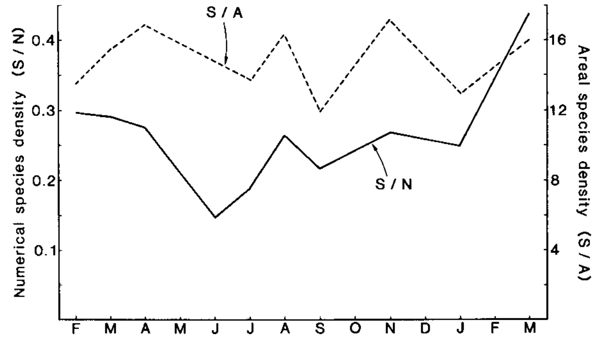

Fig. 4. Variation in numerical species density (S/N) and areal species density (S/A) during the study period.

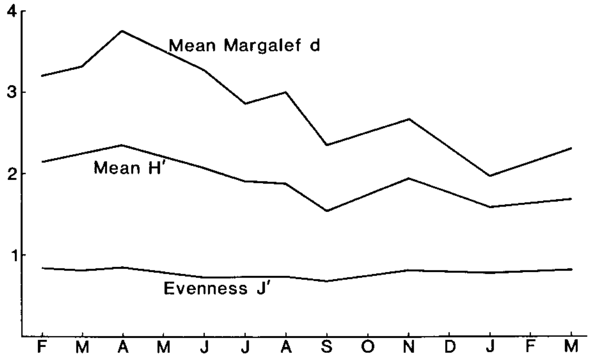

Fig. 5. Variations exhibited by the two heterogeneity indices and evenness, $\lambda' = J'$.

In the community, species constantly come and go. However, although the species turnover rate did not change markedly with time, the mean species turnover rate was a relatively high 0.48 species · day^{-1}. As a consequence of this, and also because of two further factors — the relatively flexible life histories of Australian stream insects (LAKE 1982) and the presence of two recognized forces of disturbance (floods and drought) — a fluctuating and unstable community is to be expected.

On every sampling occasion the species richness (number of species) of the community was not significantly different from an expected value of 32 (Fig. 3). Similarly, no significant change with time was observed for areal species density (number of species per stone/surface area) (Fig. 4). However, the density of animals (number of animals per stone/surface area) did change significantly with time: densities were highest (1024 animals · m^{-2}) in mid-winter and lowest (282 animals · m^{-2}) in late summer (Fig. 3). Consequently, numerical species density (S/N) also varied significantly with time, the values being high in summer and low in winter (Fig. 4).

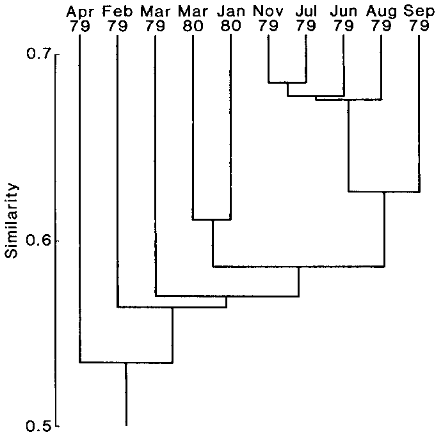

Fig. 6. Dendrogram showing levels of similarity between the different assemblages, based on the Canberra Metric coefficient.

Two heterogeneity indices, Shannon-Wiener H′ and Margalef's d, were calculated for each series of collections. Both varied significantly over the study period: high values were obtained in late summer—autumn and low values in late winter—early spring (Fig. 5). Evenness (λ'), on the other hand, did not change markedly during the study, implying that the variations in the heterogeneity indices are responses more to changes in species abundance than to changes in species richness.

No evidence was found to indicate that the community was adversely affected by winter floods: species richness did not decline with the onset of flooding and the total abundance was also unaffected. On the other hand, abundance reached its lowest level during the drought of February—March 1980 when the discharge was very low, although the species richness again remained unchanged.

Clustering analysis, using either the Jaccard similarity coefficient or the Canberra Metric coefficient (Williams 1976), revealed that the winter—spring assemblages (collections of June, July, August, September and November) formed a distinct group, while the two summer assemblages were dissimilar not only to the winter—spring group but also to each other (Fig. 6). The existence of these distinct groups was confirmed by the use of ordination using Gower principal coordinate analysis (Williams 1976). The similarity between the two summer assemblages, or their persistence (vide Grossman 1982), was low.

It is evident, therefore, that while the upland stream stone fauna community, by the criteria of Grossman (1982) and Grossman et al. (1982), exhibits some properties of a deterministic community (e. g. a constancy in species richness in spite of possible perturbation, i. e. resistance) it also shows several properties suggestive of a stochastic community (e. g. high species turnover rate and low persistence of at least the summer assemblages). The stochastic nature of the community is further attested to by unpublished work of ours on faunal colonization of stones: the colonization is rapid, suggestive of a high resilience typical of stochastic communities.

Acknowledgement

The work was partly supported by a Monash University Special Purpose Research Grant.

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