HIGH-ALTITUDE STREAM FAUNAS IN THE MT PELION EAST–MT DORIS AREA OF TASMANIA

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(with four tables and four text-figures)

SWAIN, R., CHLADIL, M.A. & SUMMERS, C.R., 1994 (30:vi): High-altitude stream faunas in the Mt Pelion East–Mt Doris area of Tasmania. *Pap. Proc. R. Soc. Tasm.* 128: 31–39. https://doi.org/10.26749/rstpp.128.31 ISSN 0080-4703. Department of Zoology (RS, CS) and Department of Geography and Environmental Studies (MC), University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001.

A survey was carried out of the aquatic fauna of the headwaters of two high-altitude (1170–1355 m) streams draining Mt Doris and two streams draining Mt Pelion East in Tasmania. Although the fauna above the treeline appeared to be characterised primarily by the loss of downstream fauna, three Trichoptera (*Notoperata maculata*, an unidentified genus from the Kokiriidae, and *Plectrotarsus* sp.) and one crustacean (*Neoniphargus* sp.) may form part of a specialised high-altitude fauna. The amphipod *Neoniphargus* sp. was collected from above the treeline only, whereas the other amphipod recorded, *Antipodeus* sp., was found at or below the treeline only. Cluster analyses enabled five habitat and three species groupings to be recognised. Since the habitat groupings were generally well defined by their physico-chemical characteristics as well as by the faunal groups, it is concluded that they reflect a genuine series of identifiable high-altitude stream habitats.
Keywords: alpine, high-altitude, stream fauna, Tasmania.

INTRODUCTION

Tasmania possesses a large proportion of Australia's high-altitude (above treeline) land yet, despite the considerable biogeographical importance attached to much of the island's aquatic fauna (e.g. Hynes & Hynes 1980, Swain *et al.* 1977, Williams 1974), no study of stream communities in a high-altitude source-stream has been carried out. Numerous studies of individual taxa have included high-altitude collections (e.g. Dean and Cartwright 1992, Hynes 1989, Neboiss 1977) but, since these works have been directed usually towards clarifying taxonomic or distributional questions, they have not led to generalisations about the faunal characteristics of subalpine streams in Tasmania. As part of the 1992 Wilderness Ecosystems Baseline Studies conducted by the Tasmanian Department of Parks, Wildlife and Heritage, we conducted a late summer survey of the fauna of four source-streams in the vicinity of Mt Pelion, within the Tasmanian Wilderness World Heritage Area in western Tasmania. Two streams were located on Mt Doris and two on Mt Pelion East, collectively representing a wide range of sub-alpine lotic habitats. In two of the streams, faunal samples were also obtained from just below the treeline but the topography made this impossible in the other two. All taxa found were collected, but the investigators had a particular interest in amphipods, syncarids and stoneflies, not only because these are relatively well known taxonomically, but also because it was considered that they are the most likely to contain species of value as high-altitude "markers", if such species exist.

METHODS

The fieldwork was carried out between 20 January and 2 February 1992 (MC and CS). Although the weather was generally unpleasant, we do not believe that collection efficiency was reduced. Fauna was collected from 30 sites.

Selection of streams

Four streams were selected by walking the area; the location of collection sites (fig. 1) was determined from the Tasmania 1:25 000 topographic sheet *Cathedral* (4236, Edition 2 1988), to which all grid references refer, using an altimeter and aerial photographs obtained from the 1976 Cradle Mountain Lake St Clair Project F505, Numbers T695-42 to T695-45.

Physical data

At each site elevation, slope and aspect were estimated using an altimeter, a compass and a clinometer. Water pH and temperature were measured using a Hanna Instruments® Portable Microprocessor pH Meter HI 8424. Water conductivity was determined using a Hanna Instruments® Portable Conductivity Meter HI 8633. Vegetation notes were made and summarised as communities (*sensu* Balmer 1991), with the most common species observed and identifiable being listed.

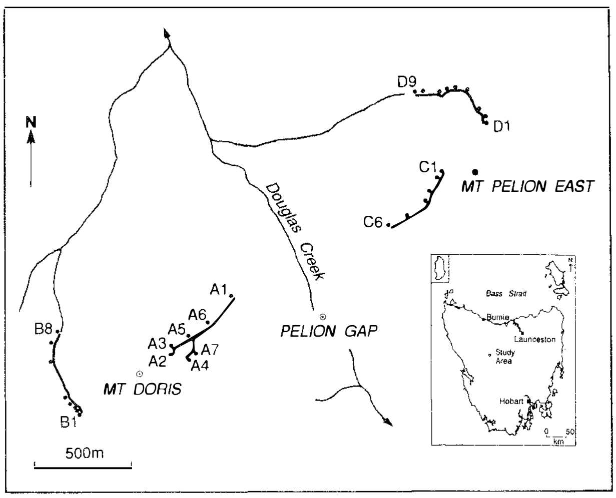

FIG. 1 — Location of study sites.

Sampling

Freshwater invertebrates and substrate samples were collected using an FBA net and hand sieves. Sampling continued until the collectors were confident that further effort would be unproductive; samples from each site were transferred to the base camp (Pelion Valley Ranger's Hut), hand sorted twice, and any fauna present preserved in formalin for later identification in Hobart.

The study streams

All four streams surveyed form part of the headwaters of Douglas Creek, itself a tributary of the Forth River. They flow through Permian/Triassic sandstones and quartzites. The Jurassic dolerite caps of Mts Doris, Ossa and Pelion East have formed scree slopes and blockstreams, largely through glacial and periglacial processes. The streams originate in these blockstreams and then flow through channels that do not seem to be actively eroding. Rather, the amount of moss in the channels and the discontinuous surface flow suggests that the channels are being infilled. Consequently the term "stream" is used somewhat loosely, since the distinctions between stream proper, pool, runnel, surface run-off, and even small tarn, were often very indistinct. Summary data identifying each collection site are provided in table 1.

Stream A is the least discrere of the streams sampled; it originates as a soak flowing from the vegetated lower section of the blockstream on the northeastern side of Mt Doris. The highest discernible point is a small tarn (Site A2, GR 209 645.5) with no inflowing channel. Seven samples were obtained from a 250 m length, with a fall from 1270 m to 1200 m where the stream flows over a small cliffline and into the treeline. It is not continuous (site A4 is directly downslope from A2 but there is no connecting channel) and overland flow obviously is a frequent feature of this "stream".

Stream B begins in the scree on the saddle between Mts Doris and Ossa and flows north. The originating pool is at 1254 m elevation (GR 205 642.5), and eight samples were obtained, the lowest being within the treeline at 1170 m. Total length of this section was 300 m. This stream is continuous, although some small tributary seepages also contribute to the flow.

Stream C originates as several small tarns on a shelf below the blockstream on the west face of Mt Pelion East at 1352 m. It flows southwesterly until it disappears underground just above a cliffline (c.1200 m) which is above the treeline north of Pelion Gap. This stream has no obvious continuous channel below the treeline. Six samples were taken from 1352 m to 1240 m, over a length of 400 m. Site C2 is the tarn marked at GR 223 654.

Stream D emerges from the scree slope above the saddle on the north face of Mt Pelion East at 1355 m and flows northwest towards the saddle. From the saddle it flows in a westerly direction down through the treeline to Douglas Creek. Although site D1 (GR 225 657.5) is on quartzite, there is dolerite lower down the slope, as a result of mass movement. The lowest sample (D9) was taken just below the treeline at 1260 m, 300 m from D1.

Statistical analyses

Sites and species were classified by cluster analysis using the statistical package PATN (Belbin 1991). For sites, the Kulczynski dissimilarity coefficient was calculated from log transformed data. The robustness of this coefficient as a measure of ecological distance was established by Faith *et al.* (1987). The dissimilarity matrix created was converted into site groupings, using the unweighted pair group average (UPGMA) procedure of Sneath & Sokal (1973). Dissimilarity coefficients for the classification of species according to their shared occurrences were obtained by the TWO-STEP measure of Austin & Belbin (1982). Since this measure is sensitive to species abundances, standardisation was carried out by dividing all samples by the square root of the sum of squares of the species' abundance (Austin & Belbin 1982). Clustering was again achieved using the UPMGA procedure. A two-way site/species table was created from the dissimilarity coefficients in order to examine the relationships between site and faunal groupings. As a test of the conclusions reached by clustering, ordination of the site dara was also carried out with PATN, using semi-srrong hybrid multi-dimensional scaling (Minchin 1987).

RESULTS

Descriptive summaries of each site and the fauna collected are provided in tables 1 and 2 respectively.

The streams proved to be somewhat depauperate, with the 30 sites yielding a total of 37 taxa (table 2). Of these, 13 occurred only once, and a further seven were found on two occasions only. Relatively few taxa could be considered common, the most frequently collected species being a phreodrilid annelid (21 sites), *Neoniphargus* sp. (18 sites) and *Anaspides tasmaniae* (8 sites); in addition, chironomids and tipulids, which were not identified beyond Family, were found at 14 and 11 sites respectively. Numerically, the collections were dominated by *Neoniphargus* sp. (752 individuals — a collection dominated by site A6), phreodrilids (297), *Antipodeus* sp. (74), *Anaspides tasmaniae* (73), and chironomid larvae (40). Diversity was similar in streams A and B (20 & 21 taxa respectively), a little lower in stream D (15 taxa) and much lower in stream C (9 taxa only); although fewer sites were sampled along stream C, the absence of fauna is probably because this stream was the most exposed — most sites faced SSW.

Only four taxa, the phreodrilid, *Neoniphargus* sp., tipulids and chironomids were collected in all streams, although the ubiquitous presence of the crayfish, *Parastacoides tasmanicus tasmanicus*, was also indicated by the occurrence of its burrows.

Clustering of the sites identified five putative groups (fig. 2). One of these is very large, incorporating 21 collection sites, one consists of a single site only and may be an artefact of the analysis, two are made up of three sites and the final group is defined by two sites. These groups were examined for any consistency in physico-chemical characteristics (table 3).

Group I consisted of a large collection of high-altitude sites, mostly small pools on moderate slopes, that represent the surface origins of the four streams studied. No consistent aspect is presented, though most sites are reasonably sheltered within low-growing alpine heath and are characterised by warm water with relatively high conductivity and slight to severe acidity. The group contains all stream C sites, all but one from stream A and all but two from stream D, but only two sites from stream B.

Group II was a single site with close faunistic similarities to Group I. Although most physico-chemical characteristics overlap with those exhibited by Group I, they are generally at the extreme of the range; the clearest differences are the easterly aspect and the low (for this study) altitude.

Group III comprised three pool sites on flat ground with a westerly aspect, identified as part of stream B. The pools were large and shallow (table 1) and the water was relatively warm, with almost neutral pH and high conductivity.

Group IV consisted of three adjacent running-water sites on a reasonably steep, westerly facing slope; they were part of stream B as it approached the treeline, and drained the pools of Group III. The water was cold with low conductivity and near neutral pH, and the surrounding vegetation was above 2 m in height (table 1).

The final grouping recognised by the analysis (Group V) consisted of two lotic sites, facing west, on stream D; although they were the lowest sites for this stream, located at the edge of the treeline, they were still the second highest of the site groups. The slope was steep, the surrounding vegetation was relatively tall (2–4 m), and the water was cold, with low conductivity and almost neutral pH.

Clustering of the fauna identified four faunal groups (fig. 3). These appear to make good biological sense and represent a "seepage/runnel fauna", a "large pool/tarn fauna" and "stream faunas", of which two were revealed (fig. 3). Both stream faunas contain typical stream-dwelling taxa and their separation is considered to be an artefact of the analysis. It arises because one of them (Group 3) was formed by five taxa, all of which occurred at site B7, with four of them occurring nowhere else (table 4). Group 1 was characterised by 17 taxa that were collected from slow-flowing runnels and seepage pools at high altitudes. Most species occurred in low numbers at a reasonably large number of sites (table 2); notable exceptions were the phreodrilid annelid and the amphipod *Neoniphargus* sp., both very numerous at some sites. Four of the taxa collected may form part of a high-altitude aquatic fauna. One of these, *Neoniphargus* sp., is a crustacean, the others are Trichoptera (*Notoperata maculata*, an unidentified genus from the Kokiriidae and *Plectrotarsus* sp.).

Six taxa found in the larger, open pools and tarns grouped together to form Group 2. Although six sites had representatives of this assemblage, most specimens were collected from just two sites: site A2, where all six taxa were found, and site D2, where three were collected.

Groups 3 and 4 comprised 14 taxa commonly collected from cold upland streams in Tasmania. Not surprisingly, since they provided the most clearly identifiable stream systems, stream B and the lowest sites on stream D, they provided most of the material collected.

The two-way site/species matrix created from the dissimilarity coefficients obtained during the clustering analyses is presented in table 4.

The five site groupings discussed above are also identifiable following the ordination of the data, adding further support to the conclusion that they represent valid habitat categories. Figure 4, which is a scatter plot of axes 1 and 2, illustrates the separation of the groupings. In figure 4, site group V is overlaid by group III; these two groups are clearly separated by axis 3.

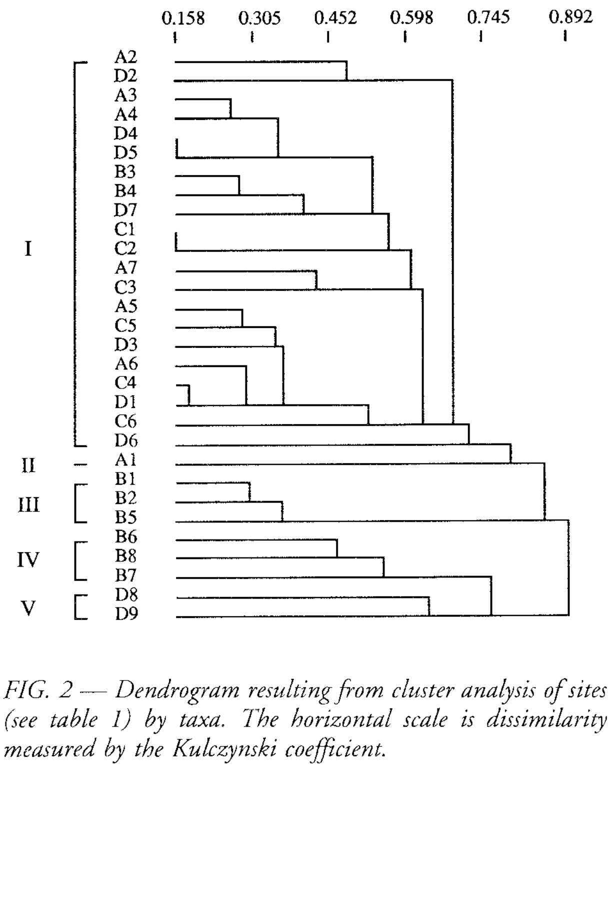

FIG. 2 — Dendrogram resulting from cluster analysis of sites (see table 1) by taxa. The horizontal scale is dissimilarity measured by the Kulczynski coefficient.

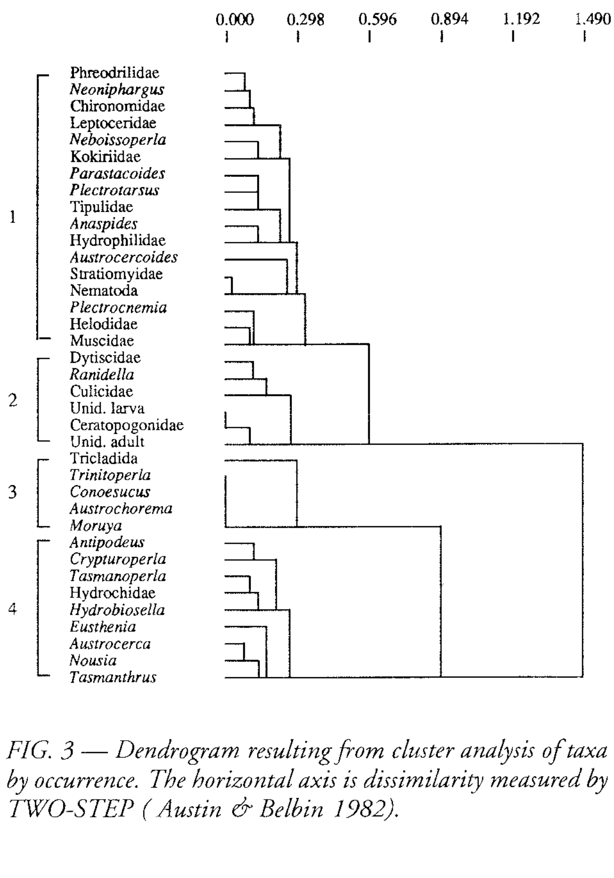

FIG. 3 — Dendrogram resulting from cluster analysis of taxa by occurrence. The horizontal axis is dissimilarity measured by TWO-STEP (Austin & Belbin 1982).

TABLE 1
Summary of site descriptions

Site	Elev. m	Aspect	Slope °	Temp °C	pH	Cond. µS/cm	Substrate	Description	Dimensions L×W×D m	Vegetation Community
Stream A (NE from Mt Doris)										
A2	1270	NNE	5	10	3.84	16	Mud	Tarn	3×5×0.1	Coniferous heath (3m,shrubbery)
A3	1270	NNE	5	9.6	5.58	26	Moss	Stream 5m below A2	5×0.3×0.02	Coniferous heath (3m,shrubbery)
A4	1245	ENE	2	10.9	4.51	27	Mud/moss	Two connected pools 30m below, but separated from A2	1.4×1×0.2; 0.7×1.3×0.15	Conif heath(1.5m)
A7	1240	N	2	9.7	4.35	41	Mud	Two pools near break in slope between A4 &A5	3×2×0.15; 2×1×0.2	Conif. heath/short alpine herbfield
A5	1240	NE	<2	12.2	4.35	22	Mud/moss	String of pools 60m from A4	5×0.3×0.2	Alpine heath (1m)
A6	1210	NNE	5	9.2	4.17	32	Moss,rock	String of pools in heath, no channel	5×0.6×0.2	Alpine heath (0.5m)
A1	1200	ENE	10	9.3	4.22	31	Mud, moss	Pools and fen at edge of cliffline	0.3×0.3×0.2	Alpine heath (0.5m)
Stream B (N from Ossa/Doris saddle)										
B1	1254	NW	<2	12.6	6.07	34	Mud	Pool in dolerite boulders	3×3×0.8	Bolster heath
B2	1254	NNW	<2	14.3	6.38	27	Mud	Pool 10m from B1 connected by fen	3×3.5×0.3	Bolster heath
B3	1252	NW	5	8.7	5.64	29	Moss	Pool 30m from B2	1.5×1×0.3	Alpine heath (1m)
B4	1245	WNW	2	12	5.88	18	Mud/moss	Stream 20m from B3	5×0.2×0.05	Alpine heath/short alpine herbfield
B5	1245	NW	2	7.1	6.14	23	Mud/moss	Stream with pools 10m from B4	5×0.1×0.1	Alpine heath
B6	1215	WNW	7	6.8	6.4	13	Moss	Stream flowing under pencil pines 25m from B5	5x0.1x0.1	Coniferous heath (2m, Shrubbery) coniferous alpine
B7	1190	NNW	10	7.3	6.23	17	Rock, litter	Stream flowing over rock at edge of treeline, 100m from B6	5×0.4×0.1	Alpine heath(2m)
B8	1170	NNW	30	8.7	5.72	16	Gravel, litter	Stream 100m from B7	5×0.6×0.2	Alpine woodland (3m)
Stream C (SW from tarns on W face of Pelion East)										
C1	1352	SSW	<2	23.8	5.24	20	Mud,moss, plants	Tarn at foot of dolerite block stream with no incoming channel	8×6.5×0.3	Alpine heath (0.5m)
C2	1350	SSW	<2	16.8	5.19	21	Rocks,mud	Large tarn on shelf fed from C1 via a series of small pools, 30m from C1	15×15×0.5	Alpine heath (1m)
C3	1348	SSW	5	18.7	4.84	18	Mud,moss, plants	Pool 25m from C2 fed by soaks and pools	5×3×0.1	Alpine heath (0.3m)
C4	1335	SSW	20	9.7	5.62	18	Mud	3 main pools 100m from C3 fed by soaks and small channels in a semi-buried blockstream	1.5×1.5×0.1; 0.5×0.4×0.15; 1.5x2×0.1	Alpine heath(0.3m)/ bolster heath
C5	1280	SW	15	7.8	5.65	10	Mud	Stream 120m from C4	5×0.4×0.1	Bolster field/fen
C6	1240	WSW	20	9.8	5.65	13	Mud	Pool and stream fed by soaks and fen disappearing underground	0.3×0.5×0.4(p) 3×1×0.15(st)	Alpine heath(1m)

Table 1 cont.

Site	Elev. m	Aspect	Slope °	Temp °C	pH	Cond. µS/cm	Substrate	Description	Dimensions L×W×D m	Vegetation Community
Stream D (W from saddle N of Pelion East)										
D1	1355	NW	10	11.9	6.29	22	Moss	Pools linked to drainage heading towards saddle	3.5×0.2×0.2	Bolster heath/ alpine heath (0.3m)
D2	1350	WNW	7	17.2	5.98	20	Mud	Pool 40m from D1	4×3×0.2	Alpine heath(0.3m)/ bolster heath
D3	1345	W	5	14.3	5.36	22	Moss	Pools 25m below D2	5×0.2×0.15	Alpine heath(0.3m)/ bolster heath
D4	1335	W	5	19.7	5.32	22	Moss	Pools 30m from D3 around cushion plants with identifiable channel	5×0.2×0.1	Alpine heath(0.3m)/ bolster heath
D5	1325	WSW	15	9.5	5.35	18	Moss	Infilled channel with soaks and pools, emerges from fen above, 50m from D4	5x2x0.1	Alpine heath(0.3m)/ bolster heath
D6	1320	WSW	20	11.1	5.96	24	Moss	Stream 20m from D5	5×0.2×0.1	Bolster heath
D7	1310	W	12	10.3	6.42	20	Moss	Stream 30m from D6	5×0.15× 0.01-0.1	Bolster heath/alpine sedgeland(0.01m)
D8	1280	W	20	7.2	6.13	16	Moss	Stream 100m from D7, just above treeline	5×0.2× 0.01-0.1	Alpine heath(2m, shrubbery)
D9	1260	SW	35	8.3	6.72	15	Gravel/sand/ mud/litter	Stream within treeline, 100m from D8	5×0.5×0.2	Wet forest(4m)

DISCUSSION

The 37 taxa collected represent about half the number recorded from lower altitude streams and rivers in western and south-western Tasmania (Swain & White 1985). The restricted fauna collected is presumably directly related to the two dominant characteristics of the "streams" sampled: lack of protection from climatic extremes and the absence of a distinct stream course. The "streams" were essentially collection pools of varying size connected, often only tenuously, by seepage channels. It is usually not until the drainage course reaches the protection of the treeline that a distinct stream channel can be identified.

Our original intention was to sample into the treeline. This proved impossible in streams A and C, and difficult in B and D, where single samples, 100 m below the treeline, were obtained in each case. Consequently, it is not possible to compare above and below faunas in any detail. It would be expected that both diversity and abundance would increase below the treeline, but the present survey provides no strong support for this hypothesis. However, it is worth noting that in stream B, at least, both taxa and individuals were most abundant at and below the treeline (table 2). Indirect support also comes from Dean & Cartwright (1992) who, working at lower altitudes in the same area, found far fewer plecopteran, ephemeropteran and trichopteran species in small headwater streams than in larger downstream sites.

Several taxa were recorded from above the treeline only, and four of these justify further investigation as potential representatives of a specialised high-altitude fauna. These are *Neoniphargus* sp. (Amphipoda) and the trichopterans *Notoperata maculata*, the unidentified genus from the Kokiriidae and *Plectrotarsus* sp. No firm conclusions can be reached until the streams have been surveyed at lower altitude, but it is interesting that none of the Trichoptera were recorded by Dean & Cartwright (1992) in their survey of aquatic insects from forested sites in the Pelion Valley. Although there may be a small number of species exclusively associated with habitats above the treeline, it would appear from our preliminary survey that the high-altitude aquatic fauna is characterised by the loss, rather than the appearance of species. Thus, for example, the greatest numbers of Plecoptera and Ephemeroptera were collected at or below the treeline, and both taxa were absent from the highest sites on each "stream" (table 2); the highest altitude for stoneflies was 1280 m (C5, D8), whilst mayflies were much scarcer, occurring at three sites only, the highest of which (D9 — 1260 m) was below the treeline. Most of the stonefly and mayfly nymphs collected were recently hatched, so it is possible that their apparent absence from the higher sites reflects adult requirements for oviposition rather than nymphal habitat needs. However, most species possess two-year life cycles, and the scarcity of larger nymphs in the collections suggests that habitat unsuitability is the more reasonable explanation.

Generalisations, however, are complicated by the very loose definition of "stream" that has been employed. The origins of high-altitude streams are generally indistinct and, although continuity between pools and seepages can usually be determined, a clear stream course is not usually established until below the treeline. In each of the "streams" examined in the present study, the fewest taxa were invariably found in small pools and soaks in very shallow soils (A1, A7, B1, B2, B3, B5, C1, C3, D1); most of these pools were filled by surface collection of rainwater rather than by seepage through the soil. Even though these pools were sampled during a period of persistent rain, only one (B1) was deeper than 30 mm. Few species are able to withstand the harsh and unpredictable conditions presented by such habitats.

TABLE 2
Fauna collected at each site

Taxon	Code*	A2	A3	A4	A7	A5	A6	A1	B1	B2	B3	B4	B5	B6	B7	B8	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	D7	D8	D9	Totals
Oligochaeta																																
'Phreodrilidae'	a	2	26	8	1	4	15				5	13					80	60	1	15	5		21	8	1	7	9	1	10		5	297
Turbellaria																																
Tricladida	x					1									1																	2
Crustacea																																
Amphipoda																																
Neoniphargus sp.	b	1	1			30	500	5	1	1			2							54	28	39	49	1	29	1	1	2	6	1		752
Antipodeus sp.	C													3	7	10														44	10	74
Decapoda																																
Parastacoides t. tasmanicus	g		p†	p				p				p			1						p	1		p								2
Syncarida																																
Anaspides tasmaniae	j								12	35	2	3	8	1		1													11			73
Insecta																																
Plecoptera																																
Eustheniidae																																
Eusthenia spectabilis gp	H															2															3	5
Notonemouridae																																
Austrocerca tasmanica	I															10																10
Austrocercoides sp.	I																														1	1
Gripopterygidae																																
Neboissoperla sp.	e					1															1	2										4
Trinotoperla tasmanica	y														1																	1
Austroperlidae																																
Crypturoperla paradoxa	D												2	3	20	2																27
Tasmanoperla thalia	E													1	1	7																9
Ephemeroptera																																
Leptophlebiidae																																
Nousia sp. 7	J													1		12																13
Trichoptera																																
Leptoceridae																																
Notoperata maculata	d	1			3	5	20	2																								31
Plectrotarsidae																																
Plectrotarsus sp.	h		1	1		1																		1	2		1					7
Philorheithridae																																
Tasmanthrus galbinomaculatus	K													1		1																2
Kokiriidae																																
unidentified genus	f																					10										10
Conoesucidae																																
Conoesucus sp.	z														1																	1
Polycentropodidae																																
Plectrocnemia sp.	o			1																												1
Philopotamidae																																
Hydrobiosella cognata?	G														2	1																3
Hydrobiosidae																																
Austrochorema sp.	A														1																	1
Moruya sp.	B														1																	1
Coleoptera																																
?Hydrochidae sp.	F	1						3						1	2	4																11
Dytiscidae sp.	r	1					1											1						3							1	7
unidentified larva	u	1																														1
unidentified adult	w	2																														2
?Hydrophilidae sp.	k		4						1			1		1																		7
Helodidae sp.	P		1																													1
Diptera																																
Tipulidae sp.	i		3	3	5	2	1					1				1			1		1				1	1						20
Culicidae sp.	t	3														1								1								5
Chironomidae sp.	c	4	2	1		1	1			2									6	1					5	3	3	7	1	3		40
Cerotopogonidae sp.	v	1																														1
Muscidae sp.	q		1	1													1															3
Stratiomyidae sp.	m																											2	1			3
Nematoda																																
sp.	n																											3				3
Amphibia																																
Ranidella tasmaniensis	s	6																						13								19
Totals		23	39	15	9	45	538	10	14	38	7	18	12	12	38	52	80	62	1	76	35	53	70	27	38	12	14	16	29	48	20	1450

* Cross reference code for table 4. † Burrows present

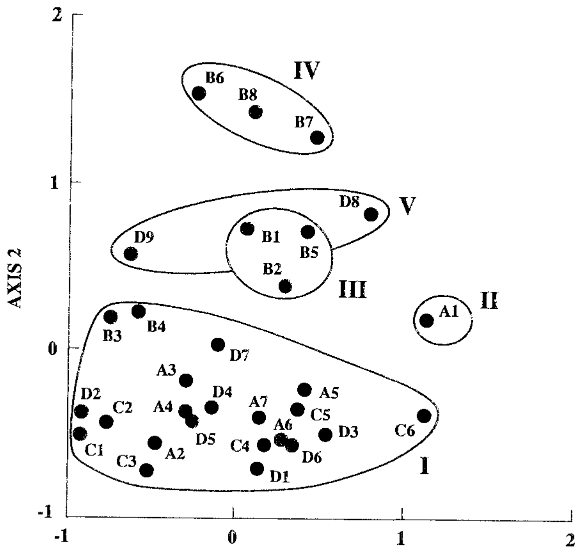

FIG. 4 — Grouping of study sites along ordination axes 1 and 2 following semi-strong hybrid multidimensional scaling. Roman numerals identify the site groupings identified in figure 2.

Syncarids, amphipods and stoneflies were expected to be of interest because they appeared to offer the best potential for delimiting high-altitude aquatic faunas. The two crustacean groups are fully aquatic and, therefore, should appear in collections made at any time of year. The stoneflies are the best known of the Tasmanian aquatic insect fauna and contain numerous low temperature adapted species (Hynes & Hynes 1980). Seven species, representing all four Tasmanian families, were collected in this study, but distributions were very patchy. For example, no species was found in more than two streams, and four occurred in only a single stream; furthermore, within any particular stream, distribution was always very localised. The single specimen from site A5, a newly hatched nymph identified as *Neboissoperla* sp., was the only stonefly species not recorded also by Dean & Cartwright (1992).

The distribution of *Anaspides tasmaniae* does not appear to be of special interest. The absence of the species from streams A and C may be explained by the presence of a physical barrier, since both these streams disappear over cliffs before entering the treeline (table 1). The occurrence at only one site on stream D may be altitude dependent, since that site is higher than any of the sites on stream B; however, *A. tasmaniae* are highly mobile and, since the animals caught were all adult, it is likely that further collecting would demonstrate their presence in at least some of the higher sites on this stream.

TABLE 3

Summaries of physico-chemical data relating to the five site groupings*

(A) Quantitative summary – means (±s.e.)

Group	No of sites	Slope °	Temp °C	pH	Conductivity µS cm^{-1}	Elevation m	Aspect °
I	21	8.9	12.5	5.3	21.9	1296	206.7
		(1.40)	(0.93)	(0.15)	(1.46)	(10.7)	(23.22)
II	1	10.0	9.3	4.2	31.0	1200	67.5
		(–)	(–)	(–)	(–)	(–)	(–)
III	3	2.0	11.3	6.2	28.0	1251	322.5
		(0.00)	(1.77)	(0.08)	(2.62)	(2.4)	(6.12)
IV	3	15.7	7.6	6.1	15.3	1191	322.5
		(5.89)	(0.46)	(0.17)	(0.98)	(10.6)	(12.25)
V	2	27.5	7.8	6.4	15.5	1270	247.5
		(5.30)	(0.39)	(0.21)	(0.35)	(7.1)	(15.91)

(B) Qualitative summary

Group	Cover height	Slope	Temp	pH	Conductivity	Elevation	Aspect
I	low	moderate	warm	acid	high	high	varied
II	low	moderate	warm	acid	high	low	northeast
III	medium	flat	warm	neutral	high	moderate	northwest
IV	"tall"	steep	cold	neutral	low	low	northwest
V	"tall"	steep	cold	neutral	low	high	westerly

* Identified by cluster analysis

TABLE 4
Two-way table of site-taxa groupings

Site group/ site	Faunal group* 1																	2						3					4								
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	A	B	C	D	E	F	G	H	I	J	K
I/ A2	1	1	4	1														1	5	5	5	5															
I/ D2	3	1					5	1										5	5	1																	
I/ A3	4	1	2				5	1	4		5					5	5																				
I/ A4	3		1				5	1	4						5		5																				
I/ D4	2	1	3						1																												
I/ D5	3	1	3					1																													
I/ B3	2									2																											
I/ B4	3						5		1	2	1																										
I/ D7	3	2	1							3			1																								
I/ C1	5																																				
I/ C2	5																5	1																			
I/ A7	1			2					5																												
I/ C3	1																																				
I/ A5	2	3	1	3	1			1	2															5													
I/ C5	2	3	1		1		5																														
I/ D3	1	3	4					5	1																												
I/ A6	3	5	1	5					1									1																			
I/ C4	3	3	5						1																												
I/ D1	4	3																																			
I/ C6		3			5	5	5		1																												
I/ D6	1	1	5										5	5																							
II/ A1		2		2			5																									4					
III/B1		1								4	1																										
III/B2		1	2							5																											
III/B5		1								3																				1							
IV/B6										1	1																		1	2	1	1				1	5
IV/B8									1	1										1									3	1	5	5	1	1	5	5	5
IV/B7							5																	5	5	5	5	5	2	5	1	3	5				
V/ D8		1	3																										5								
V/ D9	2											5						1											3					5			

* see table 2 for taxa identifications

Neoniphargus sp. was found in the full range of habitats investigated, except at those sites located below the treeline (B8, D9), suggesting that the species may be restricted to high altitudes. In contrast, *Antipodeus* sp. was collected only from sites immediately above or within the treeline (B6, B7, B8, D8, D9). It was never found in any of the "pool" habitats and was absent from streams A and C, presumably because the cliffs prevented penetration from downstream, forested sites. Distribution of the two amphipod species appeared to be mutually exclusive, and only at D8, where a single *Neoniphargus* sp. specimen was present among 44 *Antipodeus* sp., was co-occurrence recorded.

The analysis of the physico-chemical characteristics of the site groupings suggests that, with the possible exception of group II, the five groups identified in figure 2 form a reasonably coherent set of sites. Their validity is supported by the ordination of the data (fig. 4). Table 4 enables the faunal bases of these groups to be examined and conclusions to be drawn about their biological validity.

The large number of sites in Group I might suggest that this is something of an eclectic group. However, it is clearly well defined faunistically (table 4) and is created almost entirely by its faunal group 1 component. We conclude, therefore, that the high-altitude runnels, seepages and soak pools, from which identifiable streams develop, do form a coherent set of biological habitats with its own distinctive, though not exclusive, fauna.

Group II is not well defined faunistically; this single site grouping is separated from Group I by the relatively high abundance of one of the taxa from faunal Group 4

(?Hydrochidae sp.). This suggests that site A1 (Group II) is unlikely to represent a distinct habitat category. However, the site did possess a unique combination of physico-chemical characteristics (table 3) and it would perhaps be wise to search for other sites with these features before making a final decision on the validity of this group.

Site Group III is characterised by stream-dwelling taxa from faunal groups 1 and 4, suggesting that high-altitude flowing water sites represent an identifiable habitat utilised mostly by a subset of high-altitude seepage/runnel species, but also penetrated by a small number of additional stream species such as the stonefly *Crypturoperla paradoxica.*

Site Group IV is more certainly a distinct habitat type, defined unequivocally by faunal groups 3 and 4. It represents "typical" stream habitats immediately below the zone of origin at or very close to the treeline.

Group V is distinguished by its fauna much less clearly than by its physico-chemical characteristics. It contains elements of both faunal groups 1 and 4, possibly because it shares physico-chemical properties with both site groups I and IV.

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