A SURVEY
OF THE INVERTEBRATE FAUNA
OF MT. WELLINGTON STREAMS

BY

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ABSTRACT

Five streams, Sorell Creek, New Town Rivulet, Hobart Rivulet, Browns River and North West Bay River, which flow down Mt. Wellington, were studied.

Physical and chemical properties of the water were measured and factors likely to affect the distinction of the fauna were described.

The invertebrate fauna was sampled seasonally at three sites on each stream.

The effects of disturbances, including pollution, on the stream fauna were studied.

The main features of the fauna are its uniqueness to Tasmania, its susceptibility to destruction by disturbance of the environment, and the presence of a distinct high altitude fauna.

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CHAPTER 1: INTRODUCTION

In contrast to the mainland of Australia, which is the most arid of the world's inhabited continents, containing only some 400 rivers, Tasmania has an abundance of freshwater systems throughout its area. The lack of study of lotic environments, noted by Bayly and Williams (1975), on the mainland may be explained in part by this lack of running water, but the almost complete absence of such studies in Tasmania is surprising.

Survey work in Australia, such as the Tasmanian Biological Survey, has involved the listing of animals as a prelude to an investigation of the distribution of animals, the relation between plant and animal communities and the influence of the environment on the fauna (Hickman, 1938). Few studies of this kind have been published in Australia, and those which have, such as those by Jolly and Chapman (1966) and Walker et al. (1976) have concentrated on larger lowland streams. Similarily, although lotic environments have been better studied in New Zealand, studies such as those of Allen (1951) and Stout (1969) are confined to larger and generally low altitude rivers.

In fact, this seems to have been the trend throughout the world, where although a large number of surveys on stream fauna have been carried out, such as the vast descriptive European literature, only a few, such as those by Hynes (1961), Morgan and Egglishaw (1965), Woodall and Wallace (1972) and Arnold and Macan (1973) have studied small, torrential mountain streams.

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CHAPTER 1: INTRODUCTION

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This may be due to the difficulties encountered sampling such streams (see Chapter 4.) and also their accessibility in many places. These studies show that mountain streams are characterized by a fauna dominated by Plecoptera larvae and other insects adapted to fast current speeds and low temperatures.

Tasmania is a mountainous state (Davies, 1965) in contrast to the mainland, where mountain areas are almost entirely confined to the Snowy Mountain region in New South Wales. The mountains of the central and eastern part of Tasmania are capped by dolerite and Mt. Wellington is typical of these mountain areas which are drained by large numbers of small streams.

Despite this predominance of small mountain streams in Tasmania, no survey of the fauna has been published. Freshwater studied have been limited to larger lowland rivers such as the Coal and Jordan Rivers (Bennison, 1975 and Sloane, 1976) in relation to fish and fish feeding or in relation to metal pollution (Thorpe and Lake 1973) in the South Esk River.

The water chemistry has been more widely studied (Williams 1964, Tyler 1973 , Buckney and Tyler, 1973) although much of this work has been confined to lentic waters. The water chemistry of Mt. Wellington streams has not been studied, although the characteristics of water draining off dolerite are known (Williams, 1964).

Although the invertebrate fauna of temperate running waters displays considerable uniformity throughout the world (Hynes, 1970), the Tasmanian fresh-water fauna has many unique elements such as the presence of the syncarid Anaspides tasmaniae. Bayly and Williams (1975) notes that regional faunistic features are particularly obvious in Australia and New Zealand because of a long period of isolation by marine barriers and Tasmania is furthest from colonization sources. Neboiss (1977) suggests that the high degree of endemicity in Tasmanian waters results from its separation from the mainland, and because of past and present differences in climate between the mainland of Australia and Tasmania. He found that 74% of the Trichoptera were endemic, compared with 82% of Plecoptera (Hynes, 1976).

Although Darwin visited Tasmania in 1835 and climbed Mt. Wellington, he was not impressed by the scenery and did not take much notice of the fauna. Thomson (1893), on the other hand found the Tasmanian fresh-water mountain fauna extremely interesting and suggested future studies should follow. He was the first to discover Anaspides tasmaniae in pools on top of Mt. Wellington, and he also collected one specimen of a phreatoicid isopod and several gammarid amphipods.

Smith (1909), on a visit from Oxford, noted that Tasmania was a particularly favourable place for studying Australian fresh-water fauna, as the highlands are covered with numerous large lakes and tarns and the country is everywhere drained by large rivers and streams.

In 1937, the Tasmanian Biological Survey was established to look at the fauna, flora and geology. However, although studies have been carried out on individual groups of Tasmanian fresh-water fauna (e.g. Clark, 1939 on the Parastacidae; Nicholls 1943, 1944 1949 on the Phreatoicoidea; Hynes, 1976 on the Plecoptera and Neboiss, 1977 on the Trichoptera), no survey of Tasmanian fresh-water mountain fauna has been published.

This is puzzling because Mt. Wellington is close to the city and many other aspects of its environment, such as the vegetation (Martin, 1938, Ratkowsky and Ratkowsky, 1976) and the birds (Ratkowsky and Ratkowsky, 1977) have been studied in detail. A possible reason for the lack of such a study is the fact that until some of these more recent works, little was known about the taxonomy of some of the major insect groups, especially the Trichoptera. In fact, a great deal of work still needs to be done on individual groups. Such as the Ephemeroptera, Coleptera Diptera and the Oligochaeta.

Because of their proximity to Hobart, the streams which flow down from Mt. Wellington are affected by disturbances to the environment caused by man. The most obvious of these are the effects of clearance of the land for urban and agricultural use. Of the five streams which were chosen for this study, two (New Town Rivulet and Hobart Rivulet) flow through the city, the other three (Sorell Creek, Browns River and North West Bay River) flow through rural and semi-rural areas. On the urban creeks, there is a milk factory situated on New Town Rivulet and a brewery on Hobart Rivulet. Other disturbances include the building of small dams on Browns River and North West Bay River for the abstraction of water for the city supply.

Hynes (1970) and Bayly and Williams (1975) review the effect of man on running waters, while the specific topic of pollution is dealt with by Hynes (1963) and Klein (1968). However, as in all work on lotic environments, most of this work has dealt with the effects of man on larger rivers, since the fauna of small mountain streams differs from that of larger lowland rivers, so might the effects of disturbances in general and pollution in particular, be expected to differ.

Surveys provide basic data for future studies, including the effects of disturbances on the environment. They are, therefore, useful in the planning of future use of an area. At present there is a greater awareness of the value of the natural environment for asthetic and recreational purposes and this has resulted in an attempt to reintroduce natural conditions along the banks of the city streams. A study of Humphrey Rivulet by Russel and Clark (1977) proposed the formation of a linear park based on the stream and plans were announced recently (Saturday Evening Mercury, 12-11-77) by the Deputy Lord Mayor, Mr. Broadby, to build a park comprising natural bush, picnic areas etc. along the banks of the Hobart Rivulet from the city to the base of Mt. Wellington. The fauna of the stream is both an integral part of such a park and an indicator of the quality of the stream water. The results of this survey will be useful to the managers of these park reserves.

Knowledge of the effects of disturbances on the Mt. Wellington streams may be useful in the identification and prevention of deleterious effects on the environment in other similar mountain areas of Tasmania. This knowledge can also be used in the planning of further development in the area, for example, the planning of tourist facilities within the Mt. Wellington area.

CHAPTER 2: THE AREA

GENERAL DESCRIPTION

The Mt. Wellington area, approximately latitude 42°54' and longitude 147°17', has been described by Martin (1939). It consists of a plateau capped by a Jurassic dolerite sill about 488m thick overlying Triassic sandstones about 244m deep resting on an Upper Permian base. It is separated from the Mt. Humboldt mass by the valley of Russell Falls which is in turn separated from the Central Plateau by the valley of the Florentine and Derwent Rivers.

The area is the eastern and almost square end of a 32km. east-west range. The eastern face rises fairly evenly with increasing gradient. The summit plateau is almost flat, sloping gradually to the western face. There is then a sudden drop to a flat swampy plain. The northern and eastern sides of the range are drained by small creeks, while the whole of the top plateau drains into the swamps and thence into the North West Bay River.

The soils can be divided into two groups; high moor and skeletal soils of the plateau and upper slopes and podsols below 762m.

CLIMATE

Rainfall

Average monthly and annual rainfall readings for several stations in the area as given by Martin, are shown in Table 1a.

Rainfall decreases rapidly away from the mountain and this is almost independent of altitude. The seasonal variation in monthly rainfall is not pronounced, however, there is a marked fluctuation at irregular intervals and droughts do occur. Rain is gentle and on 70% of days rain amounts to less than 3.81mm and heavy falls are rare. Approximately 50% of the rainfall results from southern Ocean depressions. Local variations are considerable. In addition to rain, the mountain above 396m is often mist-covered as a result of dry winds from the Tasman Sea.

Temperature.

Average maximum and minimum monthly temperature readings as given by Martin are shown in Table 1b.

Wind.

Wind action is considerable especially on the plateau.

Snow.

Snow may fall in any month, but generally only lies for more than a few days at higher altitudes and in the winter months.

Exposure.

Maximum sunlight and evaporation occurs on the top and west sides of the summit and north-west sides of the range. The south face receives little direct sunlight except in summer and much of the other faces is in the shade for a large portion of the day.

Place	Alt. (m)	J	F	M	A	M	J	J	A	S	O	N	D	
Hobart	54	47	38	44	50	47	56	54	46	53	59	62	53	609
Waterworks	161	67	51	70	80	63	76	74	58	73	93	67	80	852
Ferntree	396	113	92	107	124	100	118	117	106	116	149	120	140	1401
Springs	732	114	85	121	139	113	133	120	107	124	145	70	140	1462
Gap	1219	103	85	115	138	103	117	106	89	123	153	126	148	1406

Table 1a. Average monthly and annual rainfall readings for stations in the Mt. Wellington area, metricated from Martin, 1939.

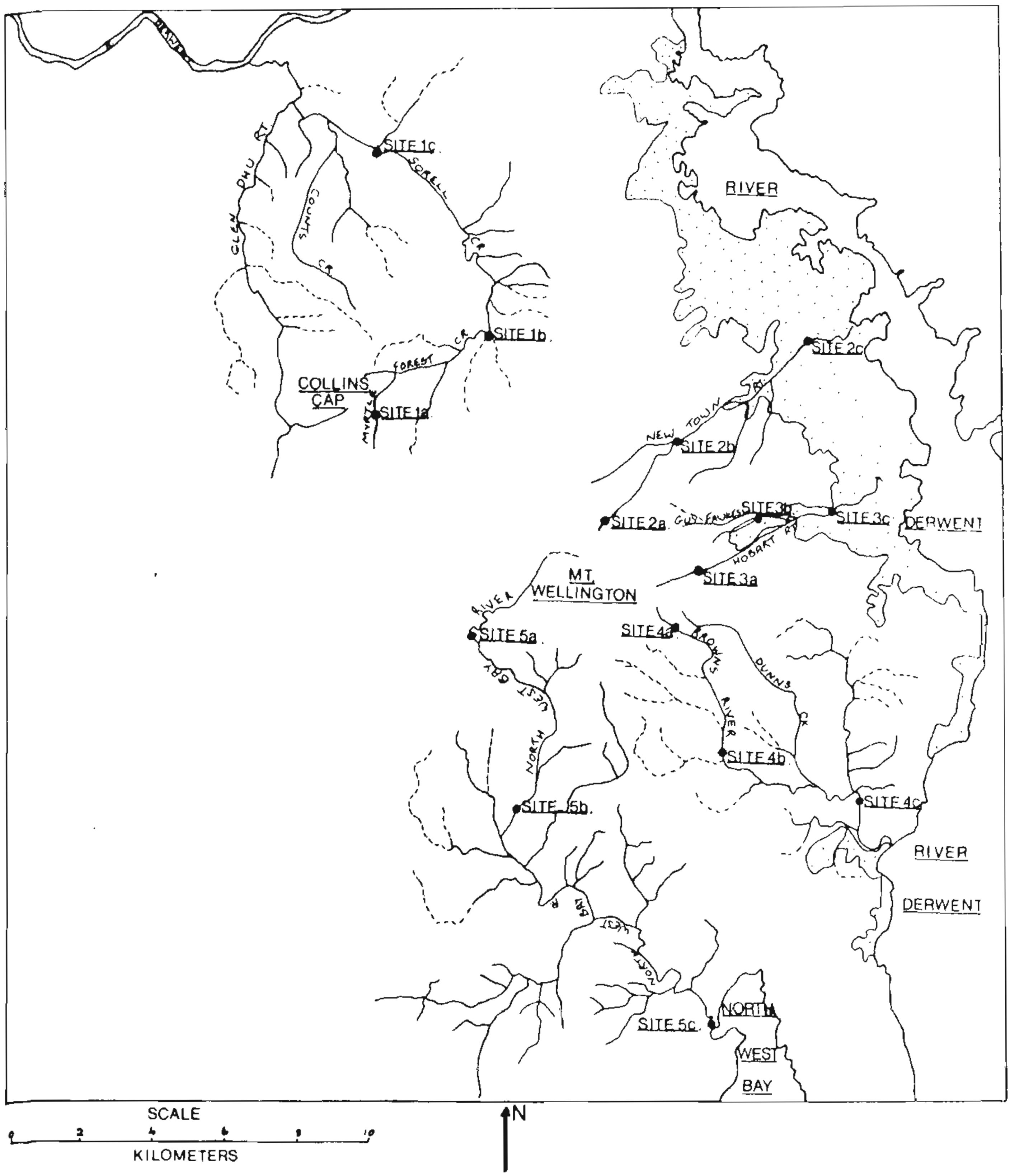
Place		J	F	M	A	M	J	J	A	S	O	N	D	Average
Hobart	max.	21.6	21.7	19.9	16.9	14.1	11.5	11.3	12.8	14.9	17.0	18.8	26.1	16.8
	min.	11.5	11.9	10.5	8.7	6.6	5.0	4.2	5.1	6.3	7.6	9.1	10.7	8.1
Springs	max.	15.6	16.5	14.3	11.3	9.1	7.1	6.6	7.4	9.4	11.2	13.1	14.6	11.3
	min.	6.7	7.6	6.5	4.8	3.4	2.2	1.6	1.8	2.4	3.3	4.4	5.9	4.2

Table 1b. Average maximum and minimum monthly temperature readings for Hobart and the Springs, metricated from Martin, 1939.

Figure 1. Map of the area showing the relative positions of the drainage basins of Sorell Creek, New Town Rivulet, Hobart Rivulet, Browns River and North West Bay River with respect to Mt. Wellington and the position of sampling sites on these streams.

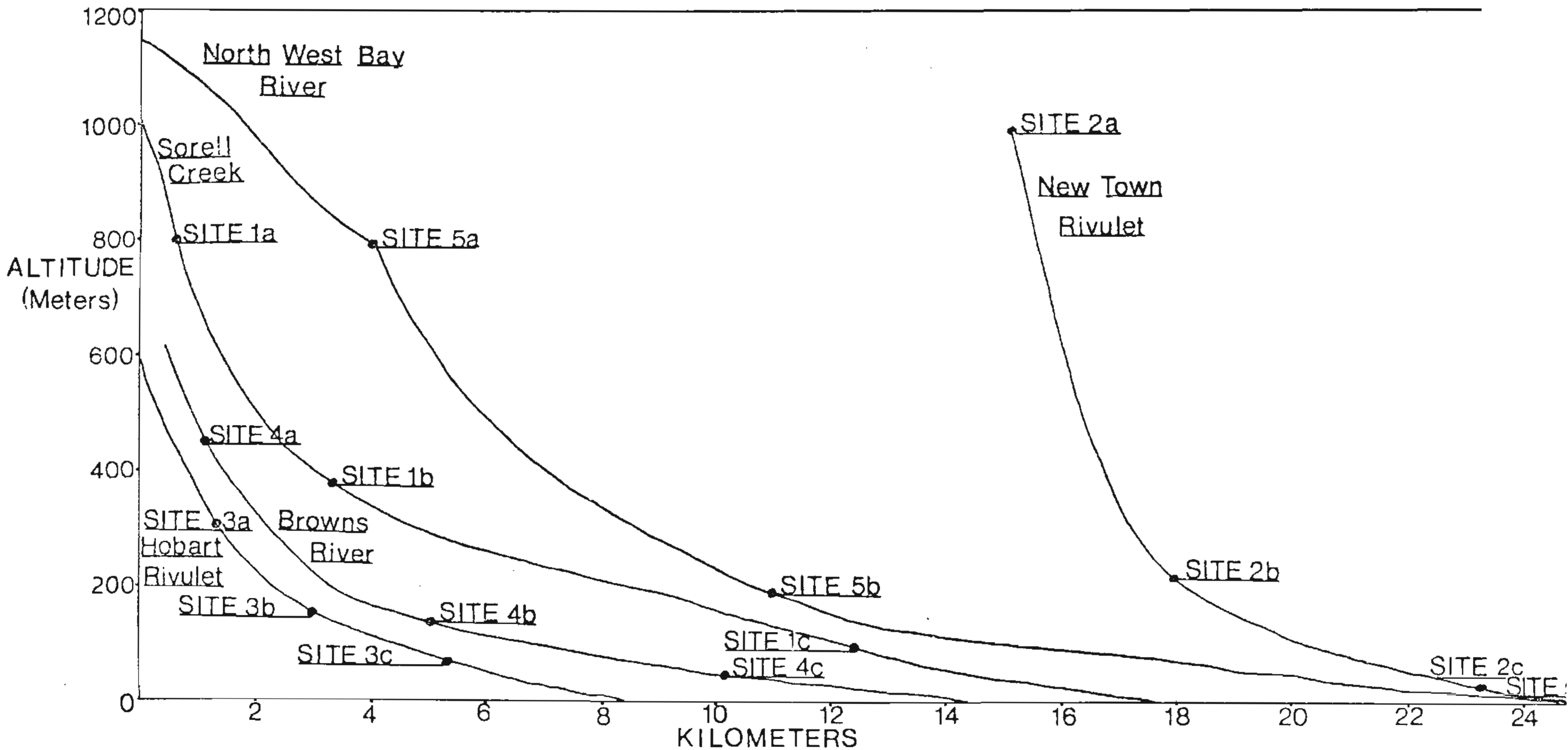
Key.

Urban areas.



SITE 1c
SORELL CR
GLEN DHU RT
COUNTS CR
SITE 1b
FOREST CR
COLLINS CAP
SITE 1a
RIVER
SITE 2c
NEW TOWN RT
SITE 2b
SITE 2a
GUY FAWKES
SITE 3b
SITE 3c
DERWENT
HOBART RT
SITE 3a
MT. WELLINGTON
SITE 5a
SITE 4a
BROWNS RIVER
DUNNS CK
NORTH WEST BAY
SITE 4b
SITE 4c
SITE 5b
RIVER
DERWENT
SITE 5c
NORTH
WEST
BAY
SCALE
0 2 4 6 8 10
KILOMETERS
N

Figure 2. Profiles of the streams, showing the positions of the sites with respect to altitude.



ALTITUDE (Meters)
1200
1000
800
600
400
200
0
2
4
6
8
10
12
14
16
18
20
22
24
KILOMETERS
North West Bay River
Sorell Creek
New Town Rivulet
Browns River
Hobart Rivulet
SITE 1a
SITE 1b
SITE 1c
SITE 2a
SITE 2b
SITE 2c
SITE 3a
SITE 3b
SITE 3c
SITE 4a
SITE 4b
SITE 4c
SITE 5a
SITE 5b

THE STREAMS.

As mentioned above, several small streams drain the eastern side of the range. I chose to study three of the larger of these streams; New Town Rivulet, Hobart Rivulet, and Browns River. I also studied North West Bay River which drains from the top of the plateau and flows south, and Sorell Creek which flows north from Collins Cap. These are the main streams draining Mt. Wellington (with the exception of Mountain River which drains to the south-west.) They cover a wide range of aspects. This can be seen from Figure 1, which is a map of the area showing the drainage systems of these streams. The streams also flow through a variety of different land uses, ranging from natural vegetation in the higher reaches to urban and rural land use in the lower reaches. Figure 2 is a diagram of the profiles of the streams, showing the differences between their lengths and gradients. North West Bay River and Sorell Creek are longer streams with an initial steep part then a long gradual gradient. The other three streams are much shorter with a greater overall gradient.

Sorell Creek.

Sorell Creek has an approximate catchment area of 78km^2. It is fed by a large number of tributaries. It rises as Myrtle Forest Creek at an elevation of 1000m on Collins Cap. The vegetation at this stage is mixed forest (Jackson 1965). It flows north for a short distance, then east through wet sclerophyll forest (Jackson, 1965), then north again through dry sclerophyll (Jackson 1965), to enter the Derwent River near Boyer. At several places the surrounding area has been cleared for farming, especially further downstream.

The stream flows through two small towns; Collinsvale and Molesworth.

New Town Rivulet.

New Town Rivulet has an approximate catchment area of $13km^2$. It has only a small number of tributaries compared with Sorell Creek. It rises on the eastern slope of Mt. Wellington at 1000m where the vegetation is open woodland, consisting of scattered stunted eucalypts with heath plants such as Richea spp., Pimelea spp., Orites spp., and Drimys lanceolata. It descends steeply down the face of the mountain through wet sclerophyll, then more gradually as it enters the urban area. It then flows parallel to Lenah Valley road through increasingly urbanised areas and past light industry, the most prominent being Bakers Milk Factory. At several places parks and barbeque sites have been constructed alongside the stream.

Hobart Rivulet.

Hobart Rivulet has a catchment area of $19km^2$ with few tributaries. It has its source at elevation 600m on the eastern slope of the mountain, where the vegetation is wet sclerophyll. It descends rapidly then flows through increasingly urbanised areas and finally disappears in culvets beneath the city. It also passes Cascade Brewery where it is joined by a tributary; Guy Fawkes Rivulet.

Browns River.

Browns River has a catchment area of approximately $11.1km^2$

and has many tributaries. It has its source at elevation 620m and descends rapidly to Silver Springs where water is piped off for the city water supply. It flows through the Hobart City Council Reserve to Fern Tree then south-east through a steep sided valley of wet sclerophyll. The vegetation then changes to dry sclerophyll and some of the surrounding area has been cleared for agriculture and settlement. It enters the Derwent at Kingston after receiving primary treated sewage.

North West Bay River.

North West Bay River has a catchment area of 101km^2 and is fed by a large number of tributaries. It rises at elevation 1150m from a series of pools. It descends rapidly to Wellinton Falls, then flows in a south-easterly direction through a heavily wooded steep-sided valley. Below the falls, water is piped off for the city water supply. Near Longley the surrounding area is cleared for agriculture which is the main land use for the rest of its course to Margate where it enters the River Derwent.

CHOICE OF SITES

Several authors for examples Allen (1951), Carpenter (1927), Percival and Whitehead (1929, 1930) and Hynes (1961), have observed a change in the composition of stream fauna with altitude. Some of the most important work on the subject is by Illies (1964; Illies and Botosaneanu, 1963), who proposed a universal series of zones in running water. These zones are: Eucrenon, the spring region; Hypocrenon, the spring brook; Rhithron, where the mean monthly temperature rises to 20°C, flow rate is fast, and the bed is composed of rocks stones or gravel; and Potamon, where the mean monthly temperature rises to over 20°C, flow is slower, and the bed is mainly sand and mud. In stony streams and small rivers the rhithron can often be further divided into epi-, meta-, and hyporhithron.

Because of the probable existance of similar altitudinal zonation in the streams studied, three sites were chosen on each stream; one close to the source, one approximately midway downstream, and one further downstream. The choice of sites was modified by their accessibility.

The position of the sites is shown on the map (Figure 1.). Altitudes and gradients at the sites are shown on the profiles in Figure 2. Plates 1-14 give an indication of the vegetation type, stream size, and the type of flow at each site.

Sorell Creek

Site 1a. This site is at an altitude of 800m in the Myrtle Forest. The vegetation is mixed forest with many ferns. It overhangs the stream so that little direct sunlight reaches the stream, which is quite narrow at this point, average width being 60cm. The substrate consists of cobbles and boulders (Cummins 1962, refer chapter 3) up to 30cm diameter with smaller material in between. It is clear of algae and moss.

Site 1b. This site is at an altitude of 380m. The vegetation is dry sclerophyll and as the stream is much wider here than at site 1a, (approximately 2m), it is only shaded near the banks. The substrate is similar to that of site 1a, but a brown alga grows on the rocks.

Site 1c. This site is at an altitude of 95m at Molesworth, a farming area. It is near hop fields and the riparian vegetation contains a number of exotic plants including willows. At this stage the stream is approximately 2.5m wide and is only shaded near the banks. The substrate consists of cobbles and boulders which are covered with a growth of brown alga, this being quite prolific in the summer.

New Town Rivulet

Site 2a. This site is at an altitude of 1000m. The vegetation consists of stunted eucalypts and heath plants as described above. The stream consists of a number of small channels about 30cm wide. The substrate is mainly clay with small cobbles up to 10cm diameter and highly irregular in shape.

Site 2b. This site is at 210m at the bottom of a steep gradient. The vegetation is dry sclerophyll. The stream is approximately 150cm wide and direct sunlight reaches only the middle part. The substrate consists of cobbles and boulders of up to 30cm in diameter and these are covered with small amounts of green algae.

Site 2c. This site is at an altitude of 30m. The riparian vegetation consists mainly of willows which overhang the stream and allow little direct sunlight to reach the surface. The surrounding land is urban and the site is approximately 1.2km below Bakers Milk factory. The stream is about 120cm wide, the substrate consists of cobble and boulders covered with large amounts of brown algae which traps some fine sediments.

Hobart Rivulet

Site 3a. This site is in thick wet sclerophyll forest at 300m. The stream has an average width of 1.5m and overhanging vegetation shades most of the stream. The substrate is extremely variable, ranging from large boulders to coarse gravel.

Site 3b. This site is at altitude 150m and is situated just above Cascade Brewery. The vegetation which was originally wet sclerophyll, was burned during the year, and one bank of the stream below this site was cleared and sown with grass at the same time. This site, which is on Guy Fawkes Rivulet, is more open than site 3a, the width being similar. The substratum ranges from bedrock to coarse gravel.

Site 3c. This site is 1.5km below Cascade Brewery at an altitude of 60m and in a totally urban area. The riparian vegetation consists of willows and other exotic plants. The width is about 4m. The substrate consists of cobbles and boulders up to 30cm diameter which are covered with large amounts of brown alga which traps the finer sediments.

Plate 1. Site 1a, Sorell Creek.

Plate 2. Site 1b, Sorell Creek.

Plate 3. Site 1c, Sorell Creek.

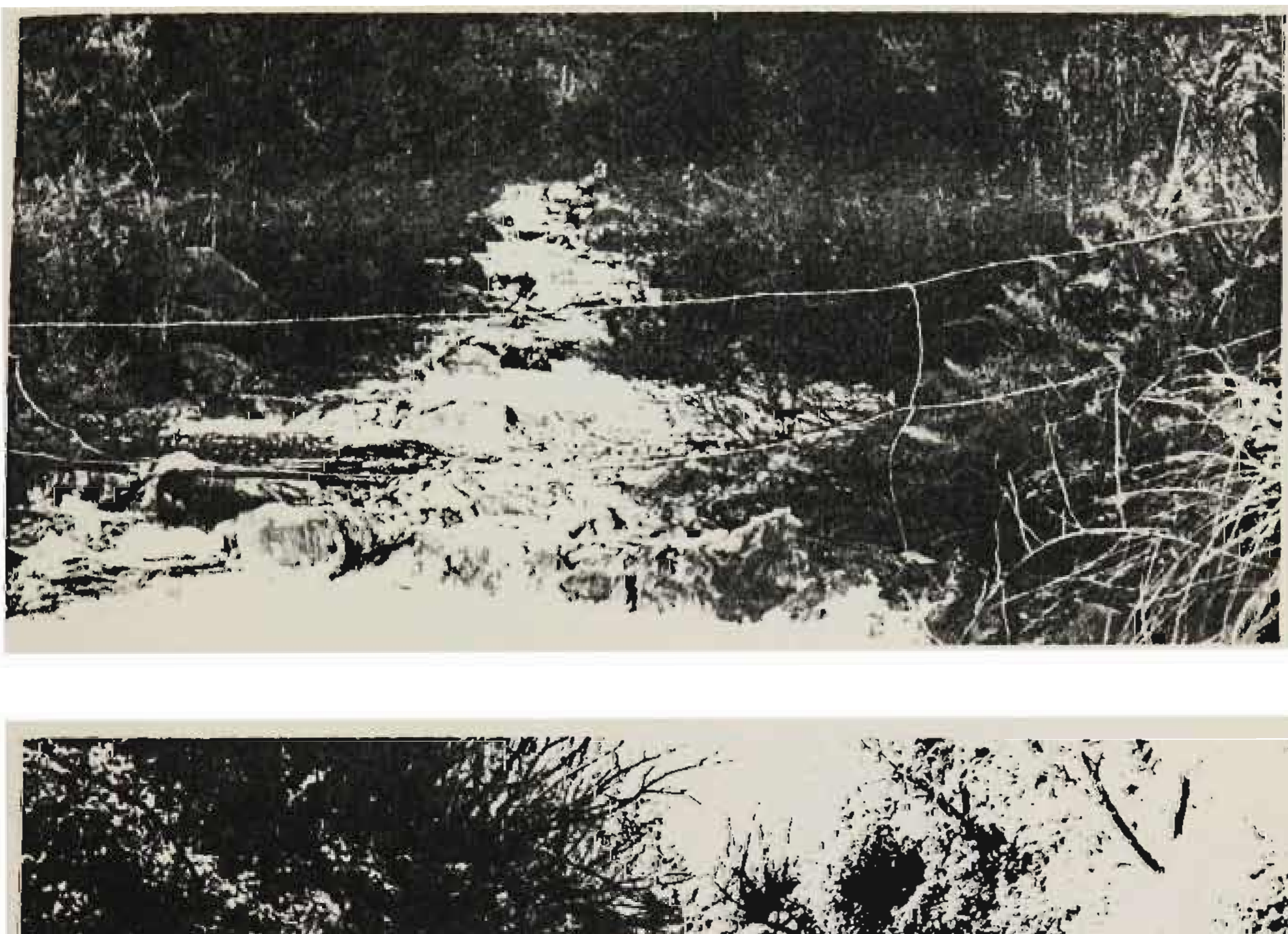


Plate 4. Site 2a, New Town Rivulet.

Plate 5. Site 2b, New Town Rivulet.

Plate 6. Site 2c, New Town Rivulet.

Plate 7. Site 3a, Hobart Rivulet.

Plate 8. Site 3b, Hobart Rivulet.

Plate 9. Site 3c, Hobart rivulet.

Plate 10. Site 4a, Browns River.

Plate 11. Site 4b, Browns River.

Plate 12. Site 4c, Browns River.

Plate 13. Site 5b, North West Bay River.

Plate 14. Site 5c, North West Bay River.

Browns River

Site 4a. This site is located below Silver Falls in wet sclerophyll at altitude 450m. Water is piped away for the city water supply at the falls. The stream is approximately 120cm wide at this site and the substrate consists of cobbles and boulders up to 30cm.

Site 4b. This site is at altitude 140m. The vegetation is dry sclerophyll, although some of the surrounding area has been cleared for agriculture. At this point the stream is approximately 2m wide so the centre of the stream receives direct sunlight. The substrate is variable, ranging from coarse gravel to large boulders covered with small amounts of algae.

Site 4c. Located near Kingston, this site is at altitude 40m. The vegetation is dry sclerophyll with some willows but some of the surrounding area is cleared. The vegetation provides almost complete shade to the stream which is about 120cm wide at this site. The substrate is similar to that of the above site but the algae is more abundant.

North West Bay River

Site 5a. This site is at Wellington Falls, the top of the falls being at altitude 800m. In this area the vegetation consists of a thick forest of wet sclerophyll. Even at this altitude the stream is approximately 2.5m wide, allowing direct sunlight to reach a large proportion of the stream. The substrate consists of cobbles and boulders up to 60cm diameter. Not far below this site, water is abstracted for the city water supply.

Site 5b. This site is located at Longley at altitude 190m in a farming area. Vegetation along the banks is dry sclerophyll. The stream is about 3m wide at this stage, but as the stream bed is much wider due to past flooding and greater flow prior to abstraction of water for city supply, it receives little shade from the vegetation. The substrate consists of smooth rounded stones of average diameter 15cm. These were covered with small amounts of green algae.

Site 5c. This site is located at Margate, almost at sea-level. Most of the vegetation has been cleared and only scattered willows, acacias and eucalypts overhang the stream, providing little shade. At this site the stream is approximately 3.5m wide. The substrate is similar to that at site 5b, however it is covered by large amounts of brown algae which traps some finer sediments.

Table 2. Summary of description of sites. Substrate is classified according to Cummins, 1962 (see Chapter 3.) Shade is quantified on a 0-5 scale such that 0=no shade and 5= completely shaded by the vegetation. Riparian vegetation is classified according to the terms of Jackson, 1965.

M.F. = Mixed forest

O.F. = Open forest

D.S. = Dry sclerophyll

W.S. = Wet sclerophyll

Ex. = Exotic

Site	Altitude (m)	Width (cm)	Riparian Vegetation	Surrounding Land Use	Substrate	Algae	Water Abstraction	Shade
1a	800	60	M.F.	Bush	Cobbles + boulders	-	-	5
1b	380	200	D.S.	Rural	" "	+	+	3
1c	95	250	Ex.	Rural	" "	+	+	1
2a	1000	30	O.F.	Bush	Clay + cobbles	-	-	1
2b	210	150	D.S.	Bush	Cobbles + boulders	+	-	3
2c	30	120	Ex.	Urban	" "	+	-	4
3a	300	150	W.S.	Bush	Boulders--gravel	-	-	4
3b	150	250	W.S.	Bush	Bedrock--gravel	-	-	2
3c	60	400	Ex.	Urban	Cobbles + boulders	+	-	1
4a	450	120	W.S.	Bush	" "	-	+	4
4b	140	200	D.S.	Rural	Boulders--gravel	+	-	3
4c	40	120	D.S.	Rural	" "	+	-	3
5a	800	250	W.S.	Bush	Cobbles + boulders	-	+	1
5b	190	300	D.S.	Rural	" "	+	-	0
5c	2	350	Ex.	Rural	" "	+	-	0

CHAPTER 3: FACTORS CONTROLLING FAUNAL DISTRIBUTION

INTRODUCTION:

Many factors control the distribution of aquatic macro-invertebrates. Hynes (1970) considers current speed, temperature, substratum and dissoved substances to be the most important, while he considers liability to droughts and floods, food, competition between species, shade and zoogeography to be of lesser importance. There may be a considerable degree of correlation between these factors, for example between current speed and substratum type, so that it is frequently difficult to distinguish precisely the effect of one from that of others.

Current speed

Arnold and Macan (1973) cite examples of animals (e.g. *Rhithrogena*, *Rhyacophila* and *Baetis*) that require a certain current speed to satisfy oxygen requirements. Edington (1965) has shown that some aquatic invertebrates such as the net-spinning Trichoptera require a certain current speed for feeding. Thus some animals are limited by a minimum current speed. It is obvious that invertebrates without morphological adaptions for postion-holding would be swept away by high current speeds. However, as Arnold and Macan (1973) point out, most invertebrates in fast streams live under stones away from the direct current.

Hynes (1970) describes several methods for measuring current speed. Initially measurement was attempted by timing a floating orange over a certain distance. Unfortunately many of the sites have boulders in the substrate and these obstructed the path of the floating orange, thus preventing an accurate result being obtained. Also in the high altitude sites, the depth of water was not great enough for this method.

One of the most straight forward methods is by the use of a current meter. Mr Williams of the Rivers and Water Supply Commission suggested that the flow at all the sites was far too variable for meaningful results to be obtained using a current meter. Also as the meter works on the principle of a rotating propellor, it requires a minimum depth. Most of the higher altitude sites are too shallow for the use of such a meter.

Allen (1951) suggests that type of flow may be more useful than actual current speed. He uses the following flow types:

Broken - waves $\geqslant \frac{1}{2}$ depth

Turbulent - small waves, distortion of vision

Smooth - clear vision

Cascade - irregular flow among large protruding stones in sections of steep gradient.

These were used to describe the flow at the sites.

He also describes water types as follows:

Table 3. Flow and water types at each site using the classifications of Allen, 1951.

Site	Flow type	Pools	Riffles	Runs
1a	Cascade	+	+	-
1b	Turbulent	+	+	-
1c	Broken	+	-	+
2a	Cascade	+	+	-
2b	Turbulent	+	+	-
2c	Broken	+	-	+
3a	Cascade	+	+	-
3b	Turbulent	+	+	-
3c	Broken	+	-	+
4a	Cascade	+	+	-
4b	Turbulent	+	+	-
4c	Broken	+	-	+
5a	Cascade	+	+	-
5b	Turbulent	+	+	-
5c	Broken	+	-	+

Pools - considerable depth for size of stream

Flats - less depth than pools and flow smooth

Runs - turbulent flow, velocity moderate to rapid

Stickles - broken, rapid flow

Cascades - steep, irregular flow

These were defined using a combination of depth, velocity and flow type.

Thus for

Stickles	Current	$>$	1.24 ft/sec
	Depth	$<$	0.75 ft
Run	Current	$>$	1.24ft/sec
	Depth	$>$	0.74 ft
Flat	Current	$<$	1.25 ft/sec
	Depth	$<$	1.50 ft
Pools	Current	$<$	1.25 ft/sec
	Depth	$>$	1.50 ft.

At all sites the current speed was variable but was classified as rapid (at least 50cm/sec) by the nature of the substrate (Hynes, 1970). Table 3. gives the flow types and water types according to Allen's (1951) classification.

Substratum

Current speed has an important effect on the substratum, which has been shown to affect the distribution of stream macro-invertebrates (Cummins and Lauff, 1969). Hynes, (1970) gives a table showing the speed of current at which particles of different sizes are removed from the stream bed. Cummins,

Classification	Particle size range (mm)
Boulder	256
Cobble	64 - 256
Pebble	16 - 64
Gravel	2 - 16
V. coarse sand	1
Coarse sand	0.5
Medium sand	0.25
Fine sand	0.125
V. fine sand	0.063
Silt	0.0039
Clay	0.0039

Table 4. Substrate particle size terminology and categories, Cummins, 1962.

(1962) has given a classification of substrates based on particle size (Table 4.) and this was used in Chapter 2. where the substratum of each site was described.

Temperature

Temperature controls the distribution of stream invertebrates in several ways. Some require a certain temperature range to breed and develop. Arnold and Macan (1973) cite the planarian *Crenobia alpina* which does not breed in water warmer than 12^{0}C. They also suggest that competition restricts the distribution of some animals to lower temperatures.

Temperature readings were taken at each site at the same time as the fauna was sampled using a mercury in glass thermometer. Continuous readings are desirable to give a true picture of stream temperature but due to large number of sites and the time necessary to visit each of these sites, it was not considered worthwhile to make more frequent temperature recordings. Several authors, including Hynes, (1962) and Jolly and Chapman (1964), found significant temperature trends using only isolated temperature readings.

Seasonal temperature readings at each site are given in Table 5. These show a marked increase in temperature downstream in summer. This trend is less in autumn and spring and there is no real difference between the sites

Table 5. Water temperature readings at each site at the time of sampling the fauna. The fauna was not sampled at sites 4c and 5a in summer and autumn and 5a in spring, so temperature recordings are absent for these. The temperature was not recorded at site 4a in winter.

SITE	SUMMER	AUTUMN	WINTER	SPRING
1a	10.5	4.2	5.0	5.5
1b	11.5	6.5	6.0	7.5
1c	17.5	7.0	6.5	8.0
2a	8.0	6.5	5.5	6.0
2b	17.5	8.5	5.5	7.5
2c	16.5	10.0	6.5	9.0
3a	14.0	8.0	6.5	7.0
3b	17.0	7.5	6.2	8.5
3c	16.5	8.0	6.0	10.0
4a	11.5	7.0	6.0	5.5
4b	17.0	8.0	6.5	8.5
4c	–	–	–	10.0
5a	–	–	2.0	–
5b	15.0	9.0	7.0	9.0
5c	20.5	8.5	6.5	10.5

in winter. There is also a seasonal change in temperature. This is more marked at the lower sites than at the higher altitude sites.

Although Macan (1958) showed that little reliance could be placed on isolated temperature readings such as those made here, temperatures of lotic waters do not vary in the short term and isolated readings have been widely used by other workers such as Hynes (1961).

Hynes (1961) found similar results to those in this study, however he found that the higher altitude sites were warmer in the winter than the lower sites and this fact he could not explain. In this study, the winter readings were similar for all sites. The lowest temperature recorded was 2°C at site 5a. This was lower than any of the others (next lowest was 5°C at site 1a), possibly because of snow melt, although snow was settled at sites 1a and 2a when the recordings were made. Another factor affecting these recordings may be the cover of vegetation, which would provide some insulation. Site 5a, being much more open than the other high altitude sites, would be less insulated than the high sites and would suffer greater heat loss.

Dissolved substances

Many authors such as Carrick and Sutcliffe, (1973), Egglishaw and Morgan (1965) have attempted to show the relationship between chemical composition of the water and distribution of the fauna. However, chemical composition does not seem to have a great deal of effect except in extreme conditions. For example, Carrick and Sutcliffe (1973) found that the fauna changed when pH values dropped below 5.7. It would seem obvious that crustaceans, which require calcium for their exoskeleton, would be limited by water hardness. However, Hynes (1970) states that Gammarus pulex has been found in water containing less than 5mg/l calcium.

Hynes (1970) states that oxygen is rarely a limiting factor in fast flowing streams, although low values in areas of organic pollution.

Free CO_2, alkalinity and pH were measured in the field. Free CO_2 must be measured as quickly as possible without agitation of the sample because it is readily lost to the atmosphere. The procedure used was that outlined by Welch (1948). 100ml of sample was titrated against $^{N}/_{44}$ NaOH using phenophthalein as indicator. The titre was multiplied by 10 and expressed as mg/l.

Alkalinity in most natural waters is due to (a) carbonate, (b) bicarbonate and (c) hydroxide ions. The use of two indicators, phenolphthalein and methyl orange, in a titration against $^{N}/_{50}$ H_2SO_4 enables these to be distinguished. Phenolphthalein alkalinity gives the alkalinity due to carbonate ions and is measured by titrating 100ml of the sample against $^{N}/_{50}$ H_2SO_4 using phenolphthalein as indicator. The titre is multiplied by 10 and expressed as ppm. Methyl orange alkalinity measures bicarbonate plus carbonate ions and is measured in the same way as the phenolphthalein except that methyl orange is used as the indicator.

pH was measured using a Titron Model p-120 pocket pH meter.

Water samples were collected from each site in polythene bottles for laboratory analysis of cations and anions. Samples for analysis of phosphates were collected in bottles pretreated with a solution of iodine in potassium iodide for several days then rinsed with distilled water and filled with distilled water until collection of the sample. This procedure was recommended by Heron (1962) who suggested that bacteria adhering to the walls of the bottles caused lower readings by taking up phosphorous. This treatment was also recommended by Bowditch *et al*. (1976).

Calcium and magnesium concentrations were determined by the ETDA method (Golterman, 1969).

Sulphate was determined turbimetrically using barium chloride (Golterman, 1969).

Orthophosphate was determined colorimetrically as described by Golterman (1969).

Nitrogen as nitrate was determined by the Brucine method (Standard methods, 1966). Huxley and Wisel (1974), in a review of methods for the determination of nitrate in waters, name this method as one of the most reliable in the range 0.01 - 10mg/l.

Conductivity at 18°C (K_{18}) was determined electrometrically. Total dissolved solids (T.D.S.) was calculated according to the formula (Bayly and Williams, 1975).

Bayly $$T.D.S = \frac{(3.4K_{18}}{10^6} + 0.666)\, K_{18}$$

Dissolved oxygen and B.O.D.

Dissolved oxygen was determined by the Winkler method (Standard Methods, 1966). Samples were collected in ground glass stoppered bottles and "pickled" with alkaline iodide and manganous sulphate immediately. The remainder of the analysis was carried out later in the laboratory.

B.O.D. samples were collected in the same type of sample bottles as used for the oxygen determinations. The samples were kept for 5 days at 20°C in the dark, after which they were analysed for oxygen.

Table 6 summarizes the chemical features for the five streams. It is apparent from the T.D.S. values that these waters are quite dilute. Williams (1964) found a range of T.D.S. values from 21 to 1400 p.p.m. in Tasmanian rivers. Bayly and Williams (1975) note that some Australian saline streams have T.D.S. values as high as 6000 p.p.m. but that most streams world-wide have less than 3000 p.p.m.

Table 6. Physical and chemical properties of the water at each site.

K_{18}, T.D.S., Mg^{++}, Ca^{++}, and SO_4^{--} values are for water samples collected in summer. Alkalinity, free CO_2 and pH values are average values. As free CO_2 was generally low, it was not tested at all sites.

N.R. = too low to be detected.

SITE	K_{18} (uS/cm)	TDS (ppm)	pH	Free CO_2 (ppm)	Alkalinity (ppm HCO_3^-	Mg^{++} (ppm)	Ca^{++} (ppm)	SO_4^{--} (ppm)
1a	31	20.65	7.6	-	5.5	N.R.	0.20	N.R.
1b	31	20.65	7.3	-	7.0	"	0.20	"
1c	125	83.30	7.4	1.4	23.5	"	0.75	8.0
2a	26	17.32	7.4	-	5.5	"	0.15	0.2
2b	45	29.98	8.0	1.0	9.5	"	0.22	1.8
2c	240	160.03	8.3	1.2	39.0	"	0.80	2.0
3a	46	30;64	7.4	2.5	8.0	"	0.22	"
3b	113	75.30	7.5	2.2	13.2	"	0.45	11.0
3c	143	95.31	7.7	2.0	17.0	"	0.55	8.0
4a	58	38.64	7.5	-	14.0	"	0.27	0.8
4b	97	64.63	7.1	1.0	14.5	"	0.36	8.0
4c	-	-	7.5	-	16.8	"	-	-
5a	-	-	7.3	-	24.0	"	-	-
5b	51	33.97	7.3	-	14.5	"	0.28	1.0
5c	155	103.31	7.4	-	22.5	"	0.46	7.0

Hynes (1970) states that the chemical composition of running waters is a reflection of the local geography and climate. As these streams are in the same area with the same climate and geology the water chemistry is expected to be similar. Also since the streams rise in steep gradients, with little soil formation and thick vegetation, little dissolved material would be transported from the surrounding area.

The results compare favourably with those obtained by Williams (1964) for streams rising in the Cradle Mt. Area, an area similar in geology, geography and climate to the study area.

The T.D.S. and ionic concentrations show a gradual increase downstream. Pennak (1971) found similar results. Often, as in this study, downstream sites are at a much lower gradient and soil is much deeper, allowing rainwater to percolate and remove ionic substances. Also on these streams most of the lowland areas were cleared, resulting in greater runoff, carrying more solutes.

Phosphate and nitrates were undetectable. The main sources of nitrate and phosphate in streams are rainfall and the land surface, especially agricultural land. It was, therefore, expected that the sites in agricultural areas, that is, sites 1b, 1c, 4b, 4c, 5b, and 5c might have had detectable amounts of these ions. However, Hynes (1970) states that normally the concentrations of nitrate and phosphate actually in solution in stream or river water are low because the ions are rapidly taken up by plants. Neel (1951) noted that the concentrations of these nutrients fell as the water passed over riffles. This may be a contributing reason for the low concentrations. Although no macrophytes were present at any site, there were large amounts of algae and the streams were fast flowing, with many riffle areas.

Oxygen levels were close to 100% saturation at all sites. Hynes (1970) noted that in small turbulent streams, (such as the streams studied), the oxygen content is normally near, or above saturation. Even at sites 1c (summer) and 2c and 3c (all seasons) where lower oxygen concentrations were expected (because algal growth suggested organic pollution) the values were as high as the other "cleaner" sites, probably because of the turbulent movement. This may also have been the reason all B.O.D. values were low (less than 2), indicating clean water.

Shade

Hughes (1966) showed that shading and direct illumination has an effect on the distribution of stream fauna. This factor may have several components, for example its effect on the temperature of the water, oviposition behaviour or food availability. The riparian vegetation and its shading effect at each site has been described in Chapter 2.

Food

The availability of food is an obvious factor controlling the distribution of stream fauna. The main sources of food in the Mt. Wellington streams are algae and allochthonous plant material, since rooted macrophytes were absent. The occurrence of algae at the sites has been dealt with in Chapter 2. The amount of allochthonous material available depends on the nature of the riparian vegetation. The native vegetation is evergreen, providing a more or less continuous supply of material to the stream. Most of the exotic plants found at the lower sites are deciduous, providing a distinctly seasonal input of food in autumn.

Flood

Allen (1951) showed the marked effect of spates on stream fauna. This is partly due to disturbance of the substratum. Also during spates there is an increase in turbidity. Dorris et al. (1963) found a relationship between discharge and turbidity, Bennison (1975) confirmed this on the Coal River. According to Williams (Rivers and Water Supply Commission, personal communication) all the Mt. Wellington streams are subject to flooding, especially North West Bay River. This could be seen from the erosion of the banks. However, during sampling, the streams were only affected by minor spates in the winter months. An increase in turbidity was noted at these times.

Drought

Harrison (1966) and Harrel and Dorris (1968) have studied the effects of drought on stream fauna. At all sampling times there was a continuous flow of water in all streams. Williams (personal communication) noted that, from the records for North West Bay River and Browns River, neither had dried up during the past 15 years, although on odd occasions the flow had almost ceased during the summer months.

Microbiology

The coliform bacteria have a density bearing some relation to the degree of organic pollution. The higher the coliform count the greater the health hazard presented by the water. The presence of the coliform group in water suggest the possibility of faecal contamination by the warm-blooded animals, including man. The presence of Escherichia coli always mean pollution by these faeces.

Water samples were collected from each site in sterile 500 ml bottles from near the centre of the stream. They were analysed by the State Health Laboratories for Coliforms, faecal coliform and faecal streptococcus using the membrane filtration method described by Williams and Dussart, (1976).

Table 7 gives the result of the microbiological analysis of the water at each site. There is a general trend of increase in the count of organisms downstream. Exceptionally high counts occurred at sites 3b and 3c. There were three houses above site 3b, so high counts could be due to leakage of sewage into the stream. Only one sample was analysed from each site, so that the high level observed may have been due to contamination just prior to sampling. The Health Laboratory suggest that a single water sample is of little value in assessing contamination and that a sample programme should be established. This was not feasible for this study as the aim was to obtain an indication of contamination only.

Standards for coliform density vary from country to country and are related to water usage, (Bayly & Williams, 1973). Zajic (1971) suggests that counts should not be greater than 4/100 ml for drinking water. A limit of 1000/100 ml was proposed by the Commonwealth Department of works for Australian streams subject to occasional bathing. Bayly & Williams (1973) give data for rivers in the Melbourne area in which the counts are much higher than those obtained in this study.

Table 7. Coliform, faecal coliforms and faecal streptococci counts of water collected from sampling sites and tested by the State Health Laboratories. Site 5a was not sampled because of inaccessibility.

SITE	DATE	Coliforms per 100ml.	Faecal coliforms per 100ml.	Faecal Strept. per 100ml.
1a	16/8/77	4	0/50	0/50
1b	"	32	0/50	0/50
1c	"	128	24	26
2a	15/8/77	0/50	0/50	0/50
2b	"	4	8	0/50
2c	"	170	60	150
3a	"	6	2	2
3b	"	4120	3480	2000
3c	"	3700	660	440
4a	"	2	0/50	4
4b	"	58	84	0/50
4c	"	105	120	36
5b	"	14	6	8
5c	"	40	42	16

CHAPTER 4: THE FAUNA

Sampling the fauna.

The nature of stream beds makes them difficult to sample. The current interferes with many sampling procedures and large stones and boulders are often present, causing variable flow. This results in a variety of different substrates which are colonised by different animals (Cummins and Lauff, 1969). The small size of streams such as those studied here provides a further difficulty in that it may be difficult to replicate results. However, as Hynes (1970) notes, in order to study such an environment, it is essential to have some measure of the abundance of the species present. For this reason, the study of small streams seems to have been largely neglected, in favour of larger rivers with greater expanses of homogeneous habitats.

Many methods for sampling stream invertebrates have been suggested. These have been reviewed by Macan (1958), Cummins (1962) and Hynes (1970). Many of these methods have been devised for specific situations, for example, corers can only be used in soft substrates, dredges require a movable substrate, and methods using nets require a certain minimum current.

One of the methods most commonly used is the Surber (1937) sampler, which consists of two quadrats, each one square foot ($30\ cm^2$), at right angles to each other, with a net attached to one of these. The quadrat without the net is placed on the substrate such that the net extends downstream in the current. Larger stones within the quadrat are picked up, held in front of the net, and any animals picked off. The area within the frame is then stirred thoroughly and animals so disturbed are swept into the net.

The Surber sampler has the advantages that it is small, light, easy to carry, and secures samples from a definite area of the stream bottom (Needham and Usinger, 1956). It also collects animals both on stones and within the substrate. It has the limitations that it can only be used in certain conditions. It requires a certain minimum current, it cannot be used in water deeper than arms length and Chutter (1972) suggests that it not feasible to use it in water deeper than the frame because at these depths, back currents at the mouth of the net and edge effects causes many animals to escape.

Because of the variability of the stream bottom, several samples need to be taken to obtain a good representation of the number of animals and species present. Needham and Usinger (1956) examined the reliability of Surber sampler results and from 100 samples concluded that 194 would be required to give significant figures (95% level confidence) as to the total wet weight of organisms and 73 for the total numbers. Chutter (1972), in a reappraisal of Needham and Usinger's work (1956), suggest that in reality these numbers are much higher. Chutter (1972) also points out that in many streams it is impossible to sample even 18 square feet in a single riffle.

In many parts of the streams studied this was indeed the case.

Although it is rarely possible to obtain a reliable estimate of the total numbers of animals present, Needham and Usinger (1956) showed that in only two or three samples, at least one individual of the most common species could be collected. Similarily, in a consideration of the time and effort involved in sampling, identification and counting the animals, Chutter and Noble (1966) also concluded that three square feet was an adequate area to sample.

However, these investigations were carried out in homogeneous sampling areas and as Chutter and Noble (1966) note, the variance of dispersion (senu South wood, (1966) of individual species increases with heterogeneity of the area sampled. Thus Gaufin et. al. (1956) found that as many as 10-15% of species present were not discovered until at least 8 Surber samples had been taken. They suggest the need for careful selection of bottom types to be sampled in order that a small number of samples may give a comprehensive faunal picture. Following this suggestion a small stream, such as at site 2a, could be effectively sampled without removing all the animals in the area.

As mentioned above, the use of the Surber sampler requires a minimum current and can only be used in shallow water. Thus, although it was suitable for sampling the riffle sections of the Mt. Wellington streams, it was unsuitable for sampling the pools. Methods described by Macan (1958), Cummins (1962) and Hynes (1970) for sampling pools, for example using dredges or grabs, can only be used where the substrate is soft. In the pools sampled, the substrate consisted of cobbles and coarse gravel. A method was thus devised, whereby a standard F.B.A. net was dragged across a certain area of substrate, disturbing it and collecting any animals released. Unfortunately, as it was difficult to judge the exact area disturbed by this method and as many animals would have escaped the net, this method could not be considered more than weakly quantitative.

The fauna was sampled four times in the year, corresponding to summer, autumn, winter and spring at all sites except sites 4c and 5a. Site 4c was only sampled in winter and spring due to difficulty in finding suitable site, and site 5a was only sampled in spring due to its inaccessibility. In summer and autumn, both riffle and pool samples were taken where possible (at some sites such as site 1c, it was difficult to distinguish true riffle or pool areas.) Because of this and the lack of comparability of pool samples, pools were only sampled in summer and autumn. At least three riffle and pool samples were taken at these times, while in winter and spring 6 riffle samples were taken at each site except in winter when high flows made sampling difficult and only three samples could be taken at site 1b and 5 at site 3c.

Samples were emptied into a white plastic tray and any large plant material and stones were removed. The sample was then placed in a vial of alcohol to be further sorted and identified later in the laboratory. Samples were hand sorted because this was considered more efficient than sieve methods mentioned by Hynes (1970).

Animals were identified to species level where possible, otherwise they were identified to the highest level possible, then labelled sp1. etc. Difficulty was encountered identifying the Trichoptera because although this group has recently been revised Neboiss (1977), as yet no new key exists to the larvae. Identification of most groups was based on keys given by Williams (1968) and in the C.S.I.R.O. "Insects of Australia" (1970). Identification of the Plecoptera was supplemented by the descriptions of McLennan (1971), Illies (1975), and Hynes (1976).

Composition of the fauna.

A complete species list, giving the number of individuals per sample, is given in Appendix 1. Both riffle and pool samples are given. The animals are typical of those found worldwide in temperate stony streams (Hynes, 1970), consisting mainly of insect larvae. Although much of the southern hemisphere fauna is unique, parallel evolution is evident and many faunal types found here have similar counterparts in the northern hemisphere. Thus the fauna found in mountain streams by Hynes (1961), Morgan and Egglishaw (1965) and Arnold and Macan (1973) appears similar to that found in this study, except for the presence of the syncarid *Anaspides tasmaniae* and the amphipod Neoniphargus sp. which have no counterpart in the northern hemisphere. Although not collected in this study because of sampling methods, the phreatoicid Colubotelson thomsoni and Astacopsis fluviatilis also occur in this area and are unique to Tasmania. Nicholls (1946) found that Colubotelson thomsoni was abundant in puddles on the summit and in runnels upon the higher slopes of the mountain. Clark (1939) found Astacopsis on Mt. Wellington in Hobart and at Ridgeway. The fauna is best dealt with in faunal groups.

Ephemeroptera:

The Ephemeroptera formed a large portion of the fauna collected, the genus Atalophlebioides being the most abundant and widespread, occuring at sites at all altitudes and in both riffles and pools. Riek (1970) states that the genus Atalophlebioides contains the most common Australian mayfly species, the only controlling factor being a need for swift flowing water. This genus belongs to the family Leptophlebiidae, which is the dominant family in Australia, where it has invaded habitats similar to those occupied by other families in the northern hemisphere (Williams, 1968). Atalophlebia sp. was the only other member of the Leptophlebiidae found in this study. It was found only in slower flowing water and in pools which is the habitat mentioned by Riek (op. cit.) Two members of the family Baetidae were collected, the cosmopolitan Baetis being found mainly at the lower altitude sites and Tasmanophlebia sp. which burrows in sand occurred in pools. The remaining genus found is Tasmanocoenis, which belongs to the family Caenidae. This is also a burrower and was similarly found in slower currents and pools. Riek (op. cit.) gives the distribution of this genus as pools and slow streams from Tasmania to the Kosciusko region.

Plecoptera:

The Tasmanian Plecoptera are considered to be almost entirely endemic by Hynes (1976). They also constituted a prominant portion of the Mt. Wellington fauna. Although *Eusthenia spp.* and *Tasmanoperla spp.* only occurred in low numbers, they were a significant part of the biomass because of their relatively large size. Both are endemic, but have counterparts on the mainland. *Eustheniopsis*, which is found in the Kosciusko area resembles Eusthenia; and Austroheptura, which is found in southern Victoria, Mt. Kosciusko, and New England is similar to *Tasmanoperla*. *Eusthenia* was found only at sites of altitude greater than 140m, while *Tasmanoperla* was found at all altitudes but was more common at higher altitudes. Riek (1973) found the genus to be distributed throughout Tasmania. Only one specimen of the other Tasmanian member of the Austroperlidae, *Crypturoperla paradoxa*, was collected. Riek (1973), described this species as occurring only in a restricted area in the west of the state, but Hynes (1976) has since collected specimens from Mt. Wellington, so it may be more widespread.

Members of the family Notonemouridae were expected from the distribution given by Illies (1975), but only one species, *Tasmanocera bifasciata*, was collected and at only one site, 3c.

Members of the Gripopterygidae were widespread, occurring at altitudes. Seven species were collected, *Cardioperla nigrifrons* being the only endemic. Hynes (1976) noted morphological differences in this species throughout the state, namely a variation in the prominance of the dorsal ridges and a similar range of forms was observed in those collected in this study.

Coleoptera:

The most common beetle larva found was a new species of *Sclerocyphon* (Davis, 1975) found at all altitudes but occurred in greater numbers at the higher altitude sites, possibly due to the amount of algae and sediment at low altitude sites. Davis (1975) found that it occurred along the entire lengths of Lambert Park and Hytten Hall Creeks in both pools and riffles and also in the substrate, but that it preferred habitats where stable contact with the substrate was available.

Other Coleoptera were larvae and adults of the families Helminthidae, Helodidae and Dytiscidae. These were found mainly at lower altitude sites.

Trichoptera:

15 families of trichopterans, including 8 case-dwelling species and 7 free living species were collected. Case-dwelling species occurred at all altitudes but more species were found at lower altitudes. Some such as the Helicopsychidae and the Limnephilidae were found clustered in large numbers in

crevices on rocks. Gaufin *et al.* (1956) found that a species widespread in any given sampling area tended to vary greatly in distribution over the area, clustering in favourable microhabitats. This type of distribution makes quantitative sampling extremely difficult.

Free living species were not found at sites above 450m. This may be related to their feeding habits, since although they require a certain current to built nets but this current must not be too great.

Diptera:

The most common diptera collected were members of the family Chironomidae. Several species were found but it was difficult to identify them. However, a distinct species with a case was found at high altitude sites.

Simulidae and Blephariceridae were only found in isolated samples, due to their need for very fast current. Other Dipteran larvae included Muscidae, Tipulidae and Ceratopogonidae.

Oligochaeta:

The most prominant family collected was the Lumbriculidae. These were extremely numerous at sites 2c, 3b and 3c. Jolly and Chapman (1964) found that *Lumbriculus* tolerates organic enrichment but favours recovery zones. According to Brinkhurst and Cook (1974) lumbriculids replace tubificids in stony streams.

Other oligochaetes occurred at all sites but were not abundant.

Mollusca:

The two snail genera, Potamopyrgus and Bulinus, were found at the lower altitude sites and were prolific at site 3c all year and site 1c in summer.

Crustacea:

The endemic syncarid Anaspides tasmaniae was found only at sites 1a, 2a, 4a, and 5a. It was found in both pools and riffles, but was more abundant in pools. Williams (1974) described the typical habitat as small upland streams and moorland pools, also lakes. It is usually found in the highlands although he gives the total altitudinal range as 15 to over 1200m A.S.L. Most collections have been taken at over 150m and most of these localities he found were subject to near - freezing temperatures in winter. He gives an upper temperature tolerance of between 15°C and 20°C. Anaspides is eaten by the introduced Brown Trout Salmo trutta, which is found in all the streams studied. This may explain the presence of Anaspides above Wellington Falls on the North West Bay River, and its absence below. Trout have not penetrated above the falls.

The amphipod Neoniphargus sp. was found as low as 140m but was more frequent at higher altitudes. Lake and Knott (1972) note that the larger neoniphargids are confined to cool, flowing streams often in association with Anaspides tasmaniae as was the case in the Mt. Wellington streams.

The shrimp *Paratya australiensis* (Walker, 1972) was found only at site 5c. Williams (1974) notes that it occurs in lowland creeks near the coast and in inland lakes. Site 5c is much closer to the coast than the other low altitude sites.

Summary:

The fauna of Mt. Wellington streams contains a large proportion of endemic species, including *Eusthenia spp.*, *Tasmanoperla spp.*, several members of the family Gripopterygidae, *Neoniphargus sp.*, *Anaspides tasmaniae* and some Trichoptera (also *Astacopsis fluviatilis* and the phreatoicid *Colubotelson thomsoni* not found in this study). Also important is the widely distributed mayfly *Atalophlebioides sp.*

Although no similar surveys have been conducted in Tasmania, various collections of these groups indicate that the fauna of Mt. Wellington streams is similar to that of other mountain areas, such as Mt. Field, Cradle Mt. and Mt. Hartz. The degree of endemicity of the fauna makes it distinct from mainland lotic fauna, however, some groups such as the Plecoptera have similar counterparts in mountain areas such as the Kosciusko region.

CHAPTER 5: ANALYSIS OF RESULTS

HISTOGRAMS:

One of the problems of presenting the results of survey work is that the information is often in the form of long lists of species, from which it is difficult to draw a great many conclusions. One method of summarizing such results (used by many authors including Hynes 1961, Hughes 1966, Ward 1975 and Armitage et al., 1974) is in the form of histograms.

Riffle samples for each site were pooled and groups of similar animals such as Gripopterygidae, were represented as a percentage of the total number of animals collected at that site. Groups represented by greater than 10% of the total catch were then plotted as histograms. Figures 3-7 are histograms for each site at each season. Figure 8 compares pool and riffle samples in the same way.

This method has some drawbacks, quite apart from the technical problems of presenting histograms visually. The validity of pooling samples from a site is doubtful when each site contains many different microhabitats and therefore different faunal groups, and when clustering of animals occurs. The variation of Surber samples has already been discussed in Chapter 4, and such variation can be seen from the raw data.

The use of percentages often leads to an underestimate of the importance of larger animals occurring in small numbers, for example, Eusthenia spp. Poole (1974) notes that abundance is not necessarily a good indication of the importance of a species in a community.

However, this method is a simple way of summarizing large amounts of data and does give some indication of the dominant groups of invertebrates at each site for each season.

Diversity indices

A method commonly used in the past to analyze such community results has been the calculation of diversity indices. However, in recent years doubt has been placed on the biological meaning of these indices (Hurlbert 1971, Goodman 1975), Hurlbert (1971) suggests that the term " species diversity" conveys no more information other than "something to do with community structure." Many authors in the past, for example MacArthur (1955). Margalef (1969), have used a species to indicate community stability. However, as Goodman (1975) points out, no relationship between stability and diversity has been domonstrated. Although biological implications of diversity indices may be doubtful, they are useful as a shorthand for expressing the number of species and relative abundance of species in a community for the comparison of communities.

Several indices have been devised and some of these are mentioned by Wilhm and Dorris (1968). A comparison of these indices shows that different rankings of samples can be obtained using different indices (Hurlbert 1971). Bennison (1975) used three indices and gained different interpretations from each. Hulbert (1971) suggests that if diversity indices are to be used, the choice of a particular index depends on the purposes for which it is to be.

The most commonly used diversity index is the Shannon-Weaver Index (Shannon and Weaver, 1962).

$$H' = - \sum_{i=1}^{S} p_i \log p_i$$

where S is the number of species and p_i is the proportion of the total number of individuals consisting of the i^{th} species. It incorporates the two ideas of species richness and species evenness which Hurlbert (1971) considers necessary for the diversity index.

However, there are some disadvantages in using this index. It is based on the assumption that the sample contains all the species in the community pool and as Poole (1974) points out, in most cases (including this survey) this is not the case. Also Goodman (1975) and Poole (1974) suggest that H' is only appropriate in samples containing animals of the same trophic level. The degree of clumping of individuals also affects the value of H' (Goodman, 1975).

It is evident, therefore, that precaution must be taken in the interpretation of diversity indices and that use should be restricted to that of a shorthand for comparison of results. In this respect, diversity indices have been widely used in assessing pollution (Wilhm and Dorris, 1966, 1968). This topic will be treated in Chapter 6. Shannon-Weaver diversity indices for each site and season are given in Table 8.

Similarity Indices

One reason for the use of diversity indices has been the comparison of communities (Poole 1974). Similarity indices can also be used for this purpose and may be more appropriate in this case as they are often based on the presence and absence of species and not on their abundance. They have been used by several authors such as Armitage *et al.* (1975), Robach *et al.* (1971) to compare streams, to ascertain the presence of altitudinal zonation and to determine changes in community composition due to different forms of pollution.

Mountford (1962) reviews some similarity indices which he shows to be dependent on sample size. He puts forward a new formula which is less dependent on size. This is given as

$$I = \frac{2j}{2ab - (a + b)j}$$

where j = number of species common to both sites

a = number of species in a sample from one site and

b = number from the other site.

Similarity indices can be expressed as a matrix of values for similarities between samples. However, when there are a large number of samples, it is difficult to pick which samples are most similar. Clustering of sites according to similarity to produce a dendrogram relating the samples provides a better visual representation of such results.

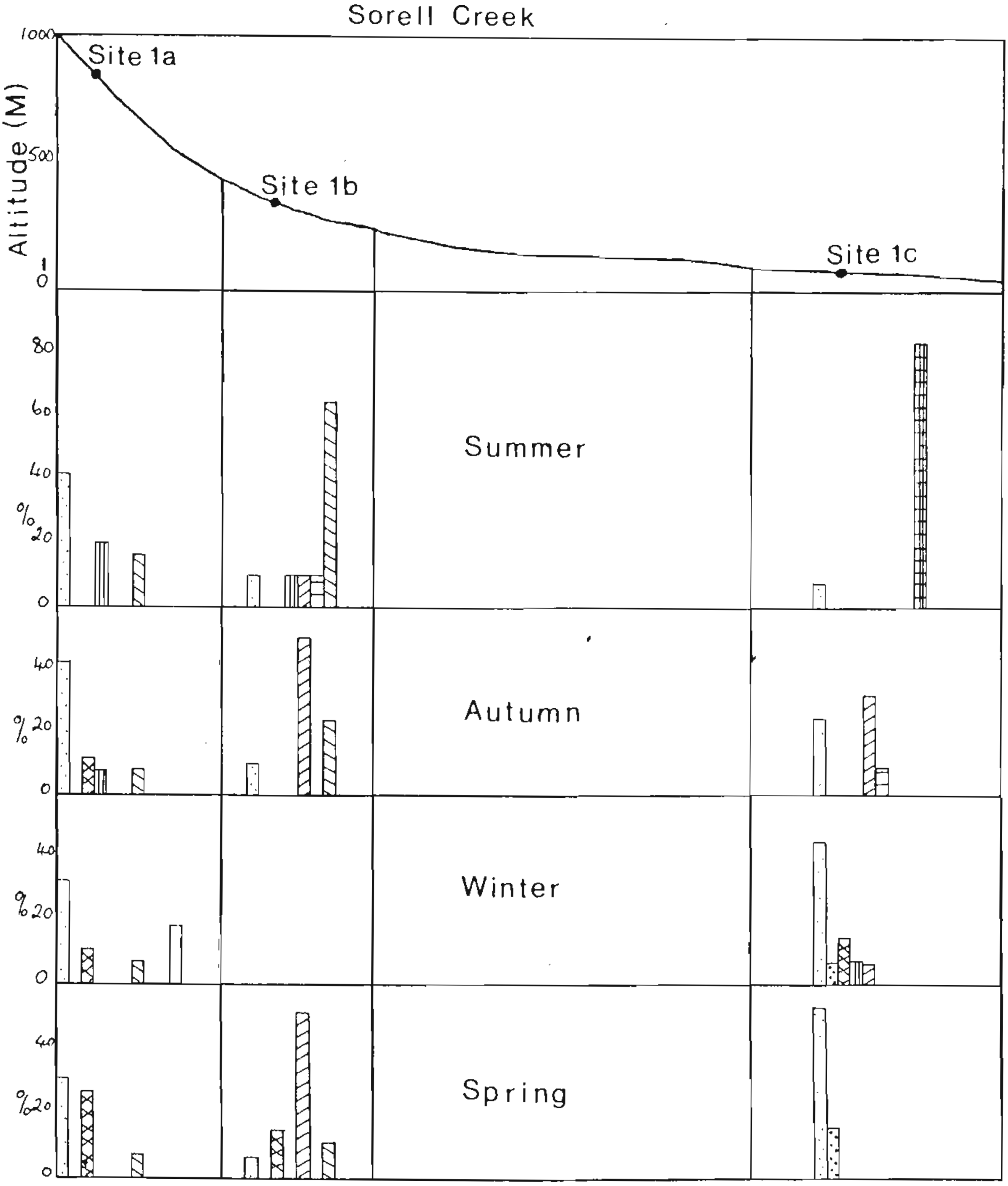
A hierarchical classification of sites was worked out, according to Mountford (1966) as follows. A table of similarity indices was drawn up. The pair of sites with the highest index were grouped together and indices of similarity were calculated between this group and the remaining sites using the formula of Mountford (1966); the index of similarity between a site B and a group composed of sites A_1 and A_2 being

$$I\ (A_1A_2;B) = \frac{I(A_1B) + I(A_2B)}{2}$$

A reduced table of indices was drawn up and the process repeated, each time groups of highes similarity index being grouped using the general formula for the index between groups A_1, A_2, ... A_m and B_1, B_2, ... as

$$\frac{1}{mn} \sum_{i=1}^{m} \sum_{j=1}^{n} I(A_i B_j)$$

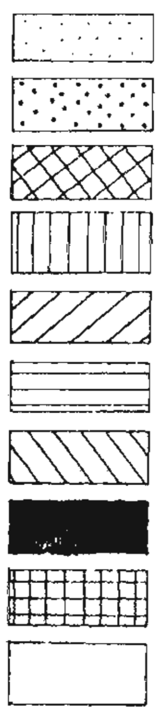
until the table was reduced to a single value.



Sorell Creek
1000
Altitude (M)
500
0
Site 1a
Site 1b
Site 1c
80
60
40
%
20
0
Summer
Autumn
Winter
Spring

Figure 3. Relative importance of major invertebrate groups in riffle samples at each site on Sorell Creek for each season.

Key.



Atalophlebioides spp.

Baetis sp.

Gripopterygidae

Sclerocyphon sp.

Case Trichoptera

Free-living Trichoptera

Chironomidae

Oligochaeta

Mollusca

Neoniphargus sp.

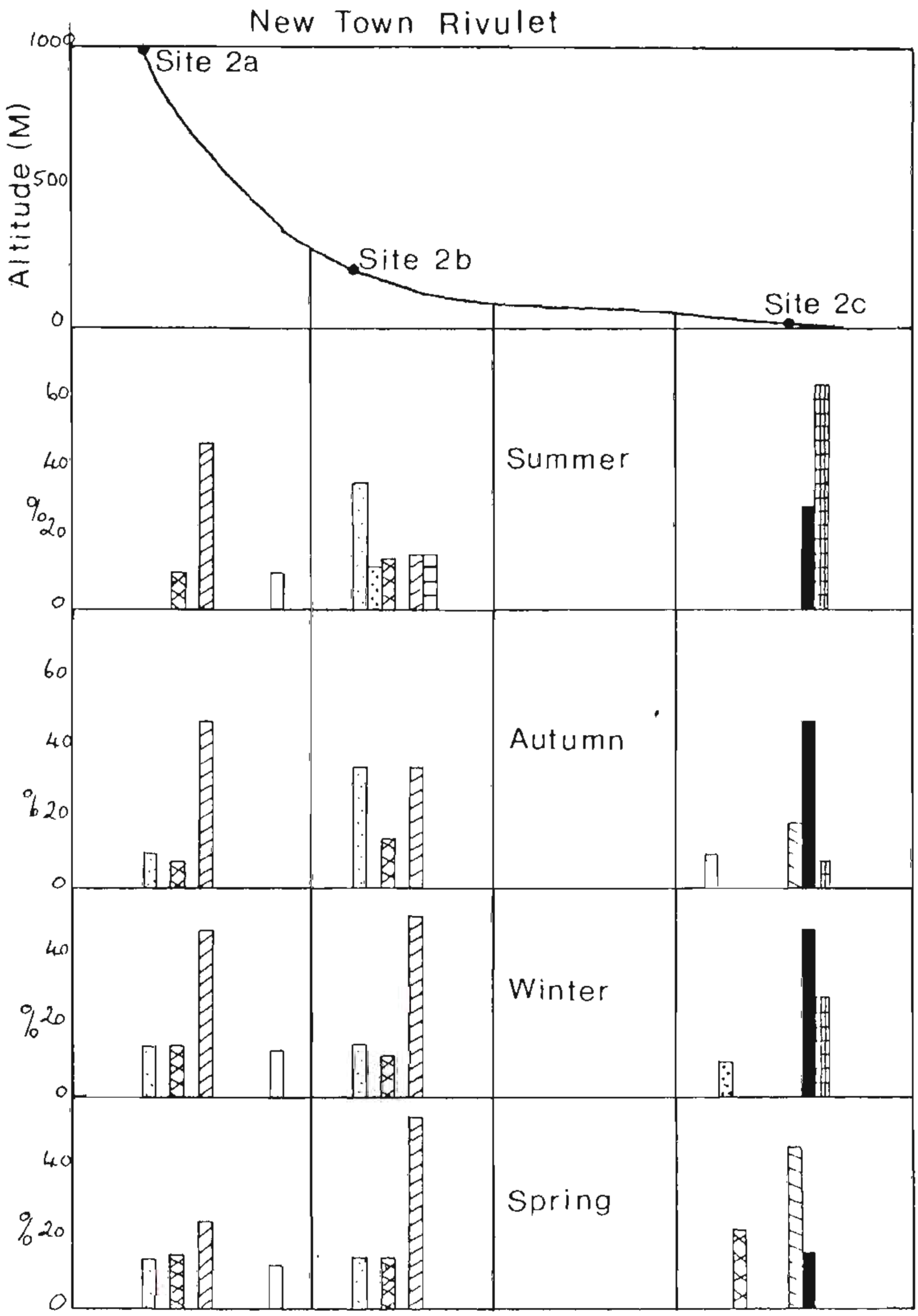
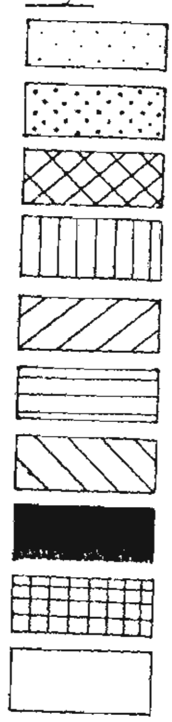

New Town Rivulet
Altitude (M)
1000
500
0
Site 2a
Site 2b
Site 2c
Summer
Autumn
Winter
Spring
%
60
40
20
0

Figure 4. Relative importance of major invertebrate groups in riffle samples at each site on New Town Rivulet for each season.

Key.



Atalophlebioides spp.

Baetis sp.

Gripopterygidae

Sclerocyphon sp.

Case Trichoptera

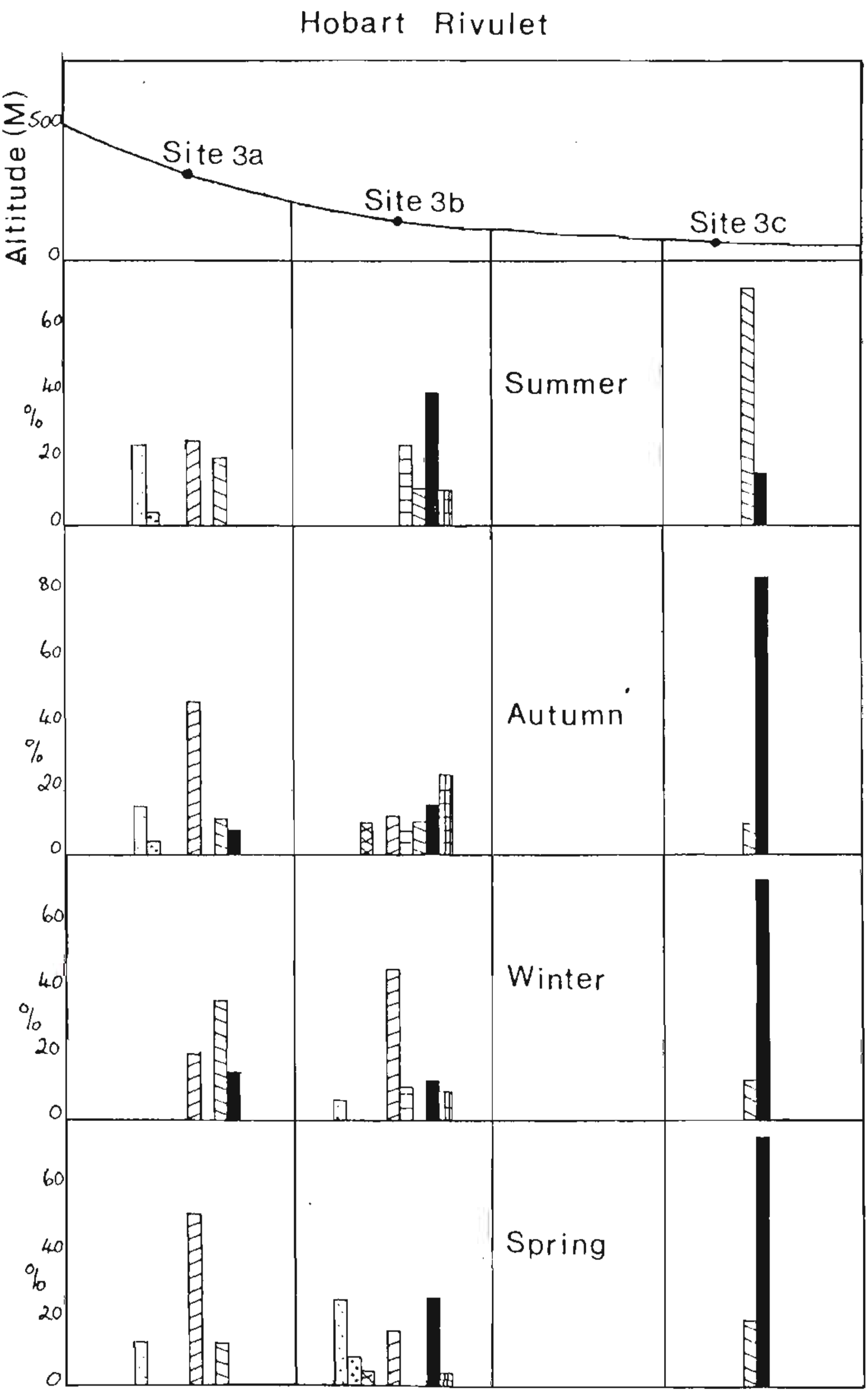
Free-living Trichoptera

Chironomidae

Oligochaeta

Mollusca

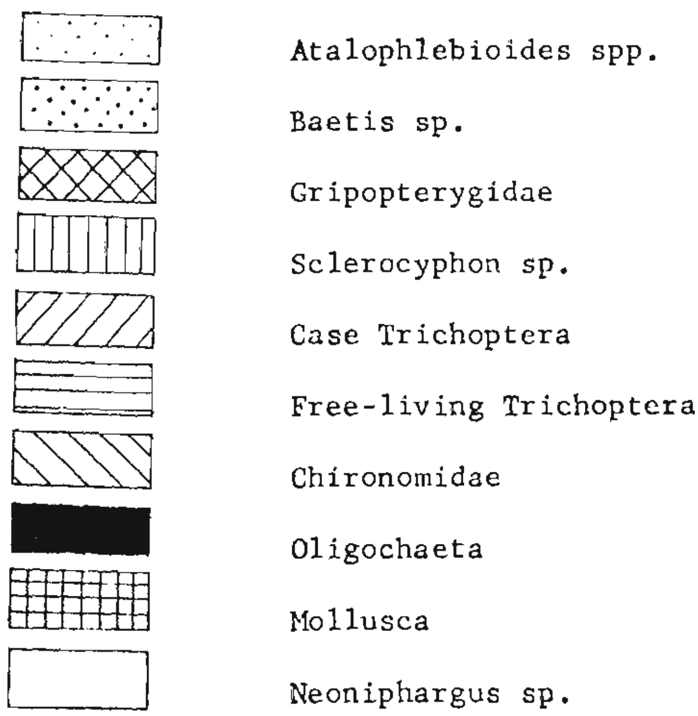
Neoniphargus sp.



Hobart Rivulet
Altitude (M)
500
0
Site 3a
Site 3b
Site 3c
Summer
Autumn
Winter
Spring
%
0
20
40
60
80

Figure 5. Relative importance of major invertebrate groups in riffle samples at each site on Hobart Rivulet for each season.

Key.



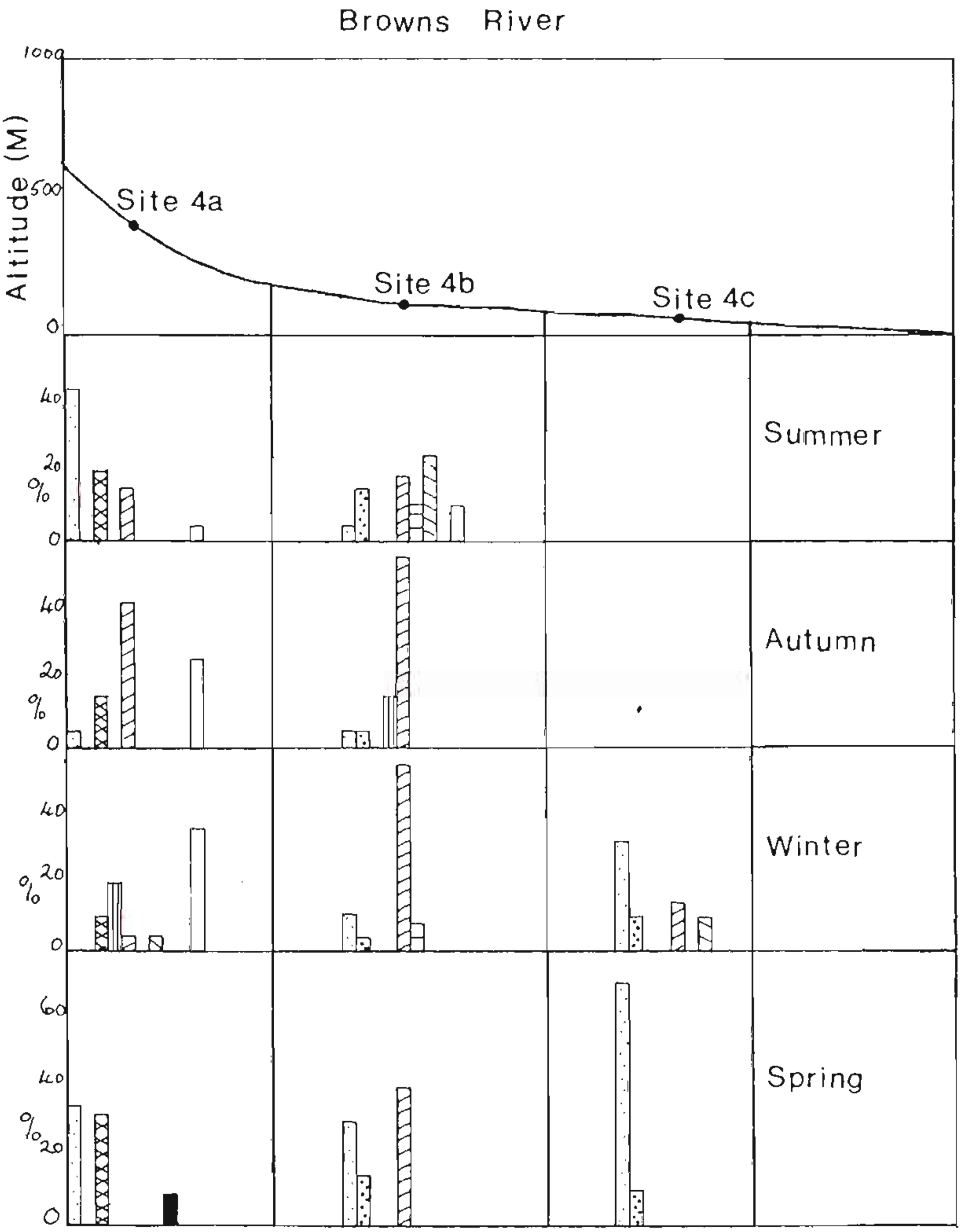
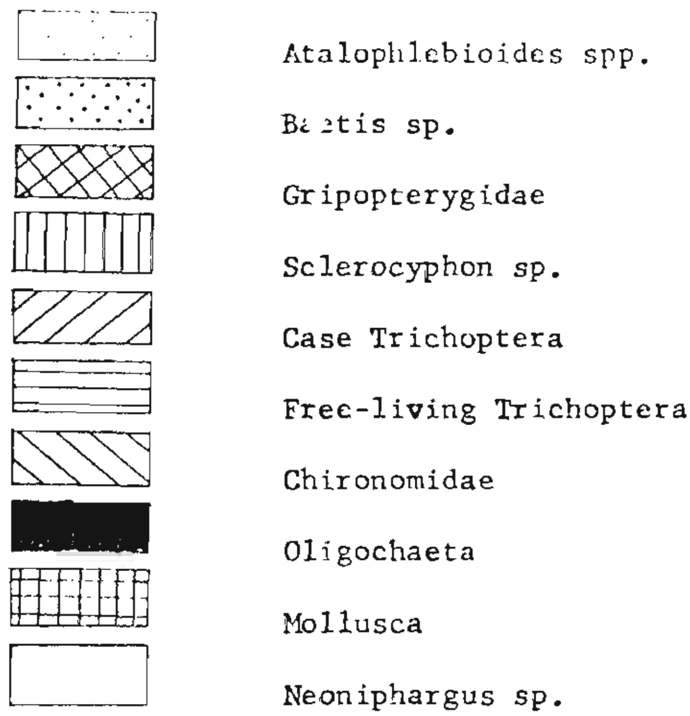
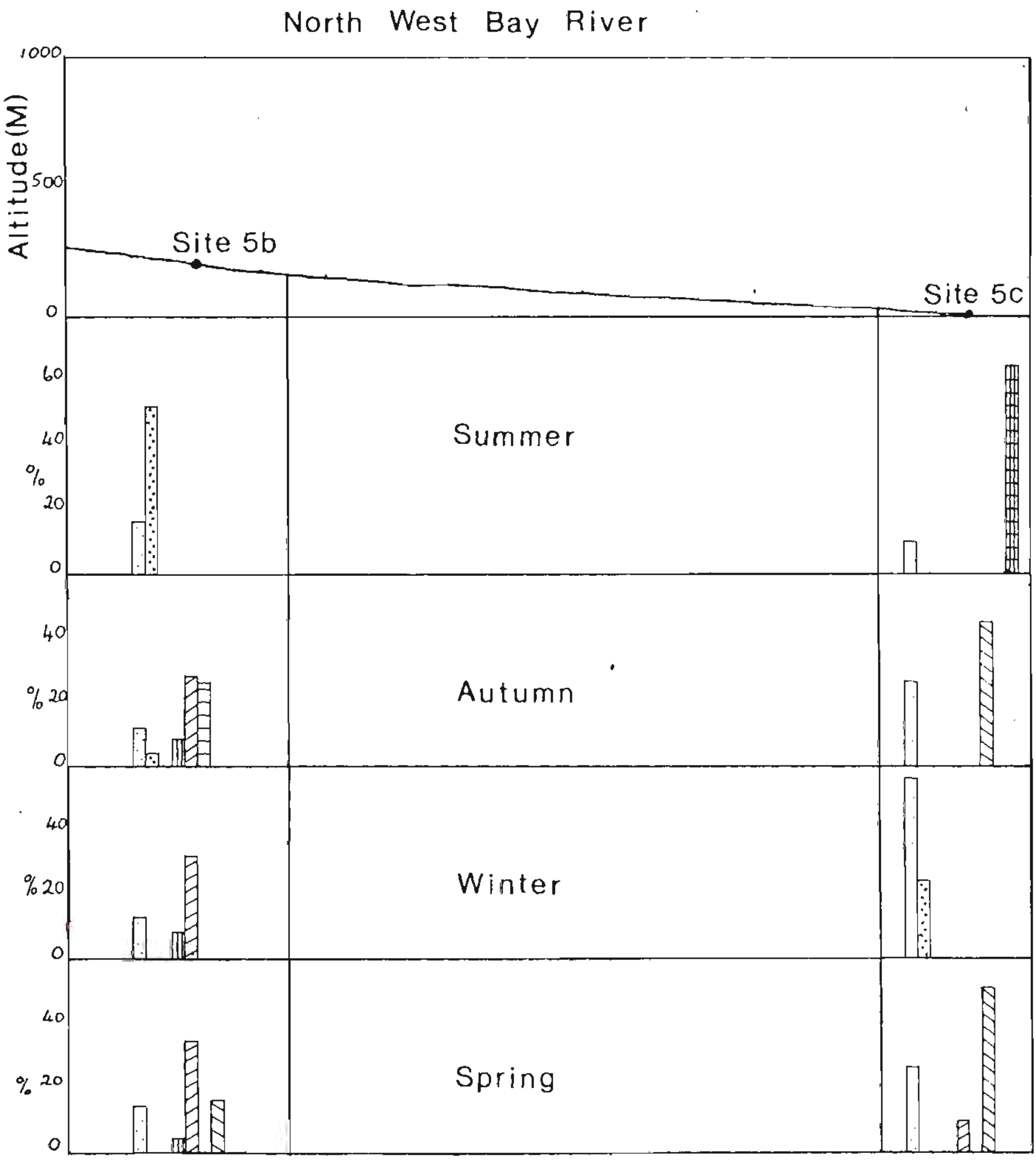

Browns River
Altitude (M)
1000
500
0
Site 4a
Site 4b
Site 4c
%
40
20
0
Summer
Autumn
Winter
60
Spring

Figure 6. Relative importance of major invertebrate groups in riffle samples at each site on Browns River for each season.

Key.

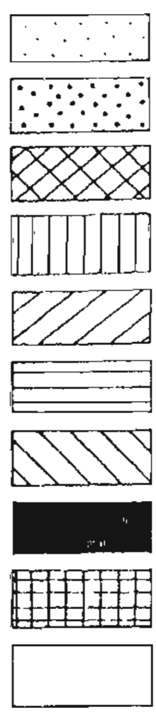




North West Bay River
Altitude (M)
1000
500
0
Site 5b
Site 5c
%
60
40
20
0
Summer
Autumn
Winter
Spring

<u>Figure 7.</u> Relative importance of major invertebrate groups in riffle samples at each site on North West Bay River for each season.

<u>Key.</u>



Atalophlebioides spp.

Baetis sp.

Gripopterygidae

Sclerocyphon sp.

Case Trichoptera

Free-living Trichoptera

Chironomidae

Oligochaeta

Mollusca

Neoniphargus sp.

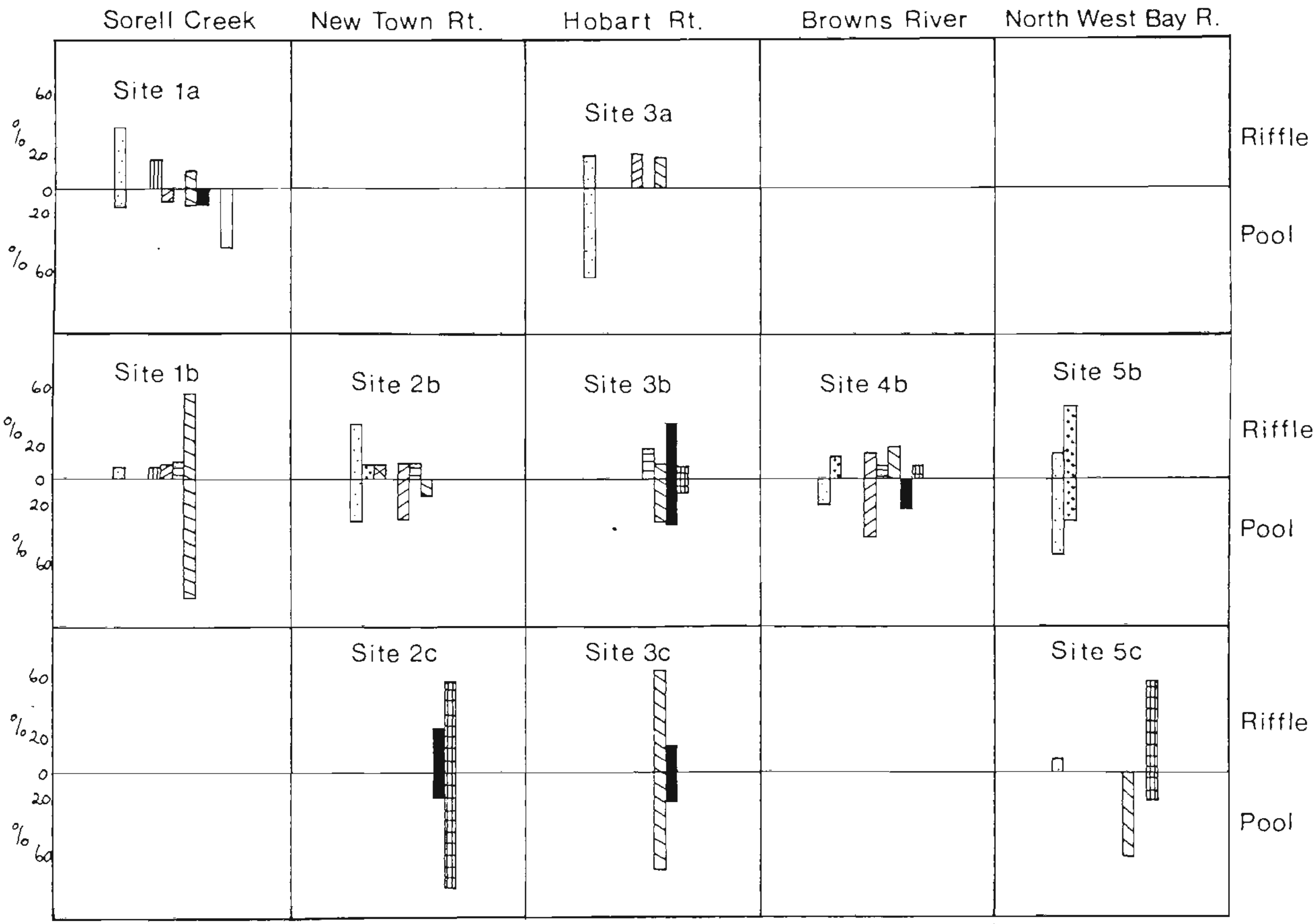
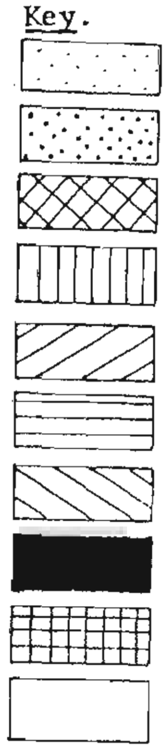

Sorell Creek
New Town Rt.
Hobart Rt.
Browns River
North West Bay R.
Site 1a
Site 3a
Site 1b
Site 2b
Site 3b
Site 4b
Site 5b
Site 2c
Site 3c
Site 5c
Riffle
Pool
Riffle
Pool
Riffle
Pool
60
% 20
0
20
% 60
60
% 20
0
20
% 60
60
% 20
0
20
% 60

Figure 8. Relative importance of major invertebrate groups in riffle and pool samples at each site in summer.

Sites 4c and 5a were not sampled in summer

There were no distinct riffle and pool are at site 1c. At sites 2a and 4a the pool ar were too small to be sampled.

Key.



Atalophlebioides spp.

Baetis sp.

Gripopterygidae

Sclerocyphon sp.

Case Trichoptera

Free-living Trichoptera

Chironomidae

Oligochaeta

Mollusca

Anaspides tasmaniae

SITE	SUMMER	AUTUMN	WINTER	SPRING
1a	2.050	1.862	2.303	2.432
1b	1.946	2.075	—	2.426
1c	0.833	2.786	2.303	2.323
2a	1.861	1.870	1.682	2.162
2b	2.587	2.143	2.218	2.241
2c	1.378	2.218	2.033	1.862
3a	2.420	1.844	2.035	2.070
3b	2.093	2.473	2.105	2.529
3c	0.899	0.524	0.804	0.922
4a	1.869	1.725	2.089	2.042
4b	2.301	1.752	2.338	2.367
4c	—	—	2.598	1.656
5a	—	—	(a)2.084 (b)1.243	—
5b	1.485	2.206	2.554	2.397
5c	2.206	2.001	2.044	1.848

Table 8. Shannon-Weaver diversity indices for each site and season.

The fauna was not sampled at sites 4c and 5a in summer and autumn nor at site 5a in spring. The values for site 5a in winter are (a) above Wellington Falls and (b) below the falls. For site 1b in winter, the number of animals collected was considered too low (due to a spate) to calculate the diversity index.

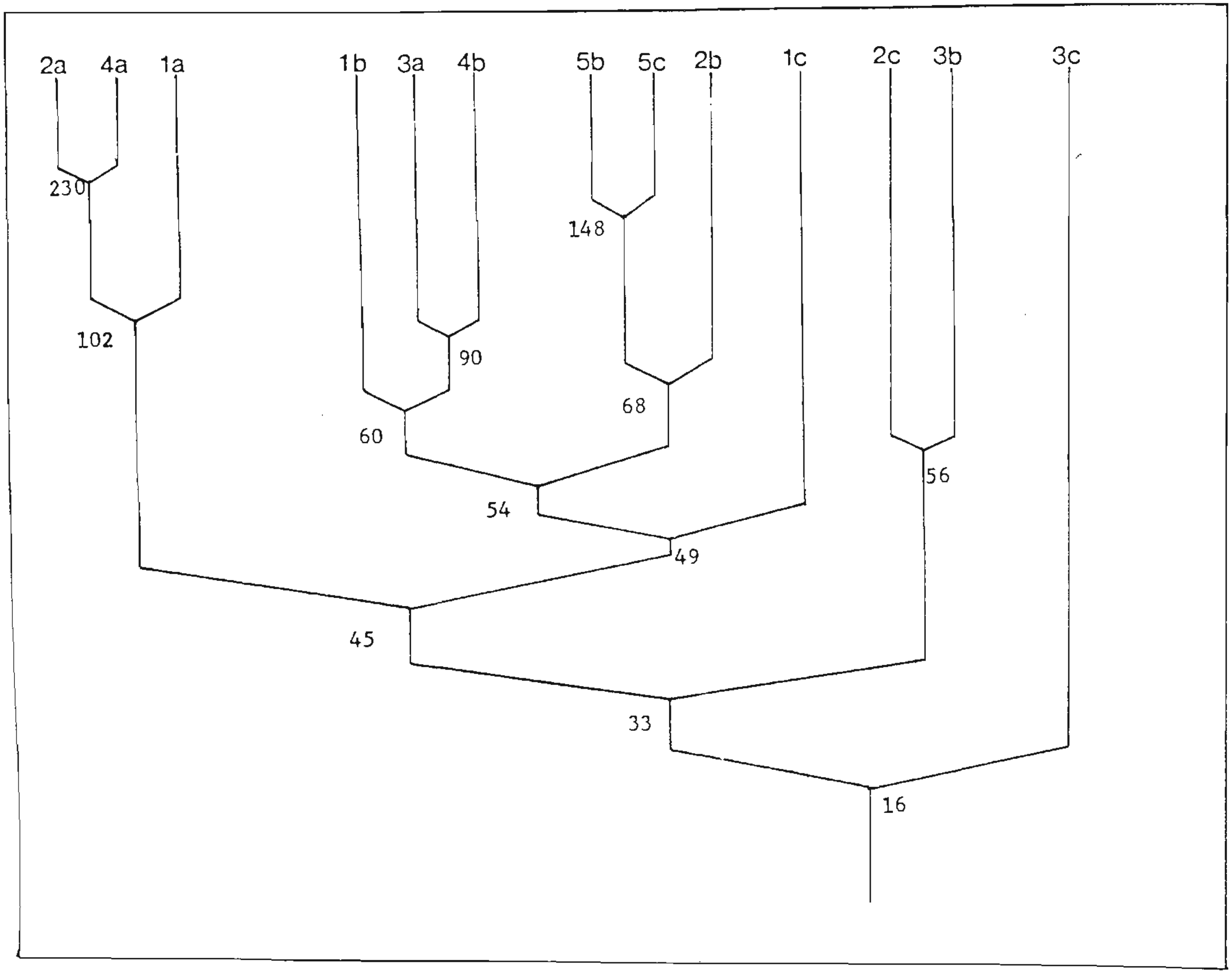

2a
4a
1a
1b
3a
4b
5b
5c
2b
1c
2c
3b
3c
230
102
148
90
68
60
54
49
56
45
33
16

Figure 9. Hierarchical Classification of sites for summer samples, according to Mountford, 1962, using Mountford's similarity index. Numerical values are similarity indices $x10^3$.

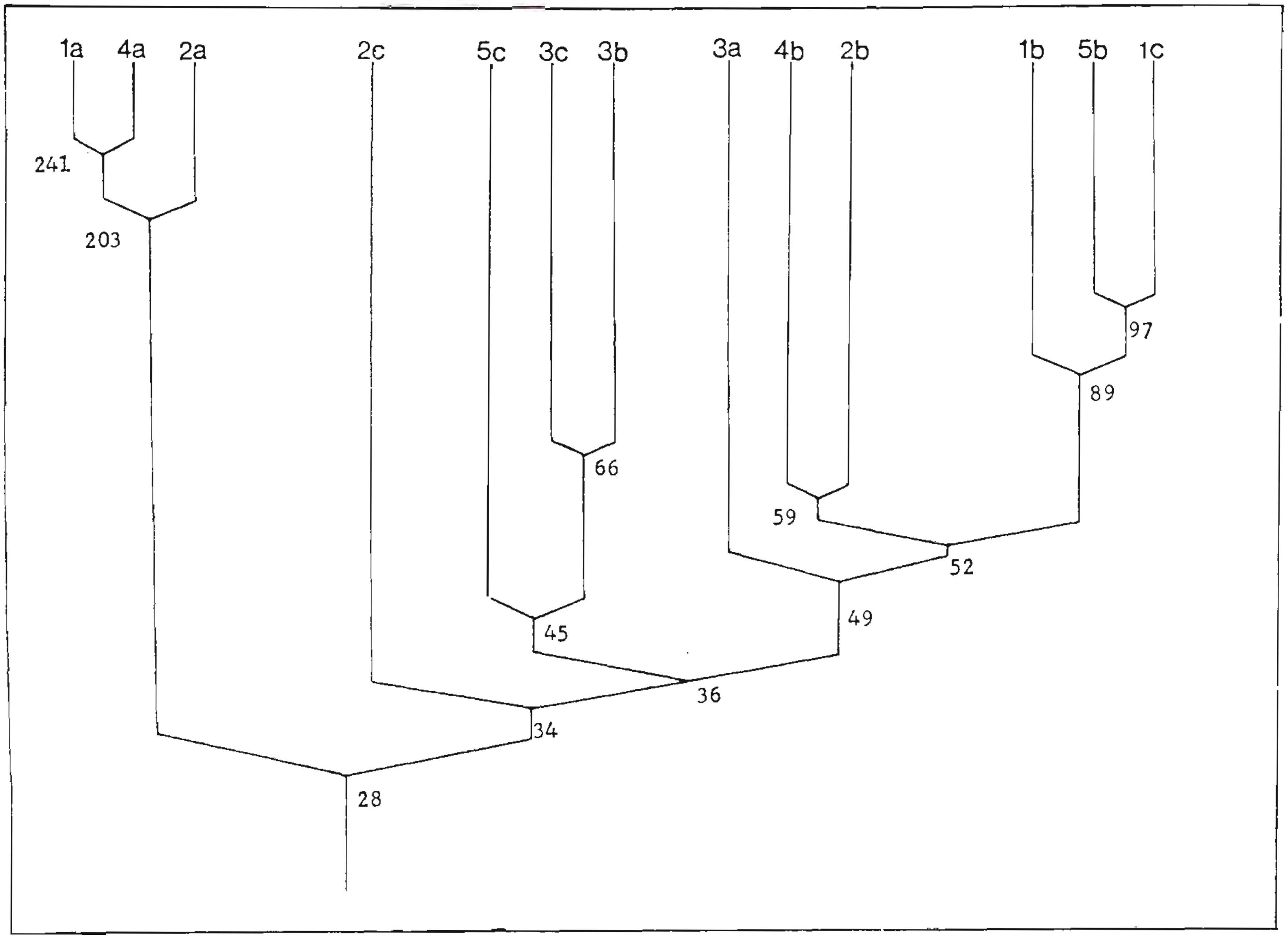

1a
4a
2a
2c
5c
3c
3b
3a
4b
2b
1b
5b
1c
241
203
97
89
66
59
52
45
49
36
34
28

Figure 10. Hierarchical classification of sites for autumn samples, according to Mountford, 1962, using Mountford's similarity index. Numerical values are similarity indices $x10^3$.

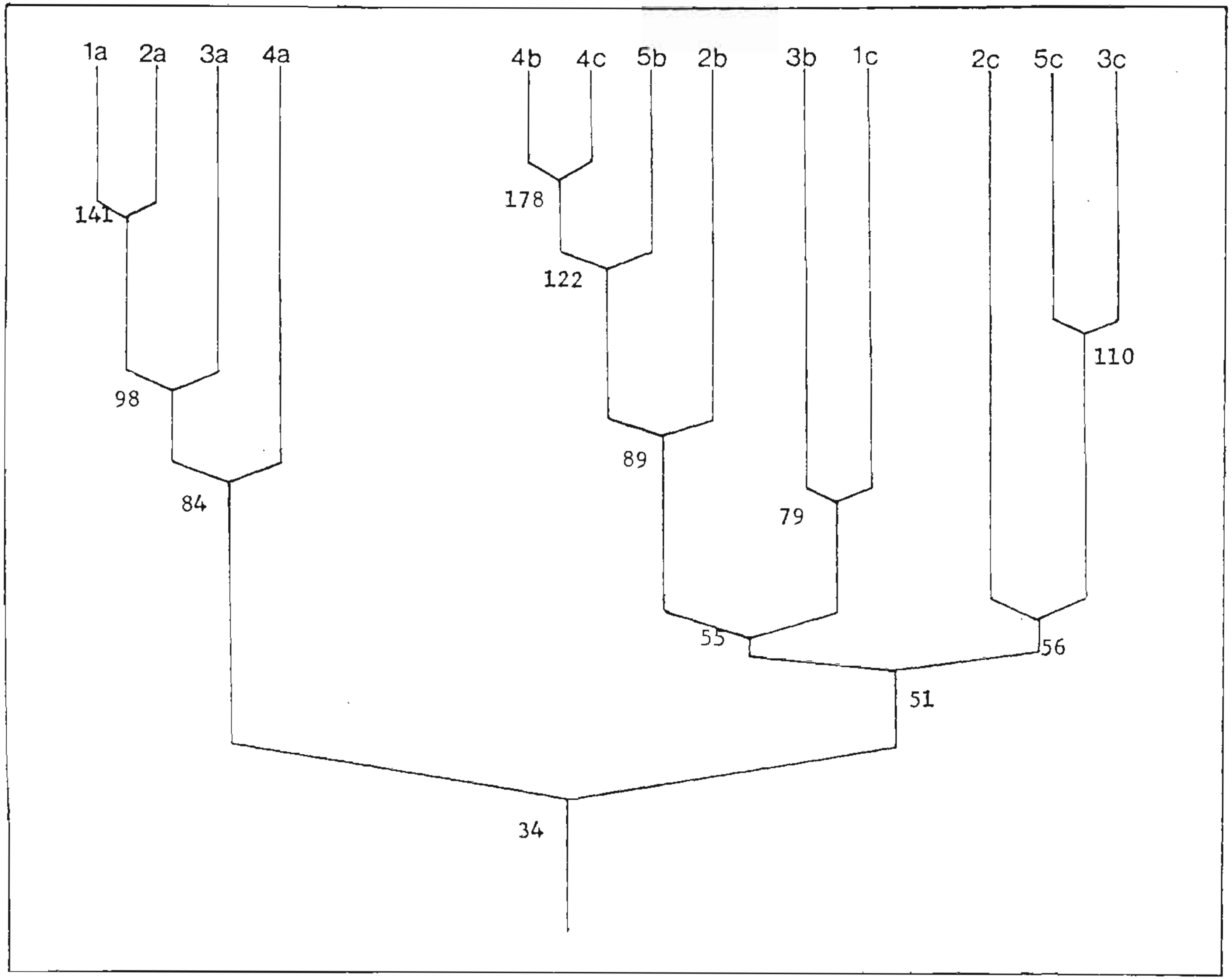

1a
2a
3a
4a
4b
4c
5b
2b
3b
1c
2c
5c
3c
141
98
84
178
122
89
79
55
110
56
51
34

Figure 11. Hierarchical classification of sites for winter samples, according to Mountford,1962, using Mountford's similarity index. Numerical values are similarity indices $x10^3$.

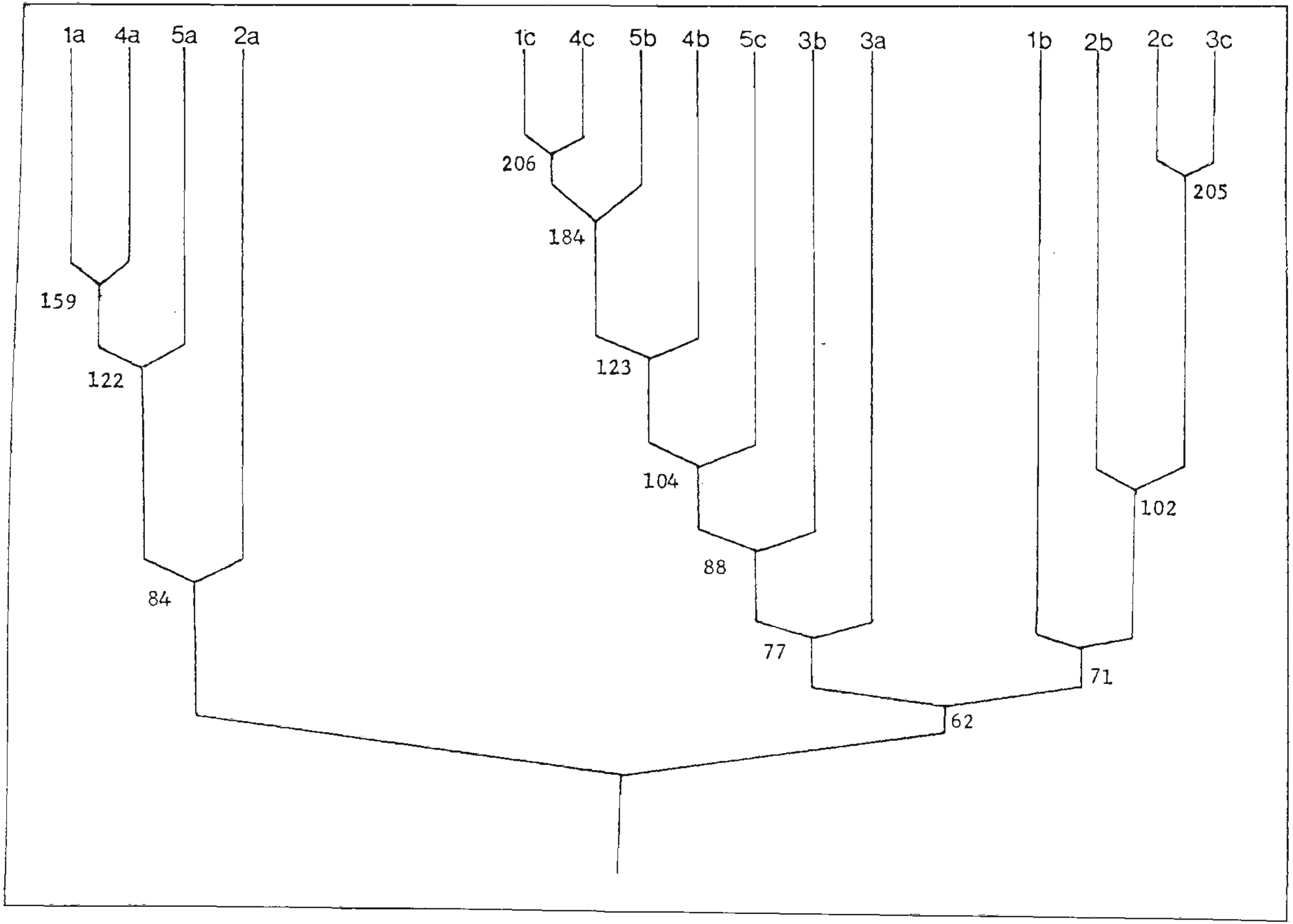

3c
2c
2b
1b
3a
3b
5c
4b
5b
4c
1c
2a
5a
4a
1a
205
102
71
62
77
88
104
123
184
206
84
122
159

Figure 12. Hierarchical classification of sites for spring samples, according to Mountford, 1962, using Mountford's similarity index. Numerical values are similarity indices $x10^3$.

Dendrograms showing the hierarchical classification of sites using this method for each season are given in Figure 9 - 12.

Comparison of Pools and Riffles

Figure 8 shows that there is a difference in the faunal composition of pool and riffle areas. Some groups such as *Anaspides tasmaniae*, *Chironomidae*, and Oligochaeta are more common in pools than in riffles. Gripopterygidae occur more frequently in riffles and other Plecoptera, that is *Eusthenia spp* and *Tasmanoperla spp*, which do not appear in this diagram were rarely found in pools. The Ephemeroptera *Atalophlebioides spp* and *Baetis spp* were found in both pools and riffles, while *Atalophlebia sp*, *Tasmanophlebia sp* occurred in low numbers and predominantly in pools.

Egglishaw and MacKay (1966), Armitage *et al.*, (1974) and Minshall (1968) also noted a difference in faunal composition between pools and riffles. They also found more animals in riffle samples than in pool samples.

Differences in composition of the fauna of these habitats is due to differences in current speed, depth and to some extent substrate which consisted of smaller cobbles and more gravel than riffles.

At some sites, especially the high and low altitude sites, it was difficult to find true riffle and pool areas, the flow being too high at the low altitude sites and too little at high sites. At some of these sites, for example site 2a, only one type of sample was taken. Where both riffle and pool samples were taken, and where there was a lack of real distinction between riffle and pool areas, similar fauna was found in both sample types, for example at site 4a.

Altitudinal zonation

Although only three sites were sampled on each stream, some evidence of altitudinal zonation is evident, from figures 3 - 7. However, this is not obvious as it might be, (except at polluted sites) because animals such as *Anaspides tasmaniae*, *Eusthenia spp* and *Tasmanoperla spp*, which are almost entirely restricted to high altitude sites, do not occur in large enough numbers to appear on these histograms.

The similarity indices, however, show a distinct difference between high and low altitude sites, the sites 1a, 2a, 4a and 5a, being linked by high similarity, whilst being dissimilar to the remainder of the sites. The remainder of the sites (except site 3a) are all under the influence of some type of disturbance. The fact that site 3a is not linked with the other high altitude sites suggests that there is a true altitudinal zonation (site 3a is the lowest of these sites) and that the separation is not due solely to the disturbed nature of the lower sites. In winter, site 3a is more similar to site 1a, 2a, 4a and 5a than the other sites. This may be due to increased flow at this time of the year causing animals from higher altitudes to be flushed down to this site.

As all lower sites are disturbed, no natural zonation was expected. Instead, sites are clustered according to the type and degree of disturbance. This will be dealt with in Chapter 6. The pattern of clustering was modified by the season and by changing sampling efficiency, for example, during high water, but in general the urban sites 2c, 3b and 3c were clustered together.

No Potamon (Illies, 1961) region was observed in these streams, as was expected from the temperature values and the substrate types. This is because these streams are short, arise at high altitudes and do not have a lowland deposition zone, in contrast to the rivers studied by Illies (1961).

The most important factor determining altitudinal zonation in this study is probably temperature, because the temperature results showed an altitudinal variation. Substrate type and flow were slso considered, but on the basis of substrate and flow, site 3a should be grouped with sites 1a, 2a, 4a and 5a. This site does differ in temperature from these four sites, however. Minshall (1968) also found that temperature was most important because of its effect on life cycles.

Seasonal variation

No distinct seasonal trends can be determined from Figure 3 - 7, except at site 1c which undergoes recovery from pollution from autumn to spring. Other changes in faunal composition during the year may be due to changes in flow due to minor spates and to variability in sampling.

Seasonal variation reflects the life histories of the faunal (Minshall and Kuehne, 1969) and special effects such as floods (Allen, 1951). Little work has been done on life cycles of Australian freshwater fauna, but a study of some mainland Plecoptera suggests that their life histories are similar to those of the northern hemisphere (Hynes and Hynes, 1975). Work in the northern hemisphere, for example, that of Arnold and Macan (1973) and Egglishaw and MacKay (1966) showed that most species, similar to those found in Mt Wellington streams, emerge in late spring to early summer. Unfortunately, no samples were taken at that time of the year., the first sample being taken in late summer and the last in early spring.

Also, some of the animals collected are non-seasonal (that is they have a life cycle greater than one year), for example, Anaspides tasmaniae and some of the larger Plecoptera.

Hynes, (1961), found that in winter and spring there was a decline in the numbers of some species due to predation. This was not observed in this study. One reason for this may be that the summer and autumn samples did not contain many very small individuals because of the mesh size of the net. Hynes, (1961), used several differnt methods of collecting and found that by using different mesh sizes, he altered the time of year when maximum numbers were found, because he was catching different sized instars.

Food may also be important. In the northern hemisphere where detrital food supply from leaves is seasonal, Hynes, (1961), found a difference in faunal composition with season, the summer fauna being algal feeders and the winter fauna detritus feeders. This would not be expected here, where the natural vegetation provides an almost constant source of food.

Comparison of streams

As mentioned in the section on zonation, temperature which is in turn determined by altitude, is the main factor causing similarity of fauna at different sites. Comparing the high altitude sites 1a, 2a, 4a and 5a, sites 1a and 4a show the greatest overall similarity, despite the fact that 1a is closer in altitude to sites 2a and 5a. Site 2a has a different substrate to the other high altitude sites and different vegetation type. It is also a much narrower and shallower stream. When all of these four sites are compared in spring, site 2a shows the least similarity to the other high sites.

The importance of substrate type has been mentioned in Chapter 3. From Figures 3 - 7, Neoniphargus appears to be more important (in terms of numbers) at site 2a. This is possibly due to the substrate type. *Neoniphargus* escapes the force of the current by burrowing into the substrate (Williams, 1974) and the substrate at site 2a is more suited to this.

Site 4a is at a lower altitude than sites 1a, 2a and 5a, however, it has a similar vegetation and size to site 1a. Site 5a on the other hand is a much larger stream, both in depth and width than sites 4a and 1a. As mentioned in Chapter 2, the greater width of site 5a results in the incidence of more direct sunlight on the stream and greater temperature fluctuations. The effect of this on the fauna has been investigated by Hughes (1966), who found that vegetational shading affected the incidences of certain species.

From this it may be concluded that temperature has the greatest effect on the distinction of fauna in these streams. This effect is modified by the effects of substrate, stream size, vegetation type and shading.

Because the lower sites are influenced by environmental disturbance, such as clearance of land for agriculture or for settlement, a comparison of these sites will be treated in a later chapter, dealing with these effects.

CHAPTER 6: DISTURBANCES

INTRODUCTION

Any interference with normal environmental conditions is almost certain to have an adverse effect on aquatic fauna and as Hynes (1970) points out there are few streams in the world that are not disturbed in some way. In Europe, man has had an influence on fresh-water environment for many centuries, so that in many cases the exact effect of man cannot be determined. However, in America, where the influence of man has been more recent, some changes caused by man (such as the clearing of land) have been monitored. Tasmania is fortunate in that some remote areas have remained untouched by man, so that precise information on the natural fresh-water environment and the effect of various forms of disturbance could be obtained. All the Mt. Wellington streams are disturbed at some stage, although the headwaters show least effects.

Hynes (1963, 1970) reviews some of the ways in which man has influenced the composition of the fresh-water fauna in the past. These include clearance of riparian vegetation, the substitution of agricultural crops for native vegetation, the impounding of streams, the canalization of streams for navigation and drainage, the abstraction of water for city use and irrigation, the introduction of exotic species and pollution. The factors that effect Mt. Wellington streams are dealt with below.

Abstraction

Water is abstracted for city use from both Browns River and North West Bay River. This has had an obvious effect on the flow of water below the sites of abstraction. It is particularly marked on North West Bay River where the flow is greatly reduced. Thus although North West Bay River at Wellington Falls is much larger than the other streams at this altitude, below the abstraction of water, it is a similar size in times of normal flow. Therefore, sites 5b and 5c have similar fauna (as shown by the similarity indices) to the lower altitude sites on the other streams, whereas, if the natural flow had persisted, the fauna would probably have had different elements, such as increased numbers of animals adapted to high currents, such as Plecoptera.

Because North West Bay River originally had a greater flow, the total stream bed is much wider than the one presently occupied and as mentioned above, the shading is restricted. This, plus the reduced depth would result in greater fluctuations in temperature, (Hynes,1970), eliminating the more stenothermal species.

In order to provide a sufficient depth for water intakes, small dams have been constructed on North West Bay River and Browns River. Retention of water in this way allow the development of lacustrine plankton (Hynes, 1970). This would occasionally be washed over into the stream, but as Hynes (1970) notes, it is quickly eliminated from streams

Another consequence of such dams occurs when abstraction of water is ceased, resulting in sudden increases in flow below the dam. This would have similar consequences to the effect of spates on the fauna, resulting in the removal of much of the fauna, (e.g. Allen 1951). However, discussion with a Hobart City Council worker at the dam on North West Bay River, indicated that this is not a frequent occurrence.

Abstraction of water for irrigation purposes occurs at most of the rural sites such as 1b and 1c. This occurs mainly in the summer and would only result in a slightly reduced flow.

Fire Tracks

Fire tracks occur across Sorell Creek and New Town Rivulet immediately above sites 1b and 2b. Although these are only used infrequently during summer, the effect on the fauna could be quite pronounced, due to the clearance of the vegetation on both sides of these streams. Hughes (1966) suggests that this results in the loss of insulation causing wider variations in the temperature of the water. Also the removal of vegetation results in erosion which increases the siltation of the stream (Douglas, 1967). The amount of runoff also increases and this will be discussed more fully under the section on removal of vegetation. The use of these fire tracks would increase these effects. No signs of siltation were visible, however, presumably because the rapid flow carries these sediments further downstream.

Fire

Bushfires have an important effect on the environment of Mt. Wellington. The area has been subject to periodic firing, since man settled the area and probably before this, the most recent severe fire being in 1967, when much of the vegetation was destroyed. Brown (1972) has studied the hydrologic effects of bushfire in the Snowy Mountains in New South Wales. Some of the observations he made are;

(i) pronounced changes in the shape of the flood hydrograph.

(ii) an increase in peak discharge.

(iii) greater runoff in the years following the fire than there would have been otherwise.

(iv) an increase in sediment loads.

The area he studied is similar to Mt. Wellington, so the effects of fire would be similar. Thus there would be greater floods after bushfires and the effect of flood on the aquatic fauna has already been mentioned. Chutter (1969) has shown that silting effects the composition of the fauna. As Brown (1972) noted, there was a greater runoff in the years following the fire. This is due to the removal of the vegetation, so that as the natural vegetation returns, the amount of runoff would return to normal. The long term effect on the fauna would therefore depend on the time lapse between the fires and the degree to which the fauna is effected and its ability to recover. At the time of sampling, regrowth of the vegetation had occurred to a large extent.

Introduced Species

The effect of the introduction of the brown trout, Salmo trutta, on the distribution of Anaspides tasmaniae has already been mentioned. Sloane (1976) showed that trout in the Jordan and Coal Rivers also feed on insect larvae, especially Atalophlebioides spp. but this does not seem to have any effect on the populations of these invertebrates in the Mt. Wellington streams. Nicholls (1946) also noted that phreatoicids were frequently found in the stomachs of trout examined from the Great Lakes so trout may affect their distribution.

Clearance of land

Vegetation acts in many ways to affect stream flow (Sartz, 1951). Firstly it intercepts rain and snow, the degree depending on the amount and type of vegetation. The rain then either percolates to the ground or is returned to the atmosphere by evaporation. Vegetation builds up litter and humus layers which absorb the water and slow down surface runoff. Roots take up moisture from the soil and return it to the atmosphere by transpiration through the leaves and stems. Thus the removal of vegetation may increase the amount of runoff. This is modified by other factors such as soil and topography, for example, deep soil may take up the moisture when precipitation is not too high. Sartz (1951) suggests that steep slopes would be more sensitive to cover removal. The effect of vegetation removal on erosion has already been mentioned.

Agriculture

Much of the land that has been cleared in the study area is used for agriculture and mostly for grazing. Hibbert (1969) found that generally flow increased in areas where forest is converted to grassland. This can be related to the amount of water intercepted by the leaves (Sartz, 1951) and to the usage of water by the vegetation (Hibbert, 1969). This also applies to most crops to a lesser or greater extent, depending on the leaf cover.

Another factor in the conversion of land for agriculture is the use of fertilizers. McElroy _et al_. (1975) note that nutrient enrichment may occur in streams due to runoff from agricultural land. Also there is an increase in salinity. This was observed downstream in Sorell Creek and North West Bay River, both of which flow through agricultural land. Sites 1c and 5c showed signs of nutrient enrichment with increased algal growth. This was more pronounced in summer, possibly because of the use of fertilizers in late spring, especially at site 1c where hops were an important crop. This enrichment is reflected in the composition of the fauna. In summer, at site 1c, there was a dominance of molluscs as is shown on the histogram, Figure 3. and the diversity index was low. This topic is dealt with in greater detail under the heading of pollution.

Urbanization

Urbanization also results in increased runoff due to the construction of non-porous surfaces, such as roads and areas of concrete. As a result materials such as waste petroleum products, waste material from building and construction sites and other solutes which build up on these surfaces during dry periods, are washed into the streams. Storm water outlets also enter the streams which run through the urban areas and solid material is occasionally deposited in the streams. These materials entering the streams can be considered under the heading of pollution.

Pollution

The term pollution has been used a great deal in recent years but the precise meaning of the word is not always clear. Klein (1962) defines pollution as anything causing or inducing objectionable conditions in any water course, and thus impairing the beneficial use of the water. However, it is essentially a biological phenomenon (Hawkes, 1962) and can, therefore, be defined in relation to its effects on the plant and animal life in the water, as the addition of substances to produce detectable changes in the biotic community structure (Wilhm and Dorris, 1968).

There are many forms of pollution. It may be solid or liquid, although it is most commonly liquid pollution that has the greatest effect on water environment, generally in the form of sewage suspension or industrial wastes. Klein (1962) and Hynes (1963) have adequately reviewed the topic of pollution. However, although a large amount of study has been carried out on the effects of water pollution, most of this work has been on larger rivers rather than small streams like those on Mt. Wellington.

In the past several methods have been used to assess pollution (Wilhm, 1972, Williams and Dussart, 1976). These include chemical analysis of the water, bacteriological assessment and assessment of composition of the flora and fauna.

In early studies of pollution, a great deal of emphasis was placed on the chemical aspects of pollution and assessment relied on measurements of pH, dissovled oxygen, chemical and biochemical oxygen demand, total dissolved solids, salinity, nitrate concentration, phosphate concentration and so on. The main problem with this is that it only gives the condition of the water at one particular time and if pollutants are not added continuously, pollution may not be detected by this method, unless sampling is carried out soon after pollutants are added (Wilhm, 1972).

More recently, the value of biological assessment has been recognized. In general, animals and plants are much more sensitive to changes within their environment than are chemical tests (Goodnight, 1973) and biological methods of assessment are based on the assumption that effluents produce distinct and measurable effects on structural and functional parameters of organisms or groups of organisms (Wilhm, 1972).

The biological effects of pollution can be assessed in many ways. The idea of indicator species has been used a great deal. Several groups of invertebrates such as oligochaetes, molluscs and chironomids have been used as indicator species.

Harman (1974) suggests that indicator species should possess certain characteristics, that is, they should be easily identifiable, they should be abundant in their preferred habitats throughout a large gerographical region, they should be indicative of the same conditions throughout their range; they should possess a relatively long life span and they should be comparatively sessile so that they cannot easily avoid a stressed environment. For this reason, the above invertebrate groups are often used.

As mentioned in Chapter 5, diversity indices have been used to describe community structure and this use has been extended to the change in community structure due to pollution, (Wilhm and Dorris, 1968). This use is based on the assumption that large numbers of individuals and small numbers of species are found in enriched areas of streams receiving organic wastes, while in clean-water areas there are smaller numbers of individuals and larger numbers of species.

None of the sites studied were characterized by low oxygen levels and B.O.D. values were indicative of clean water (Bayly and Williams, 1975), despite the fact that sites 2c and 3c are in urban areas and 2c is downstream from the Baker's Milk Factory and 3c is downstream from the Cascade Brewery. This may be explained by the high current speed and turbulence of the water at these sites. Also, these sites are some distance below these factories and Hynes (1963), notes that milk wastes decompose rapidly.

The effects of runoff and stormwater outlets would constitute a mild form of pollution which would not lead to rapid deoxygenation nor would it have a high loading of phosphates, nitrates or other ions because of the amount of dilution involved. However, accumulated solutes on areas of concrete etc. after dry periods would constitute a significant contribution to total ionic concentration with short bursts of rain.

Sites 1c (Summer), 2c, 3b and 3c were characterized by the presence of large numbers of either molluscs, oligochaetes or chironomids. These groups of animals were found at many of the other sites. Harman (1974) suggests that the absence of "clean water" species (such as Plecoptera and Ephemeroptera) is a better indication of the water conditions than the presence of tolerant ones. This also involves problems, such as restricted ranges of some of these species, the variable tolerance of these species (Roback, 1974, suggest that many insects may be quite tolerant to pollution) and the difficulties of identification of many of these species by other than experts. Although oligochaetes and chironomids may also be difficult to identify especially in Australia, they usually occur in large numbers in polluted waters and the number of species is usually restricted in these cases so that in many cases identification to family level is adequate (Williams and Dussart, 1976). Ephemeroptera and Plecoptera, which were presented at unpolluted sites, were largely absent from sites 1c (Summer) 2c and 3c, and were replaced by large numbers of oligochaetes, molluscs and chironomids.

Using the range of values for Shannon-Weaver Indices suggested by Wilhm and Dorris (1968), sites 1c (Summer), and 3c are heavily polluted and the remaining sites are moderately polluted. Inhaber (1976) notes that generally a greater number of species implies an ecologically healthier area and that an increase in pollution may result in the removal of some species but that these are merely generalizations. Similarily, Roback (1974) points out that although an undamaged stream is one which supports a diverse and balanced fauna, the physical structure and available habitats must be considered in making any evaluation. He suggests that background studies of similar stream sections whose sources and amounts of contaminations are known are necessary for comparison. Thus the low values of diversity in this study are most likely due to the harsh conditions, such as periodic fires and scouring conditions of the environment as found by Hendricks et al. (1974) in a similar study. For the meaningful use of diversity indices further studies need to be carried out on the effects of known pollutants in such environments.

Clustering techniques using similarity indices have been used by Roback et al. (1969) and Kaestler et al. (1971) to group sites affected by pollution. This method assumes a common change in community structure due to the addition of pollutants, resulting in a clustering of polluted sites separate from "clean sites". In the present analysis, the polluted urban sites were generally clustered together. However, this method does not determine which sites are polluted and requires a knowledge of the existance of pollution. It does, however, give an idea of the effect of a pollution source on a particular community.

From the above discussion, it is obvious that the urban sites are polluted to some extent. Harman (1974), Williams and Dussart (1976), emphasises the danger of over-reliance on any one method of assessing pollution, and therefore the physical and chemical characters of the environment as well as the biological component should be considered. In this case, a reliance on chemical factors would have suggested that none of the sites were polluted but composition of the fauna indicates that they are.

In general, addition of organic pollutants results in the increase in saprobic micro-organisms which cause deoxygenation of water, thus resulting in the death of organisms such as Plecoptera and Ephemeroptera which require high oxygen concentrations and allowing organisms such as certain oligochaetes and other animals that can exist in low oxygen concentrations to increase in number. In this study, although there was no observed deoxygenation, there was an observed change in fauna similar to that described above at several sites. At sites 1c, 2c and 5c there was a large amount of algae growing on the substrate and this trapped fine sediments. Hynes (1966) notes that in well oxygenated waters, mild pollution supplies nutrients which result in a change in algal growth rather than deoxygenation and growth of sewage fungus. This results in a change in fauna because the algae and settled solids interfere with the holdfast mechanisms of these animals, which depend on smooth clean surfaces.

It appears, therefore, that the sites 1c, 2c and 3c were subject to mild pollution only. This is supported by the lack of Tubificidae and sewage fungus at these sites. Brinkhurst and Coole (1974) note that although lumbriculids replace tubificids in stony streams, tubificids occur when there is sufficient build up of silt and organic matter, due to pollution. These sites were never the less characterised by a marked change in fauna, showing that even mild pollution in stony streams can have a significant effect.

In summary, the observed changes in faunal structure at the urban sites may be due to:

(1) The addition of nutrients causing increased algal growth and smothering of the fauna,

(2) sedimentation, also resulting in smothering of organisms and encouraging burrowing animals such as oligochaetes,

(3) occasional deoxygenation due to increased fungal growth, removing oxygen dependant animals with slow recolonization,

(4) occasional pollution events such as accidental discharge of sewage, as indicated by high coliform counts, or runoff from paved areas, resulting in increases in solutes.

CHAPTER 7: GENERAL DISCUSSION

One of the features of the Mt. Wellington stream fauna, evident in Chapter 4, is the altitudinal zonation, particularly the presence of a distinct mountain fauna, including *Eusthenia* spp., *Neoniphargus* sp and *Anaspides tasmaniae*. Hynes (1961) also noted that some species were confined to the higher altitudinal headwaters of the Afon Hirnant, Wales, and he explained this in terms of food availability and ability to maintain position in fast flowing conditions. In the Mt. Wellington streams, the zonation appears to be due mainly to the effects of temperature, since site 3a, which has similar vegetation, substrate and flow type, but slightly higher summer temperature to sites 1a, 2a, 4a and 5a, lacks this high altitude fauna.

Minshall (1968, 1969) noted that there was a predominance of Plecoptera in the headwaters of Morgan's Creek, Kentucky. However, the characteristic feature of the higher altitudes of the Mt. Wellington streams is the presence of *Neoniphargus* sp and *Anaspides tasmaniae* which do not have counterparts in the northern hemisphere.

Another noteworthy feature of the fauna of Mt. Wellington, in general, is the high proportion of endemic species. For example, of the 12 species of Plecoptera collected, all are confined to Tasmania. Many of the Crustacea of the area are also endemic and a further knowledge of the other invertebrate groups would, doubtless show a high degree of endemicity in these also.

Neboiss (1977) notes that 74% of the known Trichoptera of Tasmania are endemic. A similar proportion is found in the other aquatic insect groups, for example, 82% endemicity in the Tasmanian Plecoptera (Hynes, 1976). Neboiss (1977) also found that the greatest proportion of endemic Trichoptera occur in the north-west and south-west of Tasmania. This suggests that the uniqueness of Tasmanian aquatic fauna is related to climate, since the western part of the state experience high rainfall and cool temperatures, while the east is relatively dry and warmer. The mountains of the Central Plateau, and the south-east including Mt. Wellington show more affinity with the west than east, in view of their high rainfall.

Past environmental conditions, such as climate, have also had an important influence. Neboiss (1977) notes that during the last glaciation, when a land bridge joined Tasmania to the mainland (and also provided a fresh-water connection between the two land masses,) the climate of the eastern part of Tasmania was similar to that of the south-eastern part of the mainland. This has resulted in the occurrence of the same species of Trichoptera in the two areas, and different species in the western part of the state, including the Central Plateau and Mt. Wellington.

In discussing the Plecoptera, Hynes (1976) suggests that the reason why such a small proportion of species crossed this land bridge between Tasmania and the mainland may be that during periods of separation of the two land masses, the Plecoptera faunas evolved separately in Tasmania and the mainland, so that when mixing became possible, the niches were mostly filled and firmly held. He also considers that the similarity in climate between eastern Tasmania and south eastern Australia is important and notes that the species common to both areas are warm water species in Victoria.

If these theories are correct for the Trichoptera and Plecoptera, it is likely that they apply to other insect groups and possibly to the non-insect groups also. In fact, Williams (1973) suggests that the reason for limitation of the present distribution of <u>Anaspides tasmaniae</u> to mountain areas of Tasmania, is that there is at present a relative scarcity of suitable habitats on the mainland and also the differences in past and present climates between the two regions. He also suggests that the degree of endemicity of the fresh-water gammaridean amphipods in Tasmania may be due to the presence of more permanent stable fresh waters in Tasmania.

Although the faunas differ at the species level and in some instances at the generic level, (for example, some Plecoptera, Hynes, 1976) between Tasmania and the mainland, in most cases the genera are shared. In fact, Hynes suggests that there is reason to doubt the validity of some generic separations in the Plecoptera, e.g. the distinction between the Tasmanian genus <u>Eusthenia</u> and the mainland <u>Eustheniopsis</u>.

The zoogeography of the Plecoptera, (Illies, 1965), the Ephemeroptera (Edmunds, 1972) and the Trichoptera (Ross, 1967) shows the affinities of the fresh-water faunas of Australia, South America and New Zealand, reflecting previous land connections between these areas. Riek (1967) also remarks on the marked similarity between the Ephemeroptera of Australia, New Zealand and South America, and McLellan (1971) notes that the Gripopterygidae, which comprised a large portion of the fauna collected on Mt. Wellington, are restricted to Australia, New Zealand and South America.

Hynes (1970, 1970a) notes that the temperate rheophile insect fauna shows world-wide uniformity with the same families same life forms and often the same genera. However, isolated land masses, such as Australia, often have an impoverished fauna because of dispersal problems, and there is some dichotomy between the fauna of the northern and southern hemispheres. This is especially true of the Plecoptera. Thus, although the fauna of the Mt. Wellington streams is similar in appearance to that found by Arnold and Macan (1973) and Hynes (1961) in Europe and Hughes (1966a) in South Africa, it has few taxonomic affinities with these faunas below the ordinal level.

Riek (1970) notes the absence in the southern hemisphere of a whole suborder of the Plecoptera, the Perlaria, which are found in the northern hemisphere. The Plecoptera show a restricted range of distribution, families being confined either to the northern or southern temperate zones, Illies, (1965). The southern hemisphere families, especially the Eustheniidae are of ancient lineage and Illies (1965) suggests that the Plecoptera probably originated on a continuous southern land mass, including the present continents Australia, South America and Antarctica, and progressively evolved and migrated to the northern hemisphere.

The poor dispersal abilities of the Ephemeroptera are evident from the restricted Australian fauna and Riek (1970) suggests that most Australian species belong to generalized families. This has resulted in the diversification of these families in the northern hemisphere. This is particularly evident in the Leptophlebiidae, (Edmunds, 1972).

This phenomenon has also occurred to a lesser degree in the Trichoptera (Riek, 1970) in Australia, where they are represented by all but one of the major, more universally recognized families. However, as Ross (1967) pointed out many elements of the present fauna of Australia, New Zealand and temperate South America have not yet been studied in relation to the world fauna and this still holds to a large extent.

The taxonomy of the species indicative of pollution is poorly known in Australia, however the general effects of pollution in the Mt. Wellington streams appears to be similar to that found in the northern hemisphere (e.g. Klein, 1962, Hynes 1963), with the same families dominating the fauna in polluted reaches. This study has shown that the rheophile fauna is greatly affected even by mild pollution, such as that resulting from city runoff and stormwater drains.

The diversity indices at all sites irrespective of pollution, were relatively low compared with the range given by Wilhm and Dorris (1968) and Wilhm (1970). Hendricks et al. (1974) suggests that low indices in clean waters may be due to the harsh environment of the stream, that is, high and low periodic flows, heavy organic flows, coarse sandy bottoms etc. eliminating a large number of probable habitats. They suggest further that this may result in either very hardy (sic) organisms which will be able to withstand exposure to pollution or on the other hand, the organisms may be in the precarious position of being barely able to tolerate the normal conditions of the stream so that they are removed by any stress imposed by pollution.

Because of the periodic occurrence of fires and regular flooding, the Mt. Wellington streams can be considered a harsh environment. In the lower reaches of the streams apparently mild pollution has had a severe effect, so it appears that the second proposition of Hendricks et al. (1974) is the case at least in the lower reaches of these streams. Thus, precautions should be taken in any development that may take place at higher altitudes.

Although there are at present no specific plans for tourist development on Mt. Wellington, in the past plans have been proposed for the building of a hotel and a restaurant at the pinnacle. The last plan for a restaurant was proposed four years ago (J. Thompson, Mt. Wellington Range Survey, personal communication). Other possible developments include picnic areas, toilet blocks, carparks, paths and roads. Any of these developments could have deleterious effects on the general ecology of the areas, including the fauna of the streams.

One of the most important problems in the construction of a hotel, restaurant or toilet blocks would be the disposal of wastes. As Russell and Clarke (1977) point out, the development of sewage systems higher up the mountain would be difficult and expensive and disposal of waste material into the surrounding streams would cause unpleasant conditions and destroy the fresh-water fauna as it has in the urban sites. This would be highly undesirable especially because of the uniqueness of this fauna.

An increase in paved areas due to construction of roads, car parks and paths would result in increased runoff and addition of solutes to the streams of the area, as discussed in Chapter 6, in respect to the urban sites.

With greater numbers of people visiting Mt. Wellington, there is greater fire risk. Lake and Knott (1972) note that the influence of grazing and fire have caused a reduction in the bog area of the Central Plateau. The drainage from these bogs in the past maintained summer flow in creeks which are now semi-permanent, and, therefore, unsuitable for stream-dwelling custaceans and many insects. As North West Bay River is fed from similar bog areas near the summit of Mt. Wellington, the effect of fire and trampling of vegetation by sight-seers, which could disturb these bogs, should be kept at a minimum to preserve them."

The fauna of the Mt. Wellington streams is unique to Tasmania. As a mountain reserve, close to the city, Mt Wellington, therefore, offers a great deal as a resource for biological study, and every attempt should be made to conserve it. From the information gained in this study, this will involve careful planning before any disturbances are made to the surrounding environment.

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Appendix 1. The Fauna.

Species lists of invertebrates collected in each sample for riffles and pools at each site and season. All insects are larval forms, except where otherwise specified.

SITE 1a.

	1/3/77 Riffle 1.	2.	3.	4.	Pool 1.	2.	3.	4.	1/6/77 Riffle 1.	2.	3.	Pool 1.
ecta												
hemeroptera												
alophlebioides sp1.	7	5	4		2	2	2		3	3	6	1
" sp2.	1					2						
" sp4.		3	3					1	2	1		
etis sp1.						2						
coptera												
sthenia costalis				1					1			
smanoperla thalia	2									1	5	
larvalis						5						
inotoperla hardyi				1								
agricola				3			1		3	2		
ypturoperla paradoxa							1					
leoptera												
lerocyphon sp.	6	3	3						1		2	
ichoptera												
elicopsychidae						2						
eptoceridae sp1.						2						
" sp2.						2						
hilorheithridae sp1.						1					1	
iptera												
hironomidae		7	1			1	1	5		1	1	
uscidae						2						
imulidae			1									
rustacea												
ncarida												
naspides tasmaniae				13			5	5				
mphipoda												
eoniphargus sp.	1									1		
rachnida												
Hydracarina sp.						2						
ligochaeta		2										

SITE 1a

	2/8/77 Riffle 1.	2.	3.	4.	5.	6.	16/9/77 Riffle 1.	2.	3.	4.	5.	6.
XA												
secta												
phemeroptera												
talophlebioides sp1.	1		4			3	4		7	1	2	2
" sp4.	2	1	2	2	1	4	5	1	4		1	3
ecoptera												
usthenia spectabilis												1
E. costalis						1						
Tasmanoperla thalia			1				2	1	3		1	
T. larvalis						6						
Riekoperla triloba		2							1	1		1
ardioperla nigrifrons		1		2	1		1	1	2	5	1	5
Leptoperla varia									1			1
oleoptera												
clerocyphon sp.					1		1		1			1
richoptera												
Limnephilidae										1		
Conoesucidae								1	1			
iptera												
Chironomidae	1					2	3		1	4		
ymbiocladus			1									
Muscidae						1						
Simulidae							2	7		3	1	
Blephariceridae										7		
rustacea												
yncarida												
Anaspides tasmaniae					1	1			2		1	
mphipoda												
Neoniphargus sp.		3	2		2	3	1	1				2
ligochaeta			1		2	2	1					

SITE 1b.

DATE	1/3/77								31/5/77					
	Riffle					Pool			Riffle			Pool		
	1.	2.	3.	4.	5.	1.	2.	3.	1.	2.	3.	1.	2.	3.
TAXA														
Insecta														
Ephemeroptera														
Atalophlebioides sp1.	3		3	1	2			4					2	
" sp2.	6	1	2	4	5				4	5	2	2	6	3
" sp3.	2	1						1				2		
" sp4.										1				
Baetis sp1.	2	1			3			2				4	1	1
" sp2.	2							3	2	1			3	1
Atalophlebia sp1.							1	1		1				
" sp2.							1	2						
Tasmanocoenis sp.								1						
Tasmanophlebia sp.								1						
Plecoptera														
Eusthenia spectabilis	1	2							1	1	2		1	
E. costalis	2	2	2	4	1				1	1				
Tasmanoperla larvalis	1				1			2						
Leptoperla varia			1									1		
Cardioperla nigrifrons										2			1	1
Riekoperla triloba								1						
Trinotoperla hardyi								3				1	1	
T. zwicki												1	1	
T. agricola						1		2						
Coleoptera														
Sclerocyphon sp.	9	13	6	4	3	1		2		1	5		1	
Helminthidae		1	4		1									
Trichoptera														
Hydropsychidae sp1.		2												
" sp2.		5												
Rhyacophilidae sp1.	2	2	1	5										
" sp2.				2				1						
Stenopsychidae sp1.		3	3	1	4									
" sp2.		2	3	1	4									1
Philopotamidae					2									
Glossosomatidae									9	7	17			
Helicopsychidae				4							18			
Concesucidae					1									
Leptoceridae sp1.					1									
" sp2.		1	3	4		1		1			1			
" sp3.					1					2	6	1		
Limnephilidae		21		3		1			3	2				
Diptera														
Chironomidae	38	43	41	42	48	7	7	124	4	10	18	32	52	12
Muscidae	1					1								
Culicidae													2	
Crustacea														
Amphipoda														
Neoniphargus sp.					1									
Arachnida														
Hydracarina sp.		1		1										
Oligochaeta	1											3	2	

SITE 1b

DATE	29/7/77 Riffle 1.	2.	3.	16/9/77 Riffle 1.	2.	3.	4.	5.	6.
TAXA									
Insecta									
Ephemeroptera									
Atalophlebioides sp1.								2	
" sp2.	1		1	2	1	7	7	5	2
" sp3.					3			6	
" sp4.								2	
Baetis sp2.				1	2	1	2		1
Tasmanocoenis sp.									1
Plecoptera									
Eusthenia spectabilis	1			2		1	2	1	2
E. costalis						1	1		
Leptoperla varia				3	1	2	4	2	2
Riekoperla triloba				1	8		18	4	7
Cardioperla nigrifrons				5	4	8		1	3
Trinotoperla zwicki					1				
T. hardyi					4	2	2	1	
Coleoptera									
Sclerocyphon sp.				5	1	7	3	1	2
Trichoptera									
Glossosomatidae (larvae)		1		20	8	34	9	21	19
" (pupae)				21	1	13	2	19	
Helicopsychidae				1	2	1		1	1
Hydroptilidae sp4.				1	1				
Limnephilidae				14	12	14	13	38	6
Leptoceridae sp1.						2		2	
Conoesucidae				1					
Hydropsychidae sp1.				1	1	7	1	3	
" sp2.				1		3			
Rhyacophilidae sp1.								1	
" sp2.						1	1		1
Stenopsychidae				1					
Diptera									
Chironomidae			1	3	16	14	7	14	6
Culicidae				1				1	
Muscidae	1						1		
Tipulidae								2	1
Crustacea									
Amphipoda									
Neoniphargus		1			1	4	3		
Oligochaeta					1		2	3	1
Mollusca									
Potamopyrgus sp.								2	

SITE 1c.

DATE	1/3/77 Riffle 1.	2.	3.	4.	5.	31/5/77 Riffle 1.	2.	3.	4.
TAXA									
Insecta									
Ephemeroptera									
Atalophlebioides sp1.	43	8	20	3	10	3	1	3	1
" sp2.	12	15	15	1	10	11	6	2	11
" sp3.			6			6	2	1	1
" sp4.								9	4
Baetis sp1.	5	2	2						
" sp2.	1		4			2	2		6
Atalophlebia sp.	1								
Tasmanocoenis sp.	1	1							
Plecoptera									
Tasmanoperla								2	
Riekoperla triloba									1
Trinotoperla zwicki						2	1		
Coleoptera									
Sclerocyphon sp.	1	9		4		3	5	1	2
Trichoptera									
Hydroptilidae sp1.	1								
" sp2.			1						
Hydrosychidae sp1.				2		1			1
" sp2.								10	
Rhyacophilidae sp.2	5		2			1	2	2	2
Helicopsychidae	3	1	5	3	1	1	3		6
Conoesucidae		2							
Leptoceridae sp1.	3	15	6		1	10			3
" sp3.	19	1	6		3	1	2		
Limnephilidae					1	6	20		22
Philorheithridae sp1.	5	4	3						
" sp2.		1							
" sp3.		1							
Diptera									
Chironomidae		4				3	4		
Muscidae			1		1				
Culicidae		1				1			
Simulidae						3	2		
Arachnida									
Hydracarina	3		1						
Oligochaeta						1		1	
Mollusca									
Potamopyrgus	501	455	210	106	140	1	2	5	

SITE 1c.

DATE	29/7/77 Riffle						16/9/77 Riffle					
	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Emphemeroptera												
Atalophlebioides sp1.		3					6				1	12
" sp2.	2	4	1	3	2	2	11	8	17	8	24	14
" sp3.		1	5	1		1	9	15	13	10	16	14
" sp4.						1	6	4	4	2	13	2
Baetis sp1.							1	7	2	10	16	2
" sp2.	2	1			1			5	6	9	6	4
Plecoptera												
Tasmanoperla larvalis								1				
Dinotoperla sp.	2	2	1	1	1							
Rickoperla triloba		2					1			6	1	
Cardioperla nigrifrons									1		1	
Leptoperla varia								2				
Coleoptera												
Sclerocyphon sp.	1	2	1	1				5	4	2	6	3
Helminthidae	1											
Helodidae				1	1							
Trichoptera												
Philorheithridae sp1.	2	3	1					1	2			
Hydropsychidae sp1.				1				1	2			
" sp2.								1				
Helicopsychidae							8	4	3	2	1	1
Limnephilidae									5	5	2	2
Rhyacophilidae sp2.							1		1		1	
Diptera												
Chironomidae								3				
Tipulidae												1
Oligochaeta				4			2	2	1			

SITE 2a.

DATE	4/3/77 Riffle 1.	2.	3.	4.	31/5/77 Riffle 1.	2.	3.	4.
TAXA								
Insecta								
Emphemeroptera								
Atalophlebioides sp1.	3	3		1		13		
" sp2.	1	1						
" sp4.							3	2
Plecoptera								
Tasmanoperla thalia	6		4	2	1	7	8	4
T. larvalis				4				
Cardioperla nigrifrons	2	2	10	6				
Trinotoperla hardyi					3	4		4
T. agricola					1		3	
Coleoptera								
Sclerocyphon sp.	5							
Trichoptera								
Hydroptilidae sp3.						1	1	
Conoesucidae	36		45	6	4	49	12	15
Leptoceridae sp2.		2						
Diptera								
Chironomidae			4		2		3	
Muscidae	7			4		4	3	
Crustacea								
Syncarida								
Anaspides tasmaniae				8			2	
Amphipoda								
Neoniphargus sp.	13	2	4		1	6	1	3
Oligochaeta			2		2	3	1	2

SITE 2a.

DATE	1/8/77 Riffle 1.	2.	3.	4.	5.	13/9/77 Riffle 1.	2.	3.	4.	5.	6.
TAXA											
Insecta											
Ephemeroptera											
Atalophlebioides sp1.	1										
sp4.		2	3	9	29	6	6	11	11	1	4
Plecoptera											
Tasmanoperla thalia		5	1	15	1	4	5	8	3	7	2
Cardioperla nigrifrons	11		3	6	12	1	7	7	6	10	5
Leptoperla varia			3	2		2	5	4			
Trichoptera											
Limnephilidae	23	57	11	25	16	15	9	20	2	11	12
Leptoceridae sp1.									1		
Hydroptilidae sp1.						1	2		1	3	1
Diptera											
Chironomidae		3	1			1	1		1	8	
Muscidae			1	4	4	5		4	1	2	2
Culicidae								1			
Crustacea											
Amphipoda											
Neoniphargus sp.		1	5		21	2	4	5	20	4	3
Oligochaeta	1	1					2	3		12	1

SITE 2b.

	5/3/77 Riffle 1.	2.	3.	4.	Pool 1.	2.	3.	4.	18/5/77 Riffle 1.	2.	3.	Pool 1.	2.	3.
ll														
secta														
emeroptera														
talophlebioides sp1.	2	1	2	1	5	1	1		1			2	4	13
" sp2.	3	2	2	4	5	12				1		4	2	8
" sp3.	2	2		6						3	8			
" sp4.										1				
ctis sp1.		2	8	1	1								1	
talophlebia sp.						1								
ecoptera														
sthenia spectabilis	1		1											
, costalis			2										1	
asmanoperla larvalis					2	1	1							
rdioperla nigrifrons	2	1							1					
ickoperla trilobe									2	1	2			
rinotoperla zwicki	8													
leoptera														
elminthidae										1				
ichoptera														
ydropsychidae sp1.	4		1											
hyacophilidae sp1.	1													
tenopsychidae	5													1
lossosomatidae										3	7			
elicopsychidae						1					2			
onoesucidae				5	1	1	12		2		2			
eptoceridae sp1.	1													
" sp2.				3		3						1		1
" sp3.	1													
" sp4.					2	10								
hilorheithridae sp4.					1									
iptera														
Chironomidae					2	2	1	7						
rustacea														
Amphipoda														
Neoniphargus									1		1			
lgochaeta					2					1				
ollusca														
Potamopyrgus sp.	1													

SITE 2b.

DATE	26/7/77 Riffle						15/9/77 Riffle					
	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.							4	1	3	3	2	2
" sp2.		3		3		1		2		1		2
" sp3.		2	4	4	1	2	1				2	
" sp4.									1			
Baetis sp.	1		1		1	1	1	1	1			
Plecoptera												
Eusthenia costalis			1	1				1				
Riekoperla triloba		4	3	3	1		1	15		1	3	1
Cardioperla nigrifrons		1			1	1			2			
Leptoperla varia								2				
Trinotoperla zwicki				4								
Trichoptera												
Limnephilidae		10	24	4	1	2	7	11		4	9	1
Conoesucidae						1	2	4	1	2	1	
Glossosomatidae (larvae)		5	6	4	12		1	11	9	1	13	
" (pupae)		1						2	4		7	
Rhyacophilidae sp2.		1	1		1		1	2				1
Hydropsychidae sp1.		1	6	2				1				
" sp2.								1				
Tasimiidae								3	2			
Diptera												
Chironomidae	1	3		1			4		2			1
Tipulidae				1								
Culicidae									1			
Crustacea												
Amphipoda												
Neoniphargus sp.								1				
Oligochaeta			1				1					

SITE 2c.

DATE	28/2/77										30/5/77					
	Riffle					Pool					Riffle			Pool		
	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.	1.	2.	3.	1.	2.	3.
TAXA																
Insecta																
Ephemeroptera																
Atalophlebioides sp1.													1			1
" sp2.											1		1			
" sp3.								1			3	1				
Baetis sp1.											1				1	
" sp2.	6	6		5	3	1		1			1	1		4		6
Atalophlebia sp.									1							
Plecoptera																
Tasmanoperla												1				
Cardioperla nigrifrons		1		1		2							2			
Trinotoperla hardyi																3
Coleoptera																
Sclerocyphon sp		1														
Trichoptera																
Hydroptilidae sp2.																1
Hydropsychidae sp1.												1			2	
Rhyacophilidae sp1.											1					2
" sp3.		1	1	2	1		3		1							
Helicopsychidae													1			
Leptoceridae sp1.											1					
Diptera																
Chironomidae											3	8	2	1	2	1
Muscidae												1				
Tipulidae	1		1													
Arachnida																
Hydracarina							2	2								
Oligochaeta																
Lumbriculidae	28	33	18	21	11	23	12	45	20	15	14	6		8	14	17
Other		1	6	2	4		1	1	2		12				1	3

SITE 2c.

DATE	26/7/77 Riffle 1.	2.	3.	4.	5.	6.	15/9/77 Riffle 1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.					3		1	2				1
" sp3.				1					1			
" sp4.	1		1			1	1					
Baetis sp2.		7	6	11	3	3			6			
Plecoptera												
Tasmanoperla larvalis		1										
Cardioperla									1	20	1	1
Riekoperla triloba						1		4		15		
Tasmanocera bifasciata		1	1	1								
Coleoptera												
Sclerocyphon sp.					1							
Trichoptera												
Glossosomatidae	1											
Odontoceridae					1							
Rhyacophilidae sp2.		2	1	1							1	
Hydropsychidae sp2.						1				1		
Diptera												
Chironomidae	5	1		1		1	8	31	24	4	7	8
Tipulidae			1					1	1			
Culicidae								1				
Oligochaeta												
Lumbriculidae	12	15	40	6	20	12	1	8	6	1	1	1
Other	13		4			8	2	1	1	2	5	4
Mollusca												
Potamopyrgus sp.	4	2	5	4	7	3					1	
Bulinus sp.	6	20	6	8	9	5		1	1		5	
Pettancylus sp.	1	1										

SITE 3a.

DATE	2/3/77						27/5/77					
	Riffle			Pool			Riffle			Pool		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
TAXA												
Insecta												
Ephemeroptera												
Atalophebioides sp1.	7	3	3			2		4	7	3		3
" sp2.	2		1	2	3	7	2	2		11	5	5
Baetis sp1.	2			1					2			
" sp2.							2					
Atalophlebia sp.						1						
Plecoptera												
Eusthenia spectabilis	2	1	1									
E. costalis	1											1
Tasmanoperla larvalis								1		2	2	
Cardioperla nigrifrons		2							1			
Trinotoperla agricola				1								
Coleoptera												
Sclerocyphon sp.				1						1		
Helodidae										2	1	
Helminthidae	1				2					1		
Trichoptera												
Rhyacophilidae sp2.	3											
Glossosomatidae		9						29	9			
Helicopsychidae		4	1	1								
Leptoceridae sp1.		1	2									
" sp4.								2				
Philorheithridae sp1.	1											
Limnephilidae									1	1		
Diptera												
Chironomidae	5	7	2					4	7	1	1	
Muscidae		2	1		1							
Tipulidae		1	1									
Simulidae								6				
Arachnida												
Hydracarina										1		
Oligochaeta	2				7		1			2		

SITE 3a.

DATE	27/7/77 Riffle 1.	2.	3.	4.	5.	6.	14/9/77 Riffle 1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.	1		1					6	2	1	6	
" sp2.	1						5	1	1		1	
" sp3.								1		2	1	
" sp4.						1	1		1		5	
Baetis sp1.								1		5		
Plecoptera												
Eusthenia spectabilis	1	7			1			2		1		
Tasmanoperla		1							1		4	
T. larvalis							1					
Cardioperla nigrifrons		2	2									
Riekoperla triloba					1				2			1
Trinoperla zwicki				1	1							
Coleoptera												
Helminthidae		2					1					
Helodidae								2			1	
Trichoptera												
Glossosomatidae (larvae)	3	7	1	10	1	13	9	41	27	8	10	5
" (pupae)								14	2			
Helicopsychidae					1			3	1		4	1
Limnephilidae	1	5						1	1			
Conoesucidae								1				1
Tasimidae					5	2	1	2				
Hydropsychidae sp2.			1						1			
Rhyacophilidae sp2.									1			
Leptoceridae sp2.								1				
Calamatoceridae						1						
Diptera												
Chironomidae	50	3	10			4	23	1		1	7	2
Tipulidae	1									1		
Ceratopogonidae	1											
Muscidae								1			3	
Simulidae								1				
Blephariceridae									2			
Crustacea												
Amphipoda												
Neoniphargus sp.		7	1		1			2	3			
Oligochaeta	20		2			2					2	

SITE 3b

DATE	2/3/77						29/5/77					
	Riffle			Pool			Riffle			Pool		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.			1									
" sp2.				2			4		1	1	2	6
Baetis sp1.	1						1	2				
" sp2.							1		3			
Atalophlebia sp.					2						1	
Tasmanophlebia sp.										2		
Plecoptera												
Eusthenia costalis			1									
Tasmanoperla thalia								1	1			
T. larvalis		2	1		5							
Cardioperla nigrifrons				2	1	2	1			2		
Trinotoperla zwicki		1		1		4						
Coleoptera												
Sclerocyphon sp.	2	4	3		2			7	7	2		1
Helminthidae	2	4	3	1	6	3			3		1	
Trichoptera												
Hydroptilidae sp2.					1							
Hydropsychidae sp1.			4		1		2		4			
" sp2.			14					1				
Philorheithridae sp2.			9									
" sp3.	2		17									
Rhyacophilidae sp2.									2		1	
" sp3.	2	2										
Philopotamidae					2							
Helicopsychidae									1			
Conoesucidae											2	
Leptoceridae sp1.										1		
" sp2.								2				
" sp3.	4						4	1				
Limnephilidae			1					1	9		1	
Diptera												
Chironomidae	1	20	4	8	2	32	8	2	4	23	10	4
Culicidae							1			1		
Tipulidae		1							1			
Arachnida												
Hydracarina sp.						1						
Oligochaeta												
Lumbriculidae	3	75	10	9	12	23	10	2	12	4	3	3
Mollusca												
Potamopyrgus sp.	2	8	13	5	11		9	15	11		2	

SITE 3b.

DATE	27/7/77						15/9/77					
	Riffle						Riffle					
	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.							1					
" sp2.			2		1		5	1		10	23	6
" sp3.								1	5	3		5
" sp4.	1	3	1	1	1	6	7	7	17	5	3	18
" sp5.										3	3	
Baetis sp1.							5	8	8	2	4	
" sp2.	2	2		1		3					2	13
Plecoptera												
Tasmanoperla larvalis		1			1		1		1	1	2	
Riekoperla triloba			1	1				2			1	1
Leptoperla varia									1			
Dinotoperla sp.		1		1								
Coleoptera												
Sclerocyphon sp.	1		1		3	3	3	6	6	5	2	9
Helminthidae	2	1	2	1	3				3	2		
Trichoptera												
Limnephilidae	48	15	48	18	7	31	4	37	3	9	11	6
Helicopsychidae						1	1	1	2		2	8
Leptoceridae sp3.	11											
Philorheithridae sp1.			1		1	2						
" sp2.							2					
" sp4.			1									
Glossosomatidae			1				1					
Rhyacophilidae sp2.	1		1			2	1	1	1			1
Hydropsychidae sp1.	3		4	2					1			
" sp2.	2	2	1			2			1	1		1
" sp3.			22	5	2							
Ecnomidae										1		
Tasmiidae											1	
Diptera												
Chironomidae			1		1	2	2	1		4	2	
Muscidae				1								
Ceratopogonidae					1							
Oligochaeta												
Lumbriculidae		7	5	3	18	13	48	4	19	13	3	12
Other	1	3	2		4	2	15	2	1	11		2
Mollusca												
Potamopyrgus	3	1	11	2	5	8	3	3	2		3	7
Pettancylus							1					

SITE 3c.

DATE	2/3/77						27/5/77					
	Riffle			Pool			Riffle			Pool		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebes sp										1		
Baetis sp2.			1									
Plecoptera												
Cardioperla nigrifrons		2										
Trinotoperla zwicki					1							
Coleoptera												
Dytiscidae	1	1	1	6	10	3						
Helminthidae		1					1					
Trichoptera												
Hydroptilidae sp2.	2	5	1	5		3						
Philorheithridae sp1.										1		
Limnephilidae		1										
Stenopsychidae		3	1									
Leptoceridae sp2.									1			
Diptera												
Chironomidae	186	180	120	170	115	70	8	5	1	2	2	1
Culicidae	10	16	6	6	1	2	1			1		
Muscidae								1				
Ceratopogonidae		1										
Oligochaeta												
Lumbriculidae	33	53	31	16	51	35	50	16	45	55	22	13
Other	2	4	2	1								

SITE 3c.

DATE	27/7/77				14/9/77					
	Riffle				Riffle					
	1.	2.	3.	4.	1.	2.	3.	4.	5.	6.
TAXA										
Insecta										
Ephemeroptera										
Baetis sp2.			1		1					
Plecoptera										
Leptoperla varia						1				
Riekoperla triloba					1		1			
Cardioperla nigrifrons					4					
Trichoptera										
Rhyacophilidae sp2.				1			1			
Diptera										
Chironomidae	7	6	11	15	21	14	26	4	12	7
Culicidae	1		4	6	3		3		2	1
Muscidae				4						
Oligochaeta										
Lumbriculidae	65	40	26	60	80	50	60	30	30	40
Other	2				6	6			5	4

SITE 4a.

DATE	3/3/77 Riffle 1.	3/3/77 Riffle 2.	3/3/77 Riffle 3.	26/5/77 Riffle 1.	26/5/77 Riffle 2.	26/5/77 Riffle 3.	Pool 1.	Pool 2.	Pool 3.
TAXA									
Insecta									
Ephemeroptera									
Atalophlebioides sp1.	1	1	5				1	2	6
" sp2.			6						
Plecoptera									
Eusthenia costalis						2			
Tasmanoperla thalia				1					
Cardioperla nigrifrons		1	1				4		1
Coleoptera									
Sclerocyphon sp.	1	4	1	3	3	1	1	2	1
Trichoptera									
Philorheithridae sp1.	1	3		5	3	7	2	1	
Conoesucidae		1		1					
						3			
Diptera									
Chironomidae							6		2
Crustacea									
Syncarida									
Anaspides tasmaniae			1	4	1			2	3
Amphipoda									
Neoniphargus sp.		2		2	1	9			1

SITE 4c.

DATE	1/8/77 Riffle						14/9/77 Riffle					
	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.							1	8	3	6	3	2
" sp2.	1	1					5			1		1
" sp4.					2					1	1	
Plecoptera												
Eusthenia spectabilis			2	1	1	3	1					
Tasmanoperla thalia	1	1	1	2			2	4	3			
Leptoperla varia	1	3	1	2	2	8	1					
Cardioperla nigrifrons	4	2	2	2	3	12						
Coleoptera												
Sclerocyphon sp.		7	8	4	3	1	4	9	1	1	1	5
Helminthidae											1	
Helodidae	1											
Hygrobiidae (adult)		1										
Trichoptera												
Limnephilidae	1		3	8		2						
Conoesucidae				1								
Philorheithridae sp1.				2		1	2		2			
Diptera												
Chironomidae	1	11	1				1					1
Culicidae	1											
Tipulidae	1											
Ceratopogonidae		1										
Crustacea												
Syncaria												
Anaspides tasmaniae							1		2			
Amphipoda												
Neoniphargus sp.	1	5	39	14	3	18	1					
Oligochaeta	3	3		1		4	4	1	3			2

SITE 4b.

DATE	4/3/77					26/5/77						
	Riffle			Pool		Riffle			Pool			
	1.	2.	3.	1.	2.	1.	2.	3.	1.	2.	3.	4.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.	1			3	2				3	1	2	1
" sp2.	1		1		6				6	1	1	
" sp3.	2							1	1			
" sp4.							2					
Atalophlebes sp				1	5							
Baetis sp1.	3	4	5			1	1	1	1		3	
" sp2.	2											
Tasmanocoenis sp.												1
Tasmanophlebia sp.					1							
Plecoptera												
Eusthenia spectabilis	1		1				1	1				
Tasmanoperla larvalis	2			2				1	1	1		
Cardioperla nigrifrons						1	2	1				
Riekoperla triloba							2	4				
Leptoperla varia									1	2		
Trinotoperla zwicki	3						1					
Coleoptera												
Helminthidae				2					1	1		
Helodidae											1	
Sclerocyphon sp.	1											
Trichoptera												
Glossosomatidae	11	1				15	13	5				
Leptoceridae sp2.	2			2			2		2	2		1
" sp1.		1	1	3			1					
Limnephilidae				1	1	1						
Philorheithridae sp2.										1		
Conoesucidae												1
Hydropsychidae sp1.	4					1		1				
" sp2.	4											
Rhyacophilidae sp2.		1		1								
Helicopsychidae				9	1							
Diptera												
Chironomidae	16	4			2	1						
Muscidae				3			1					
Simulidae	1		-	2								
Crustacea												
Amphipoda												
Neoniphargus sp.									4	1		
Oligochaeta												
Lumbriculidae									2	7		1
Other	1			8	6							
Mollusca												
Potamopyrgus sp.											2	

SITE 4b.

DATE	25/7/77 Riffle						13/9/77 Riffle					
	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.							2	1			3	7
" sp2.		3	18		3	2	11	20	10	14	11	21
" sp3.				1	1	1	5	7	5	11	7	5
Baetis sp1.						3	10	13	7	6	3	3
" sp2.		2	5	1	8		6	2	2	4	6	3
Plecoptera												
Eusthenia spectabilis	1	1				1				1		
Tasmanoperla larvalis			2			1	1				1	1
Cardioperla nigrifrons	1											
Riekoperla triloba						1	4		2	1		1
Trinotoperla zwicki	8			5								
Coleoptera												
Helodidae					1	2						2
Sclerocyphon sp.					2							
Helminthidae								3		1	1	1
Dytiscidae (adult)						1						
Trichoptera												
Glossosomatidae (larvae)	15	14	12	15	22	33		1	14	19	3	6
" (pupae)		1							55	11		
Helicoptychidae			31		2	2	12	1	3	24		13
Leptoceridae sp2.	2		7		2	4	2	6	1	2	2	6
Limnephilidae	2	1			3					3		
Philorheithridae sp1.												1
Hydropsychidae sp1.	6	6		4	1	2				2		
" sp2.										2		
" sp3.		8										
Rhyacophilidae sp2.										1	1	
Diptera												
Chironomidae	1	16	4	1		3		5	3	2	1	6
Tipulidae						1			2		1	2
Simulidae	2			1								
Muscidae									1			
Ceratopogonidae											1	
Oligochaeta			5		1		2	3	2	1	1	6
Mollusca												
Potamopyrgus sp.	1		1			1			1			

SITE 4c.

DATE	25/7/77 Riffle 1.	2.	3.	4.	5.	6.	13/9/77 Riffle 1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp2.	3	9		3	3		8	17	19	14	12	14
" sp3.	17	11	1	5	9	7	10	7	8	8	10	5
Baetis sp1.								2	3		1	1
" sp2.	6	2	2	1	7	1	2	4	3	3	1	2
Plecoptera												
Tasmanoperla larvalis						1		1				
Riekoperla trilcba											2	
Trinotoperla zwicki					3	1						
Dinotoperla sp.					1							
Coleoptera												
Helodidae				1	1							
Helminthidae									1			1
Sclerocyphon sp.	2											
Trichoptera												
Glossosomatidae	2	7		3	3	8			2			1
Helicopsychidae	1								1			
Limnephilidae	1	2		1	7	3			2			
Leptoceridae sp2.				4	1		4		1			1
Philorheithridae sp1.					1							
Rhyacophilidae sp2.		1			4	6	2	1	2		1	1
Hydropsychidae sp1.		3	1		7							
" sp3.					1							
Diptera												
Chironomidae		5		4	7	3		1		1		
Simulidae		2			3	3						
Tipulidae						1			1			
Crustacea												
Amphipoda								1		2		
Paracalliope sp.	5											
Oligochaeta				1	4	1		1	2	1		3
Mollusca												
Potamopyrgus sp.	2	2			2							

SITE 5a.

DATE	8/8/77										
	ABOVE FALLS #						BELOW FALLS +				
	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.
TAXA											
Insecta											
Ephemeroptera											
Atalophlebioides sp1.	1			2		2					
" sp2.				1							
" sp4.	2						3	1	1		
" sp5.	1	3	3	1	1	2				1	
Plecoptera											
Eusthenia spectabilis	3				1						
Tasmanoperla thalia	1										
Cardioperla nigrifrons	3	5	2	2		3	1	2	8	9	
Leptoperla varia					2	1	2		1	4	3
									1		
Trichoptera											
Helicopsychidae		3									
Conoesucidae		1									
Diptera											
Chironomidae						1					
Oligochaeta	1						1				

1 sample with no animals

+ 2 samples with no animals

SITE 5b.

DATE	6/3/77 Riffle 1.	2.	3.	Pool 1.	2.	3.	30/5/77 Riffle 1.	2.	3.	4.	Pool 1.	2.	3.
TAXA													
Insecta													
Ephemeroptera													
Atalophlebioides sp1.		1			2	7					2	26	14
" sp2.		1	1	3	1	9	2	3				5	1
" sp3.	1	2	1					3					1
Baetis sp1.	1	11	5	2	7	2	1	1					
" sp2.		3					2			2		2	
Plecoptera													
Eusthenia spectabilis		1		1			2		3				1
E. costalis	2	2	3		1	1							
Tasmanoperla larvalis								1			3	1	1
Cardioperla nigrifrons									2				1
Trinotoperla zwicki							3		1	14			
Coleoptera													
Sclerocyphon sp.			1				1		3				
Trichoptera													
Glossosomatidae							3	2	6	5			2
Leptoceridae sp2.												5	
" sp3.								4	2	2			1
Limnephilidae							1	16	26	1			
Helicopsychidae									1				
Rhyacophilidae sp1.			1					1					
Hydropsychidae sp1.							3	1	9	5			
" sp2.									1				
Diptera													
Chironomidae				1					2	1		27	3
Culicidae												1	
Muscidae												1	
Oligochaeta							1						
Molusca													
Potamopyrgus sp.						1							

SITE 5b.

DATE	30/7/77 Riffle						12/9/77 Riffle					
	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.		1					1	2	3	2	2	6
" sp2.	1	2						3	1	1	4	3
" sp3.		2	1							1		
Baetis sp1.	1		1								2	1
" sp2.												1
Plecoptera												
Eusthenia spectabilis	1				1	2		1	1	3	1	1
Tasmanoperla larvalis	1	1	1	2				1			4	
Riekoperla triloba							2				2	2
Leptoperla varia												1
Cardioperla nigrifrons							1				2	
Trinotoperla zwicki	3		1								1	
Coleoptera												
Sclerocyphon sp.						2		2		1	1	
Trichoptera												
Limnephilidae		7	1				5	13	1	9	11	11
Glossosomatidae (larvae)		3						1	1	1	2	5
" (pupae)		3										1
Leptoceridae sp2.		1									1	
Rhyacophilidae sp2.				1						1	1	
Hydropsychidae sp1.	1						1	1		1	2	
" sp2.								2		1	1	1
Helicopsychidae		2										
Diptera												
Chironomidae							10	10	4	3	1	3
Tipulidae								4			2	
Culicidae							1				1	
Mollusca												
Potamopyrgus sp.					1							

SITE 5c.

DATE	6/3/77						30/5/77					
	Riffle			Pool			Riffle			Pool		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.	1	2	3				1	4	2			
" sp2.	1	1	1				4	5	10		1	2
" sp3.			3					7	7			
Baetis sp1.	1		1									
" sp2.							5	3	3			
Tasmanocoenis sp.				1	9		1					
Plecoptera												
Trinotoperla zwicki				1			2					
Coleoptera												
Helminthidae	1	2	1	1	1	1		2	1			
Trichoptera												
Leptoceridae sp2.	1	1		3	2	1	2	1				1
Glossosomatidae	1								7			
Limnephilidae				1	3							
Hydroptilidae sp1.										1		1
" sp3.	1					1	1					
" sp4.										2		
Calamatoceridae									1	5	3	
Rhyacophilidae sp2.								2	1	1	2	2
Hydropsychidae sp1.									1			
Ecnomidae	1	1				1		1				
Diptera												
Chironomidae	4	5	2	26	26	40	28	27	13	1	14	12
Culicidae						1	1	1		1		2
Muscidae				1					1			
Tipulidae			1		2		1					
Ceratopogonidae					2							
Crustacea												
Decapoda												
Paratya australiensis			1					1				
		1			2							
Oligochaeta												
Mollusca												
Potamopyrgus sp.	18	20	26	2	29		1		1	1		
Pettancylus sp.		1	2									

SITE 5c.

DATE	2/8/77						12/9/77					
	Riffle						Riffle					
	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
TAXA												
Insecta												
Ephemeroptera												
Atalophlebioides sp1.		2			3		5	2		1	7	
" sp2.	3	3	6	3		3	1	2	13	6	38	24
" sp3.	1	1	15	5	4	4	2	2	3		9	6
Baetis sp1.	1	6		2		1		1			1	
" sp2.	2	9	1									2
Plecoptera												
Tasmanoperla larvalis									1			1
Cardioperla nigrifrons		1	1									
Riekoperla triloba							1					
Coleoptera												
Sclerocyphon sp.		1							2			
Helminthidae											1	3
Trichoptera												
Limnephilidae												3
Leptoceridae sp2.						1	1	2	6	1	13	1
Calamatoceridae									1		1	
Hydroptilidae sp4.									8		3	11
Philorheitbridae sp2.								1	2	1		
Rhyacophilidae sp2.		2			3		1		1		2	2
Hydropsychidae sp2.									1	1	1	2
" sp3.			1		1							
Philopotamidae											1	
Ecnomidae							1					
Diptera												
Chironomidae						1	7	45	80	4	40	58
Culicidae									1		1	1
Tipulidae								1	4			
Crustacea												
Decapoda												
Paratya australiensis		1			1	1	1					4
Oligochaeta				1			1				2	1
Mollusca												
Potamopyrgus sp.			1-					3	4	2	1	2