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By

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by

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ABSTRACT

We studied aquatic invertebrates in two morphologically similar but hydrologically distinct braided rivers in Canterbury, the Ashley (a small foothills catchment river) and the Waimakariri (a large snow-fed river); the former has winter-early spring high flows and the latter spring-early summer high flows.

Each month for a year three samples of aquatic invertebrates were collected from a riffle in each of major, minor and seepage channels of each river. We plotted species group, total density and dry weights, for each channel form against river flow and between rivers.

Density and total biomass of aquatic invertebrates were generally highest in seepage channels, followed by minor channels and major channels. Floods affected this pattern so that at times major channels were more productive than other channel forms. Seepage channels were always dominated by *Deleatidium* and elmids in the Ashley River, while major and minor channels were dominated by *Deleatidium*, with elmids important in some months. In the Waimakariri River *Deleatidium* dominated in all months for all channel types with chironomids of secondary importance in most months.

Invertebrate densities and dry weights were higher in the Ashley River than the Waimakariri River for all channel types although the occurrence of floods at different times meant that occasionally higher counts and biomass occurred in the Waimakariri River. Seepage channels have high invertebrate densities and total biomass, plus a high overall diversity. Other studies have shown seepage channels to be important feeding sites for wading birds.

We have used these findings from relatively unmodified rivers as a baseline for determining future management options for wading birds on the Lower Waitaki River, a large braided river in North Otago. Future hydro-electric development of the Lower Waitaki River could have an impact on the food supply of wading birds .

Development of the Lower Waitaki River may incorporate the building of a residual river and a flood overflow channel. This study has shown seepage channels provide large amounts of invertebrate food resources for birds; along with minor channels they also provide large areas of usable feeding habitat. Development of a residual river should consider inclusion of minor channels and seepage channels as part of wading bird habitat needs. The flood channel could also, at tunes, contain significant seepage channels. Determination of the flow regime of such a channel will help identify its potential value as a bird feeding habitat.

* This report has been undertaken as a contract project for Electricorp Production. Funding and permission to publish are acknowledged.

1. INTRODUCTION

Braided riverbeds in Canterbury and North Otago are unique wildlife habitats occupied by a diverse bird community which includes many endemic, native and exotic species. Of conservation interest are some of the wading birds, e.g. wrybill *(Anarhynchus frontalis)*, banded dotterel *(Charadrius bicinctus)* and pied stilt *(Himantopus himantopus leucocephalus)*, and the gulls and terns, e.g. black-billed gull *(Larus bulleri)* and black-fronted tern *(Sterna albostriatus)*. All these birds are mostly insectivorous. Although many braided riverbeds are "outstanding" wildlife habitats (O'Donnell and Moore 1983) some have, or are subject to planning for, irrigation and hydro-electric power schemes which may detrimentally affect the bird habitat through alterations of the flow regimes and food resources.

Considerable research has been done into the ecology of these endemic and native riverbed birds, e.g. Lalas (1977), Robertson et al. (1983), Robertson et al. (1984), Pierce (1985, 1986), Hughey (1985a,b, 1986, 1987) and Hughey and Duncan (pers. comm.). Much is known of nest-site requirements, but our understanding of feeding and food supply, in relation to river flow, channel size and channel form is still inadequate.

Hughey (1985b) showed that wading birds on riverbeds fed mainly alongside or in aquatic microhabitats, especially in the smaller channel riffles. Opportunities for wading birds to feed in major channels of large rivers are limited by the greater depth and velocity compared with minor channels. However, these factors do not affect the aerial feeding gulls and terns (Hughey et al. 1986).

Scrimgeour and Winterbourn (1989) and Scrimgeour et al. (1988) studied the relationship between floods and macro-invertebrate community composition and density in the Ashley River, which originates in foothills of the Southern Alps. Pierce (1986) studied the abundance of invertebrate prey in relation to stilt *(Himantopus* spp.) diet on the Cass River Delta, MacKenzie Basin, while Sagar (1983a) compared abundance of invertebrates as fish food inhabiting riffles in minor and major channels of the braided lower Rakaia River. These latter two studies occurred in snow-fed braided rivers with catchments in the Southern Alps. Findings from all these studies indicated that, generally, invertebrate densities were inversely related to river flow, indicating that floods reduce density and biomass and long periods of low to medium flows lead to high numbers and biomass. No work has compared food resources between minor channel, seepage channel (a special type of minor channel) and major channel habitats for birds. Fish are generally present at greater depths and at greater velocities than where wading birds feed and so far lowland invertebrate studies have examined habitat needs of fish (e.g. Sagar 1983a).

No study has compared the aquatic invertebrate ecology of braided rivers originating in the foothills (e.g. Ashburton, Ashley and Opihi rivers) to the larger snow- and rain-fed rivers such as the Rakaia, Waimakariri and Rangitata. Rivers with catchments in the foothills are smaller than those originating in the Southern Alps and generally have peak flows in winter and early spring, whereas the mountain catchment rivers have peak flows in spring and early summer during snow melt. Hughey (1985b) showed that the different flow patterns of these two main river types resulted in great differences in the availability of terrestrial invertebrates, especially near the water edge. The availability of terrestrial invertebrates was higher on the foothills catchment river which did not flood as frequently or severely during the September to December breeding season of riverbed birds. Densities of solitary nesting bird species such as banded dotterels, pied stilts and South Island pied oystercatchers *(Haematopus ostralegus finschi)* were also higher on these smaller rivers (Hughey 1985b). If similar situations apply for aquatic habitats then the nature of the flow regime and the type and size of channel may provide an insight into flow management which is applicable to a wide range of braided rivers.

In this study we examined aquatic invertebrates in two different, but relatively unmodified, rivers which are known to provide good feeding and nesting habitat for riverbed birds (O'Donnell and Moore 1983). We wanted to see if our findings could be used, in addition to using habitat use information from relatively unmodified rivers, to help define guidelines for design and management of a third river, namely the lower Waitaki River. A proposed development of half the length of the lower river would involve construction of a combination floodway, power generation canal and a residual river. The latter would be designed to include the needs of instream users including fishermen, boaters, etc. In the design and management of this future waterway system it will be possible to incorporate desirable features for birds of channel size, channel form or flow regime based on knowledge of the benefits of such features in present unmodified braided rivers. We believe understanding the ecology of natural systems will help form a baseline for management of a highly modified system.

This study concentrates on the environmental factors that affect riverbird food supplies, such as channel type, flow "type" (seepage versus fully linked flows) and flow regime. It is acknowledged that other factors such as vegetation encroachment also influence the quality of riverbird habitat. The aims of our study as specified by Electricity Corporation of New Zealand were to:

(1) measure the availability of invertebrates as food for birds feeding in aquatic habitats of braided rivers;

(2) compare variations in food availability between a range of comparable habitat types in two hydrologically distinct rivers;

(3) determine some important channel characteristics for feeding birds in relation to food availability and flow regime for eastern South Island braided rivers; and

(4) comment on the implications of the study findings to the lower Waitaki residual river concept.

So far research into wildlife of the lower Waitaki River has concentrated on defining species presence, distribution and seasonality of habitat use (Robertson et al. 1984); it has not addressed food supply needs at all. Studies of the Waitaki River fishery have examined aquatic invertebrate community composition and density (Rutledge 1987), fish (Deverall 1986) and angling (Smith and Pierce 1986). Electricorp (1988) has identified development options which involve many environmental considerations including wildlife and their habitat; this report will help identify some management considerations.

2. METHODS

Two braided rivers of contrasting size and flow regime, the Ashley and Waimakariri in North Canterbury, were chosen for this study. Invertebrate sampling was undertaken in study areas where bird counts and habitat use studies had already been undertaken (O'Donnell and Moore 1983, Hughey 1985b, 1987). Riffles were sampled once a month between 4 September 1985 to 28 August 1986, during periods of generally stable flow. At high flows, during floods or freshes, sampling would have been difficult and dangerous. Riffles only were sampled because:

1. they are the main food producing areas in rivers;
2. most wading birds make extensive use of riffles for feeding (Hughey 1985b);
3. while many different habitat types, e.g. pools, backwaters and runs, could have been studied this would have greatly increased sampling needs, sorting and data analysis requirements; and
4. no method has been developed to quantitatively or qualitatively sample from a range of habitat types for comparative purposes.

Riffles are defined as areas of shallow, usually broken and rapidly moving water on a coarse substrate. They are frequently angled across the channel and form an abrupt step in the bed and water surface profile. The downstream edge of the riffle is usually clearly defined, but the stream bed on the upstream edge often grades steadily from the pool upstream of the head of the riffle and delineating this boundary is difficult. At low flows much of a riffle substrate may become exposed and form a long boulder bank across the river, with flow concentrated into a number of chute channels over the bank (definition adapted from Mosley 1982).

Riffles were sampled in major, minor and seepage channels (as defined by Hughey 1985b) of both rivers where water was <100 mm deep flowing at a velocity <0.5 ms^{-1}. Three replicate samples were taken with a modified Surber sampler (0.1 m^2; 0.30 mm mesh net) from riffles in all channel types of both rivers. Samples were collected in an upstream or across-stream direction so as to minimise disturbance for subsequent samples. Bed materials were disturbed to a depth of 100 mm. We considered 100 mm approximates the maximum probing depth for feeding birds such as South Island pied oystercatcher and pied stilt. All invertebrates were stored in 70% ethanol for subsequent microscopic sorting and identification, drying and weighing to determine biomass. Animals were generally identified to genus, or species as appropriate using the key of Winterbourn and Gregson (1981). Some groups were not identified beyond family or subfamily. Abundance and dry weight figures are the means of the replicate samples collected that day. Results presented graphically are displayed offset so as to minimise overlap where close data points occur.

Major channels were those visually estimated to be carrying more than 5 m^3s^{-1} on the Waimakariri, and greater than 1 m^3s^{-1} on the Ashley. The visual estimation of channel size was justifiable on grounds of expediency and experience (Hughey 1985b). The size distinction was based on the difference in flows of the two rivers. Rivers with flows about and higher than the Waimakariri, e.g. the Rakaia, Rangitata and Waitaki rivers, are considered large braided rivers; those about and smaller than the Ashley, e.g. the Ashburton and Opihi rivers, are small braided rivers.

Minor channels were those visually estimated to carry less than 5 m^3s^{-1} in the Waimakariri and less than 1 m^3s^{-1} in the Ashley.

Seepage channels are distinguished from minor channels by their particular hydrological nature. The seepage channels we studied normally flow in remnant flood channels or overflow channels and although they have a similar morphological character to other channel types, they flood less frequently and are consequently more stable. Water comes from throughflow within the shingle substrate, and the filtering effect of this action results in cooler and clearer water than is found in connected channels.

3. STUDY AREAS

The Ashley River is a small unstable and largely rain-fed braided river in North Canterbury with a catchment area of 1340 km^2 and a mean flow of 15.3 m^3s^{-1} (recorded at the Ashley Gorge). River flow varies seasonally with highest flows usually occurring in July to September and the lowest from January to April (Figure 2a). All samples were collected immediately upstream of Rangiora township (Figure 1) where the river was highly braided, containing up to 7 channels, and the floodplain was about 500 m wide. Surface substrate ranged from gravels to large cobbles (8 - 300 mm diameter). Floodplain vegetation was mainly willows (*Salix* spp.), broom *(Cytisus scoparius),* gorse *(Ulex europaeus)* and lupin *(Lupinus arboreus).* Populations of the following endemic and native bird species (A full species list and relative abundance for each on both rivers is in O'Donnell and Moore (1983).) breed in the area:

- pied stilt
- South Island pied oystercatcher
- banded dotterel
- wrybill
- black-billed gull
- southern black-backed gull *(Larus dominicanus)*
- black-fronted tern.

Figure 1: Study areas

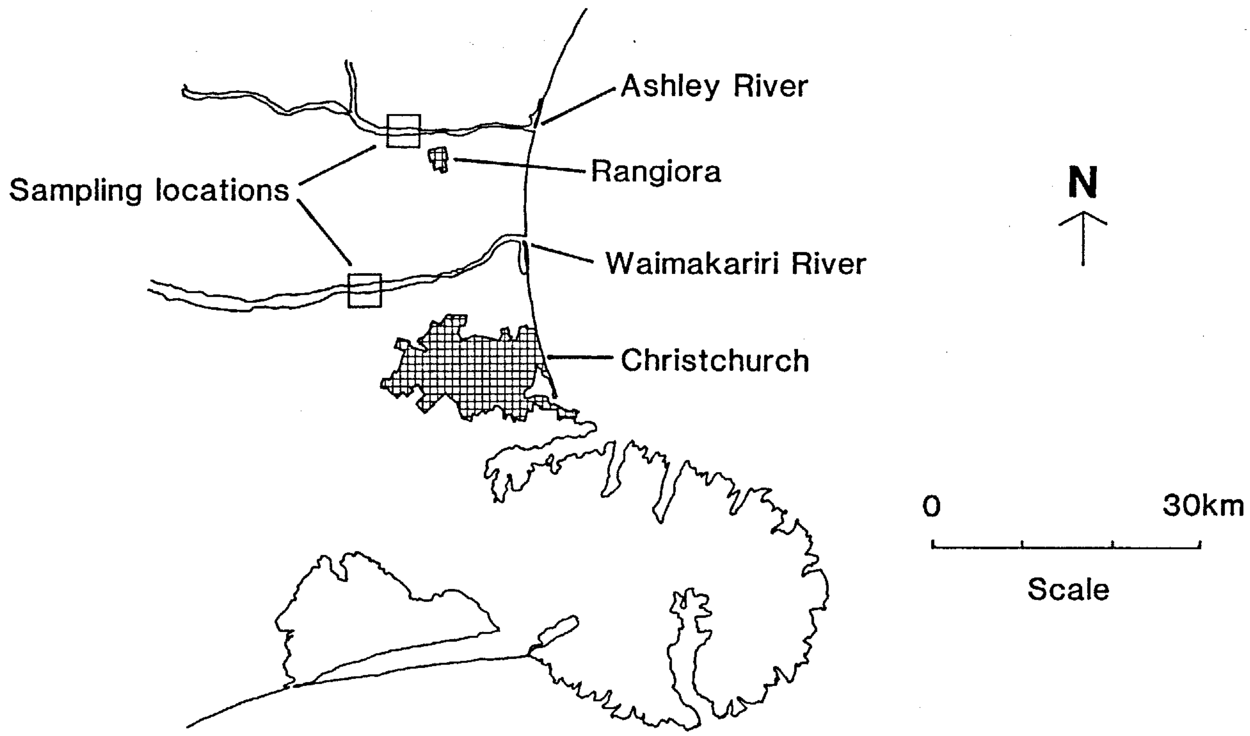


Figure 2 : Flow regimes of the Ashley and Waimakariri Rivers

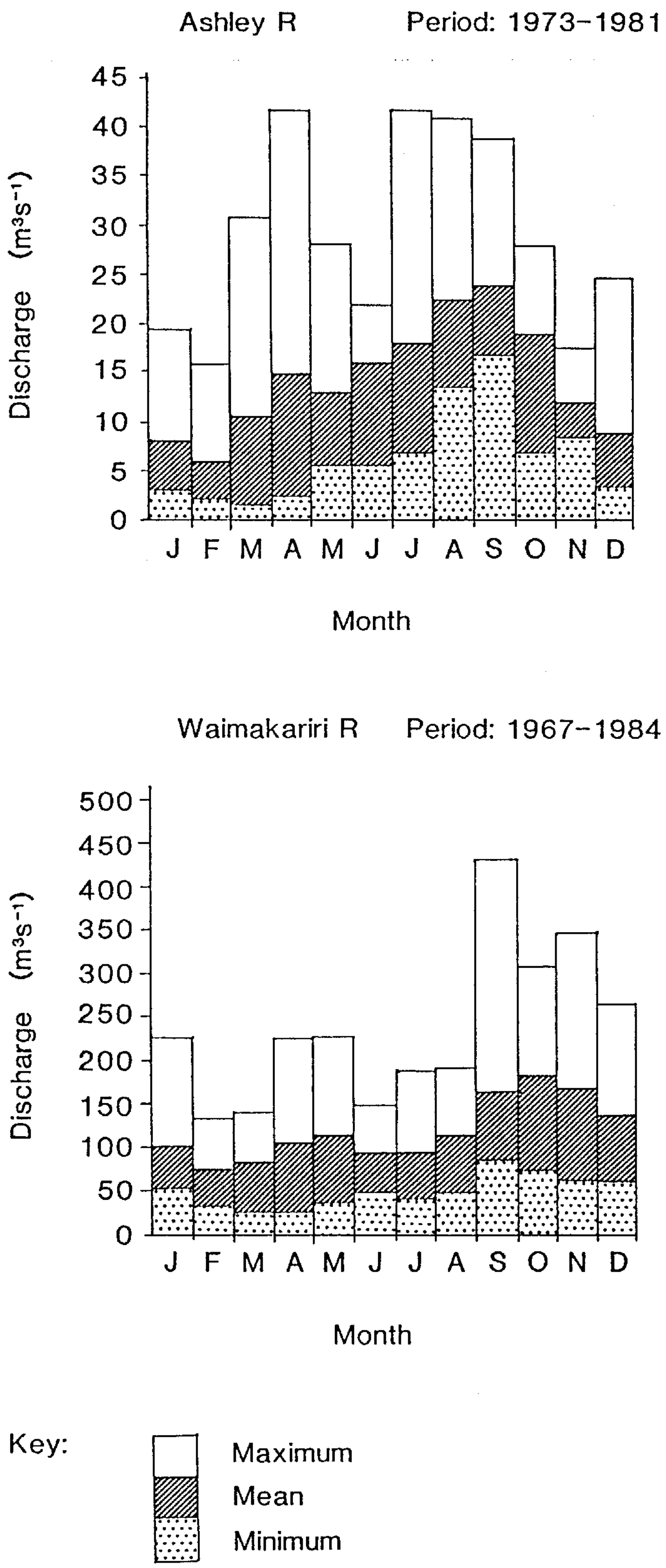


Table 1 : Number of taxa recorded in samples of aquatic invertebrates from the different habitat types in the Ashley and Waimakariri Rivers.

	Ashley River		Waimakariri River	
Channel type	Mean N=36	Range	Mean N=36	Range
Major channel	9.3	4-13	7.4	3-12
Minor channel	9.4	5-13	6.6	5-10
Seepage	11.7	8-14	9.2	6-12

Flows of the Waimakariri River (measured at the Waimakariri Gorge) are much higher than of the Ashley with a mean flow of 119 $m^3 s^{-1}$ (North Canterbury Catchment Board 1986). The catchment of the Waimakariri with an area of 3564 km^2 is in the Southern Alps; it is therefore a snow and rain-fed river with flows generally highest in late spring and early summer (Figure 2b) during snow-melt caused by moist north-westerly conditions over the Southern Alps. Lowest flows occur from February to April with medium-low flows from May until August; floods can, however, occur at any time. This river was sampled 10 km upstream of the State Highway 1 bridge (Figure 1) where the river is highly braided with up to 10 channels in a cross-section. Substrate and vegetation were similar to the Ashley study site. Although species diversity is much lower than for the Ashley, considerable numbers of birds were present during the breeding season including:

- pied stilt
- banded dotterel
- southern black-backed gull.

The occurrence of many thousands of southern black-backed gulls in the area reduces the opportunity for other more desirable species to breed (O'Donnell and Moore 1983 and Hughey 1985b).

4. RESULTS

4.1 Invertebrate taxa

We identified 18 major taxonomic groupings for counting purposes; all but Tabanidae, which did not occur in Waimakariri samples, were present in both rivers. This number would be substantially increased if several taxa (Table 2), e.g. Trichoptera, Diptera and "Miscellaneous", were identified to lower taxonomic levels. The numbers of taxa were highest in the three channel types of the Ashley River. Highest numbers of taxa were in seepage channels and the range was generally smallest there (Table 1). The greatest range in taxa numbers occurred in major channels of both rivers.

4.2 Mean density and dry weights

Invertebrate fauna of the Ashley was dominated by mayflies of the genus *Deleatidium*, followed by elmid larvae (Tables 2 and 3) in all habitat types. Total density of invertebrates averaged 517.2 0.1 m^{-2}, compared with an average of 227.9 invertebrates 0.1 m^{-2} for the Waimakariri River. Corresponding dry weights were 65.98 mg 0.1 m^{-2} and 33.82 mg 0.1 m^{-2}. The Waimakariri was dominated by *Deleatidium* larvae followed by Chironomidae larvae. Density and dry weights varied greatly throughout the year, generally being highest after long stable periods of flow and lowest after freshes or floods.

Deleatidium spp. larvae also dominated dry weights for all channel types of both rivers (Table 4). In the Ashley although there was an increase in total *Deleatidium* dry weights from major through minor and seepage channels there was actually a decline in relative proportions (Table 5) of total weight. This was matched by a proportional increase in the weight of elmid larvae. In contrast the dry weight of *Deleatidium* in Waimakariri minor channels was lower than in major channels; both were substantially lower than in Ashley minor and major channels, yet the peak total for Waimakariri seepage channels far exceeded any Ashley total.

4.2.1 Mayflies (Order: Ephemeroptera)

Deleatidium larvae were generally most numerous in seepage channels (Figure 3) of both rivers. Total densities were highest for all channel types of the Ashley River compared to the Waimakariri River (Table 2). A similar pattern occurred for dry weights (Figure 4) except for seepage zones where, in spite of density being greater for the Ashley (415.4 0.1 m^{-2} c.f. 282.5 0.1 m^{-2}) dry weights were far lower (38.95 mg 0.1 m^{-2} c.f. 54.71 mg 0.1 m- 2).

Table 2 : Mean density of invertebrates (number 0.1m^{-2}) found in three riffle habitats of the Ashley and Waimakariri rivers for 12 samples (4 September 85 to 28 August 86).

	Ashley River				Waimakariri River			
Taxa	Major channel	Minor channel	Seepage channel	All channels	Major channel	Minor channel	Seepage channel	All channels
Deleatidium	167.4	252.4	415.4	278.4	126.1	85.7	282.5	164.8
Gripopterygidae	3.0	2.8	6.0	3.9	0.6	0.3	0.8	0.5
Rhyacophilidae	2.4	2.3	8.2	4.3	3.3	1.8	8.1	4.4
Conoesucidae	1.9	0.7	10.2	4.3	*	0.0	0.1	0.1
Calocidae	0.8	0.6	14.5	5.3	*	0.0	9.2	3.1
Hydropsychidae	5.1	5.7	13.7	8.2	1.0	0.2	3.4	1.5
Dytiscidae	*	*	0.8	0.3	0.1	0.1	0.1	0.1
Elmidae	39.2	101.2	358.6	166.3	0.4	0.1	6.5	2.3
Hydrophilidae	0.3	0.4	2.1	0.9	*	0.1	1.4	0.5
Staphylinidae	0.2	0.1	*	0.1	0.1	0.1	0.1	0.1
Chironomidae	9.8	7.1	24.9	13.9	23.6	12.5	36.0	24.0
Tipulidae	5.6	9.2	10.5	8.4	2.4	1.6	3.5	2.5
Simulidae	2.2	4.9	2.2	3.1	0.3	0.6	1.7	0.8
Ephydridae	0.1	0.1	3.4	1.2	0.1	0.3	0.2	0.2
Ceratopogonidae	0.1	0.0	0.1	0.1	*	0.0		
Tabanidae	0.1	0.1	0.8	0.3	0.0	0.0	0.0	0.0
Nematoda	2.5	6.7	7.4	5.5	3.0	2.4	49.6	18.4
Miscellaneous	1.2	4.2	32.8	12.7	1.6	1.6	10.6	4.6
Total	241.9	398.5	911.6	517.2	162.6	107.4	413.8	227.9

* = present but less than 0.1 invertebrate 0.1m^{-2}

Table 3 : Proportion (%) of channel mean densities (number $0.1m^{-2}$) contributed by each of seven taxonomic groups from three riffle habitats of the Aehley and Waimakariri rivers for 12 samples (4 September 85 to 28 August 86).

	Ashley River				Waimakariri River			
Taxa	Major channel	Minor channel	Seepage channel	All channels	Major channel	Minor channel	Seepage channel	All channels
Total numbers	241.9	398.5	911.6	517.2	162.6	107.4	413.8	227.9
Deleatidium	69.2	63.4	45.6	53.8	77.6	79.8	68.3	72.3
Gripopterygidae	1.2	0.7	0.7	0.8	0.4	0.3	0.2	0.2
Rhyacophilidae Conoesucidae Calocidae Hydropsychidae	4.2	2.3	5.1	4.3	2.6	1.9	5.0	3.9
Dytiscidae Elmidae Hydrophilidae Staphylinidae	16.4	25.5	39.7	32.4	0.4	0.4	2.0	1.3
Chironomidae Tipulidae Simulidae Ephydridae Ceratopogonidae Tabanidae	7.4	5.4	4.6	5.2	16.2	14.0	10.0	12.1
Nematoda	1.0	1.7	0.8	1.1	1.8	2.2	12.0	8.1
Miscellaneous	0.5	1.1	3.6	2.5	1.0	1.5	2.6	2.0

Table 4 : Mean dry weights of invertebrates (mg $0.1m^{-2}$) found in three riffle habitats of the Ashley and Waimakariri rivers for 12 samples (4 September 85 to 28 August 86).

Taxa	Ashley River				Waimakariri River			
	Major channel	Minor channel	Seepage channel	All channels	Major channel	Minor channel	Seepage channel	All channels
Deleatidium	27.97	30.30	38.95	32.41	14.47	11.28	54.71	26.82
Gripopterygidae	0.36	0.34	0.56	0.42	0.05	0.03	0.13	0.07
Rhyacophilidae	1.00	1.58	4.07	2.21	1.15	0.71	3.54	1.80
Conoesucidae	?	?	?	?	?	?	?	?
Calocidae	?	?	?	?	?	?	?	?
Hydropsychidae	2.82	4.50	3.94	3.76	0.49	0.06	0.98	0.51
Dytiscidae	*	0.01	0.08	0.03	0.01	0.03	0.01	0.01
Elmidae	4.24	12.27	37.32	17.94	0.03	0.03	0.88	0.31
Hydrophilidae	0.01	0.13	0.53	0.22	0.02	0.11	0.30	0.14
Staphylinidae	*	0.01	*	*	0.01	0.02	0.02	0.02
Chironomidae	0.43	0.35	1.18	0.65	0.52	0.53	2.10	1.05
Tipulidae	1.11	1.64	1.75	1.50	0.48	0.24	0.51	0.41
Simulidae	0.23	0.57	0.22	0.34	0.02	0.05	0.24	0.11
Ephydridae	*	0.08	0.37	0.15	0.14	0.17	0.16	0.16
Ceratopogonidae	*	0.00						
Tabanidae	0.48	0.01	3.27	1.25	0.00	0.00	0.00	0.00
Nematoda	0.04	0.13	0.12	0.10	0.07	0.04	2.11	0.74
Miscellaneous	0.50	5.38	9.11	5.00	0.86	0.32	3.83	1.67
Total	39.19	57.30	101.47	65.98	18.32	13.62	69.52	33.82

* = present but less than 0.1 invertebrate $0.1m^{-2}$

? = weights not included due to bias caused by stony cases

Table 5 : Proportion (%) of channel toatl dry weight (mg 0.1m-2) contributed by each of seven taxonomic groups from three riffle habitats of the Aehley and Waimakariri rivers for 12 samples (4 September 85 to 28 August 86).

Taxa	Ashley River				Waimakariri River			
	Major channel	Minor channel	Seepage channel	All channels	Major channel	Minor channel	Seepage channel	All channels
Total numbers	39.19	57.30	101.47	65.98	18.32	13.62	69.52	33.82
Deleatidium	71.37	52.88	38.38	49.12	78.98	82.82	78.70	79.30
Gripopterygidae	0.92	0.59	0.55	0.64	0.27	0.22	0.19	0.21
Rhyacophilidae Hydropsychidae	9.75	10.61	7.89	9.05	8.95	5.65	6.50	6.83
Dytiscidae Elmidae Hydrophilidae Staphylinidae	10.85	21.68	37.38	27.57	0.38	1.40	1.74	1.42
Chironomidae Tipulidae Simulidae Ephydridae Ceratopogonidae Tabanidae	5.75	4.63	5.90	5.89	6.33	7.27	4.33	5.12
Nematoda	0.10	0.23	0.12	0.15	0.38	0.29	3.04	2.19
Miscellaneous	1.28	9.39	8.98	7.58	4.69	2.35	5.51	4.94

Figure 3 : Density of benthic invertebrates (x ± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily discharges: *Deleatidium* spp.

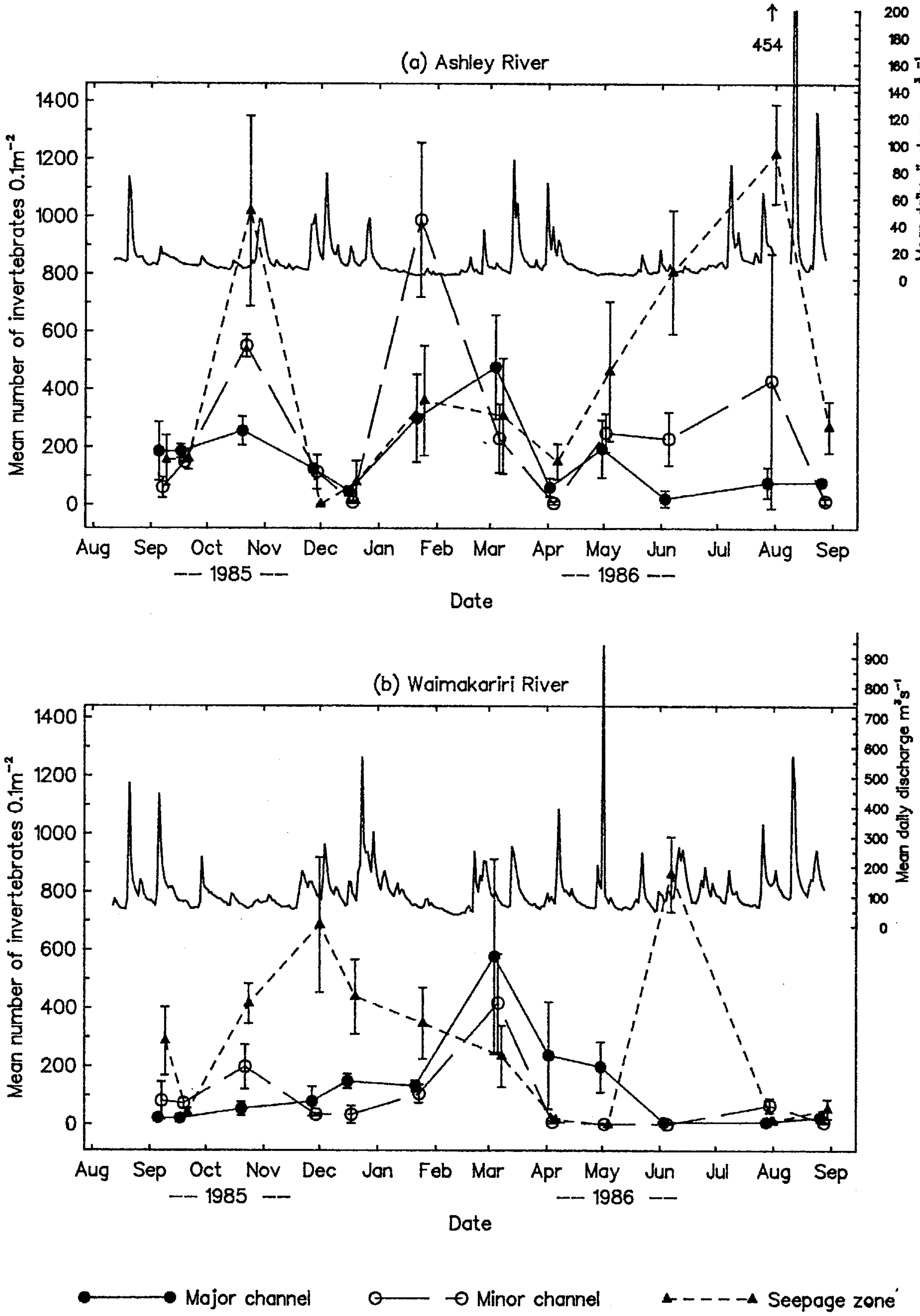
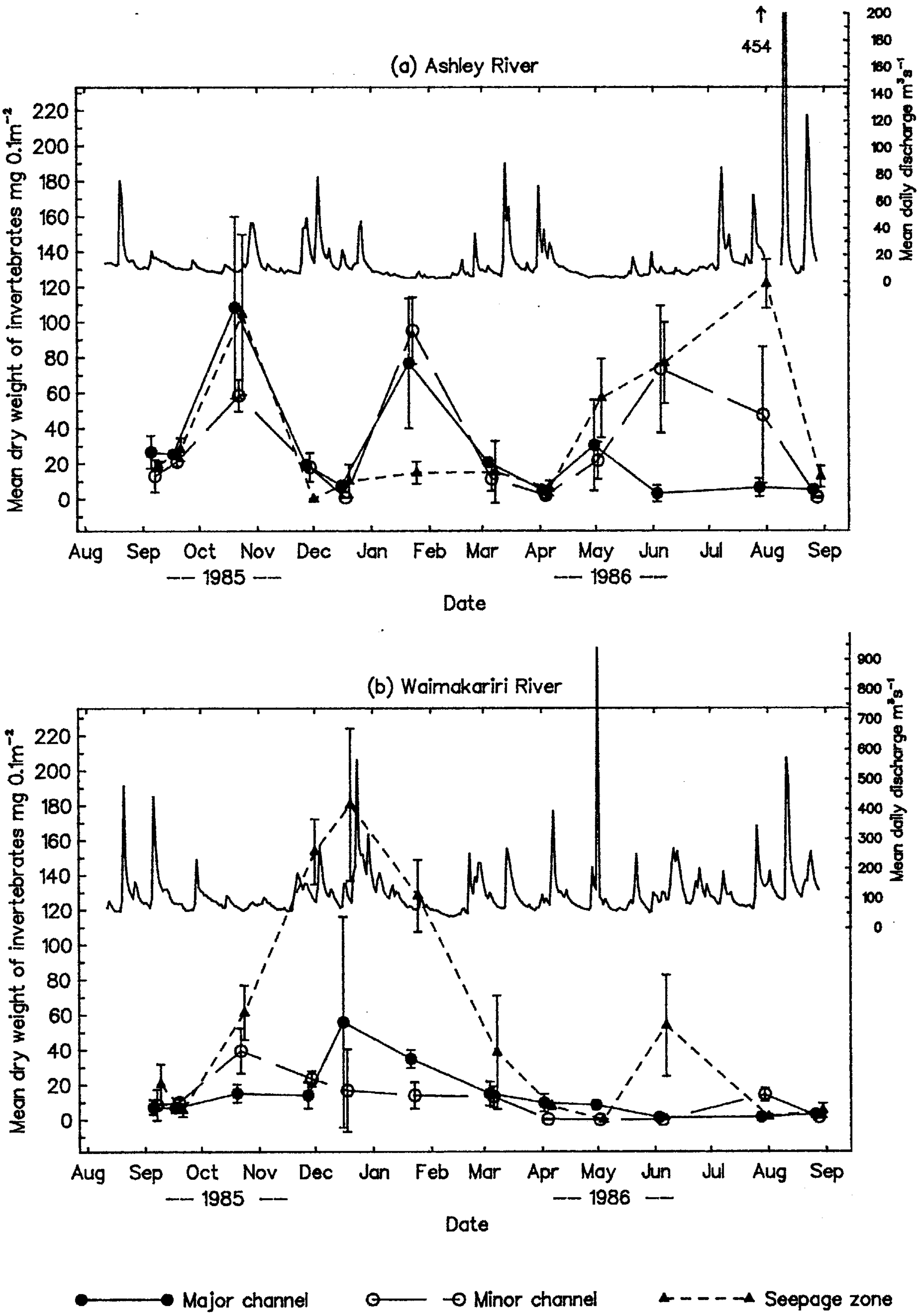


Figure 4 : Dry weight of benthic invertebrates (x ± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily mean discharges: *Deleatidium* spp.



On both rivers densities and dry weights of *Deleatidium* were low in September 1985 and August 1986 following recent floods. Low figures on the Ashley in November, December and in April also occurred during or shortly after floods. For the Waimakariri River the relationship was not so clear; lower densities in December, January and April-May were associated with periods of repetitive flooding. Generally there was little difference between densities or dry weights in minor and major channels, but at most times, except after major floods, figures for seepage channels were higher than in other channel types. The major exception to this occurred in January at the Ashley, when densities were higher in minor channels. A similar event occurred in March-May for densities in the Waimakariri, but dry weights generally stayed higher in seepage channels.

Deleatidium spp. larvae dominated in all Waimakariri channel types ranging from 78.98% (seepage) to 82.82% (minor) of invertebrate dry weight. Mean dry weights were 32.41 mg 0.1 m^{-2} for the Ashley and 26.82 mg 0.1 m^{-2} for the Waimakariri River (Tables 4 and 5).

There was a clear relationship between periods of low flow and high dry weights of *Deleatidium* larvae on the Ashley River, with highest dry weights generally occurring after periods of low flow; the exception in August 1986 when seepage channels had a high weight occurred because the seepage channel was not flooded during the most recent high flow event. Generally the highest totals were for seepage channels. Highest dry weights in the Waimakariri from November to January were for seepage channels and were higher than for any Ashley dry weight total. The relationship between flows and dry weights was not as clear as for the Ashley.

4.2.2 Stoneflies (Order: Plecoptera)

Within the order Plecoptera only one family, Gripopterygidae, was identified. Densities for this family showed little variation between channel types or between rivers. Gripopterygidae form only a small fraction of total mean invertebrate density (Table 3) and in the Ashley River ranged from 0.7% (seepage) to 1.2% (major). In the Waimakariri River the range was 0.2% (seepage) to 0.4% (minor).

Gripopterygid larvae were most common in the Ashley (Figure 5), especially in spring 1985 and winter 1986 when highest densities were associated with long periods of stable flow. A small winter peak also occurred in the Waimakariri River. Highest densities were usually in seepage channels of both rivers.

Gripopterygidae comprised 0.64% of the invertebrate dry weight in the Ashley samples and 0.21% of the Waimakariri samples. Their weights rose to maxima in spring and early summer (Figure 6). This trend occurred in all channel types, though the weights involved were relatively small.

4.2.3 Caddisflies (Order: Trichoptera)

Four families of Trichoptera were common on both rivers. Hydropsychidae was the dominant family on the Ashley River whereas Rhyacophilidae were dominant in the Waimakariri. While densities overall were considerably higher on the Ashley the relative proportions of these taxa to the total fauna counts were similar between rivers. Seepage channels were most important followed by major and minor channels. For the Ashley River densities ranged from 2.3% (minor) to 5.1% (seepage) of total mean channel counts and for the Waimakariri the range was 1.9% (minor) to 5.0% (seepage).

Only the Rhyacophilidae and Hydropsychidae were dried and weighed. Conoesucid and calocid larvae have a stony case which, if dry weighed, would have biased the dry weight data. Caddis larvae were major contributors to the total invertebrate dry weights on both rivers, being the second heaviest group in the Waimakariri samples (6.83%) behind Ephemeroptera (79.30%) and the third heaviest group in the Ashley samples (9.05%) behind Ephemeroptera (49.12%) and Coleoptera (27.57%).

Figure 5 : Density of benthic invertebrates (x± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily mean discharges: Gripopterygidae.

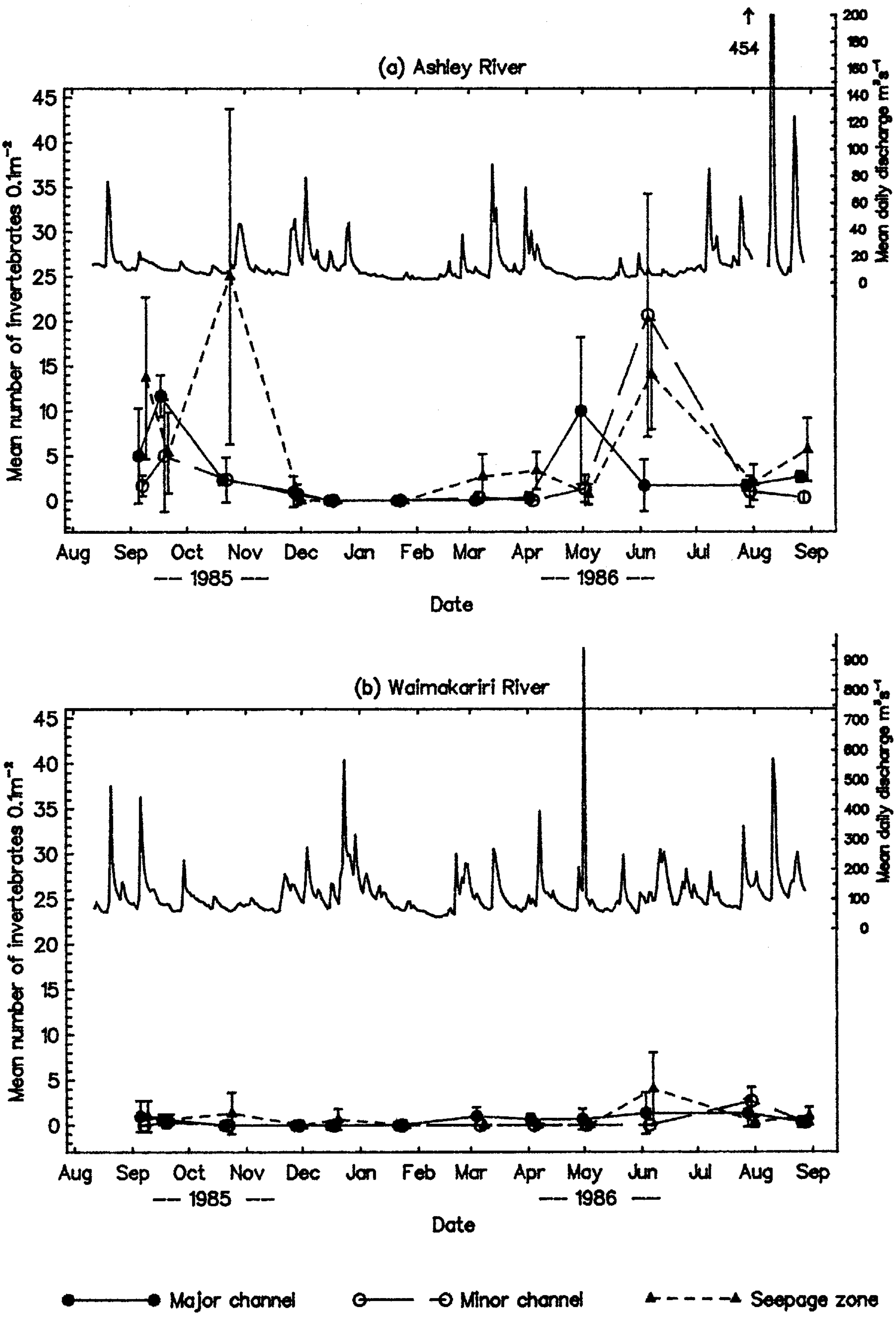
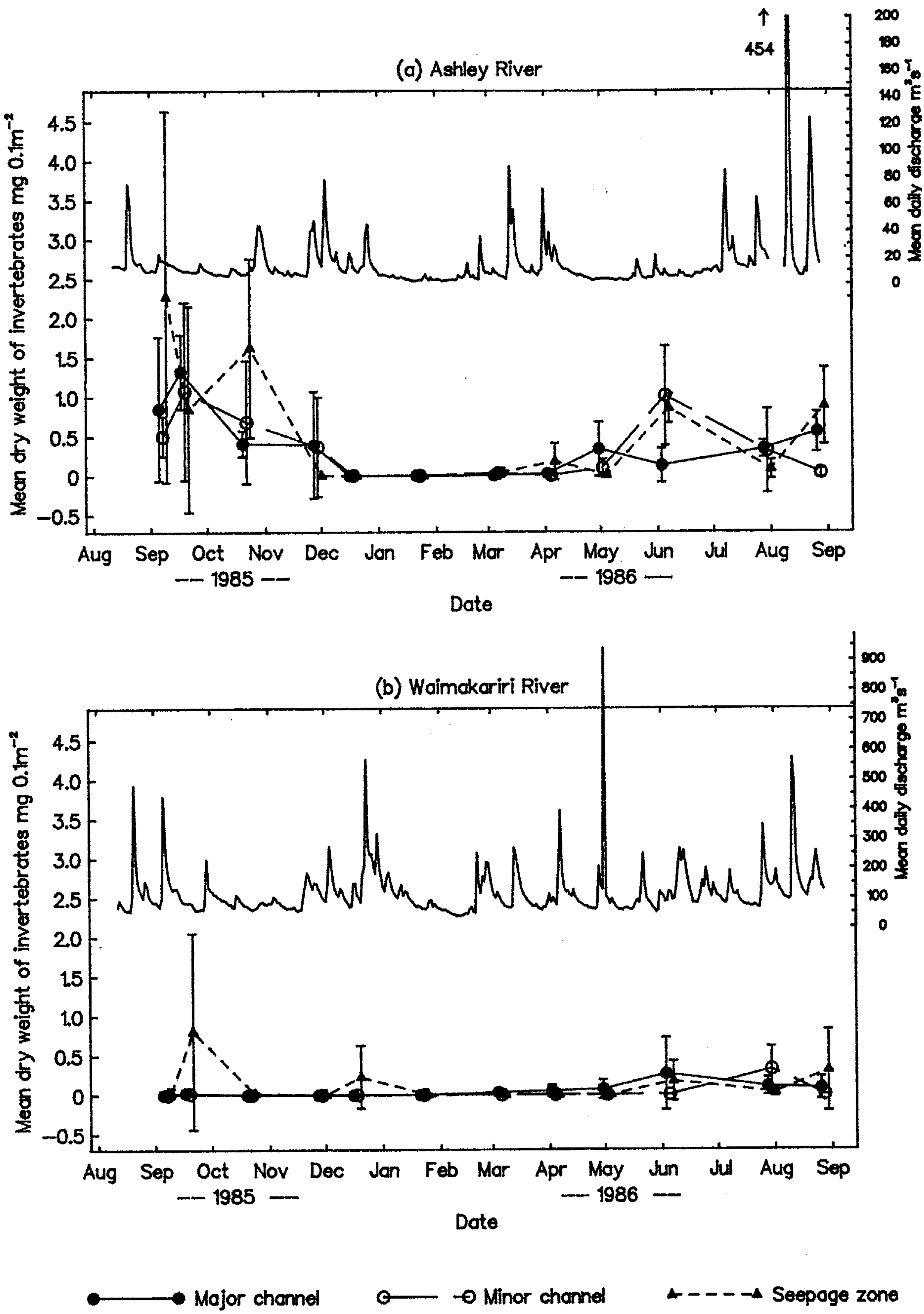


Figure 6 : Dry weight of benthic invertebrates ($\bar{x}$ ± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily mean discharges: Gripopterygidae



Rhyacophilidae
On most occasions densities and dry weights of rhyacophilid larvae (Figures 7 and 8) were higher in seepage channels of both rivers than in other habitat types; mean density in each habitat type was also similar when compared between rivers (Table 2). Samples taken during the month after a flood generally showed reduced densities and weights. Densities and weights peaked during periods of low flow, except that densities were low throughout most of the 1986 winter on the Ashley; this contrasts with a population peak recorded in seepage channels of the Waimakariri in June 1986.

Conoesucidae
Conoesucid larvae were recorded in the Waimakariri only in March and June 1986 and then in very low densities (Appendix Figure Al). In contrast densities in the Ashley, particularly in seepage zones, were high between September and March, with an October peak. None was recorded from March onwards.

Calocidae
Calocid larvae were recorded almost solely from seepage channels in both rivers (Appendix Figure A2) with the density only ever being significant in the Waimakariri during June 1986 when it was higher than at any time for the Ashley. High densities in the Ashley followed extended periods of low flow.

Hydropsychidae
Hydropsychid larvae were the most common trichopterans in the Ashley River, although densities and weights in the Waimakariri River were usually very low (Figures 9 and 10). High weights from the Ashley were associated with stable periods of flow; a similar pattern was not evident for the Waimakariri River.

4.2.4 Beetles (Order: Coleoptera)

In the Ashley River four families of Coleoptera were recorded of which Elmidae was dominant. Elmid densities in the Waimakariri River were very low compared with the Ashley River, whereas the densities of other coleopterans were similar in both rivers. For the Ashley River densities ranged from 16.4% (major) to 39.7% (seepage) of total mean invertebrate density, however, the range for the Waimakariri was 0.4% (major) to 2.0% (seepage).

Among the Coleoptera, only the elmid larvae provided significant dry weights, and the contrasting percentage contribution made by Coleptera to the two rivers' total weights (Ashley 27.57%; Waimakariri 1.42%) reflects the scarcity of elmids in the Waimakariri River. In the Ashley River Coleptera (27.57%) were second only to Ephemeroptera (49.12%) in percentage of total dry weight. The other Coleoptera families (Dytiscidae, Hydrophilidae and Staphylinidae) were generally present but their weights were insignificant.

Dytiscidae
Larvae of Dytiscidae were recorded during the spring to autumn period, and then generally in very low densities (Appendix Figures A3 and A4) and weights. Highest densities and weights occurred in Ashley seepage channels in November 1985.

Elmidae
Elmid larvae were the second most common invertebrates found in the Ashley River yet they were recorded only rarely and in extremely low densities on the Waimakariri River (Figure 11) with highest densities in seepage channels, followed by minor channels. Highest densities from seepage channels in the Ashley always occurred during long periods of stable flow. Similarly they were the greatest contributors to Coleoptera dry weight in the Ashley River, but provided only negligible weights in the Waimakariri (Figures 12). In the Ashley River the seepage samples composed 69% of the elmid weight, while the major and minor channels provided only 8% and 23% respectively.

Figure 7 : Density of benthic invertebrates (x ± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily mean discharges: Rhyacophilidae

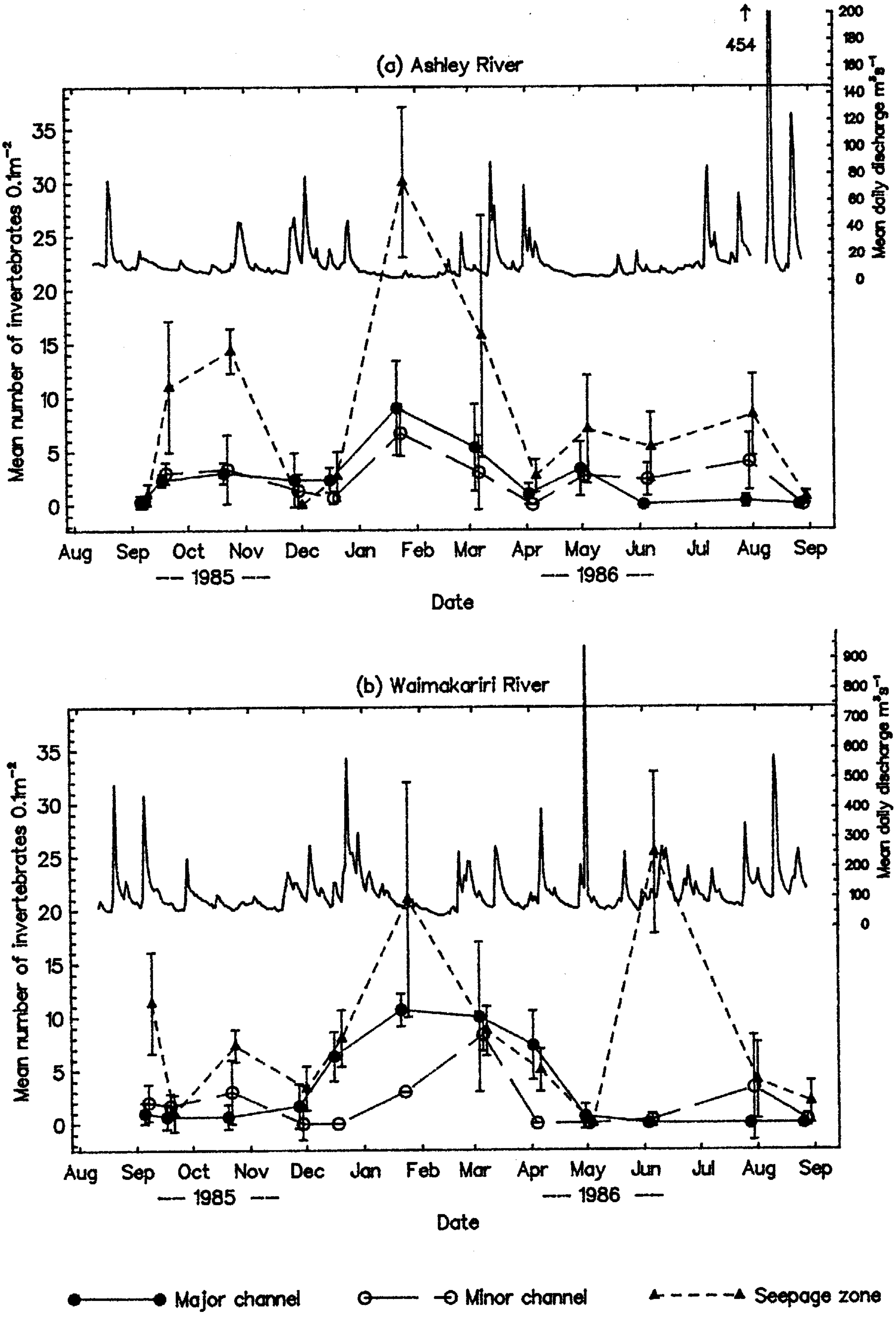


Figure 8 : Dry weight of benthic invertebrates (x ± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily mean discharges: Rhyacophilidae.

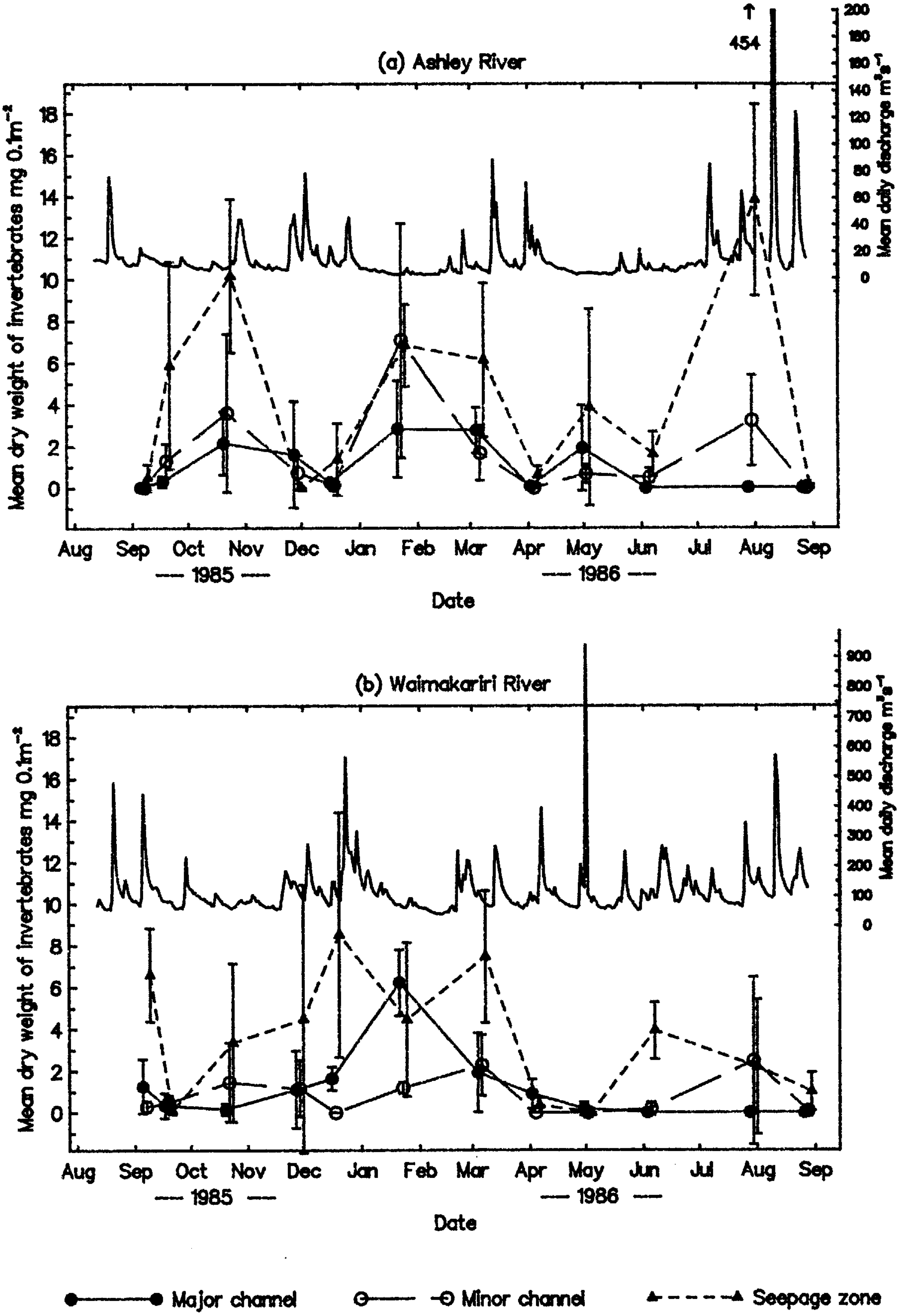


Figure 9 : Density of benthic invertebrates (x ± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily mean discharges: *Hydropsychidae* spp.

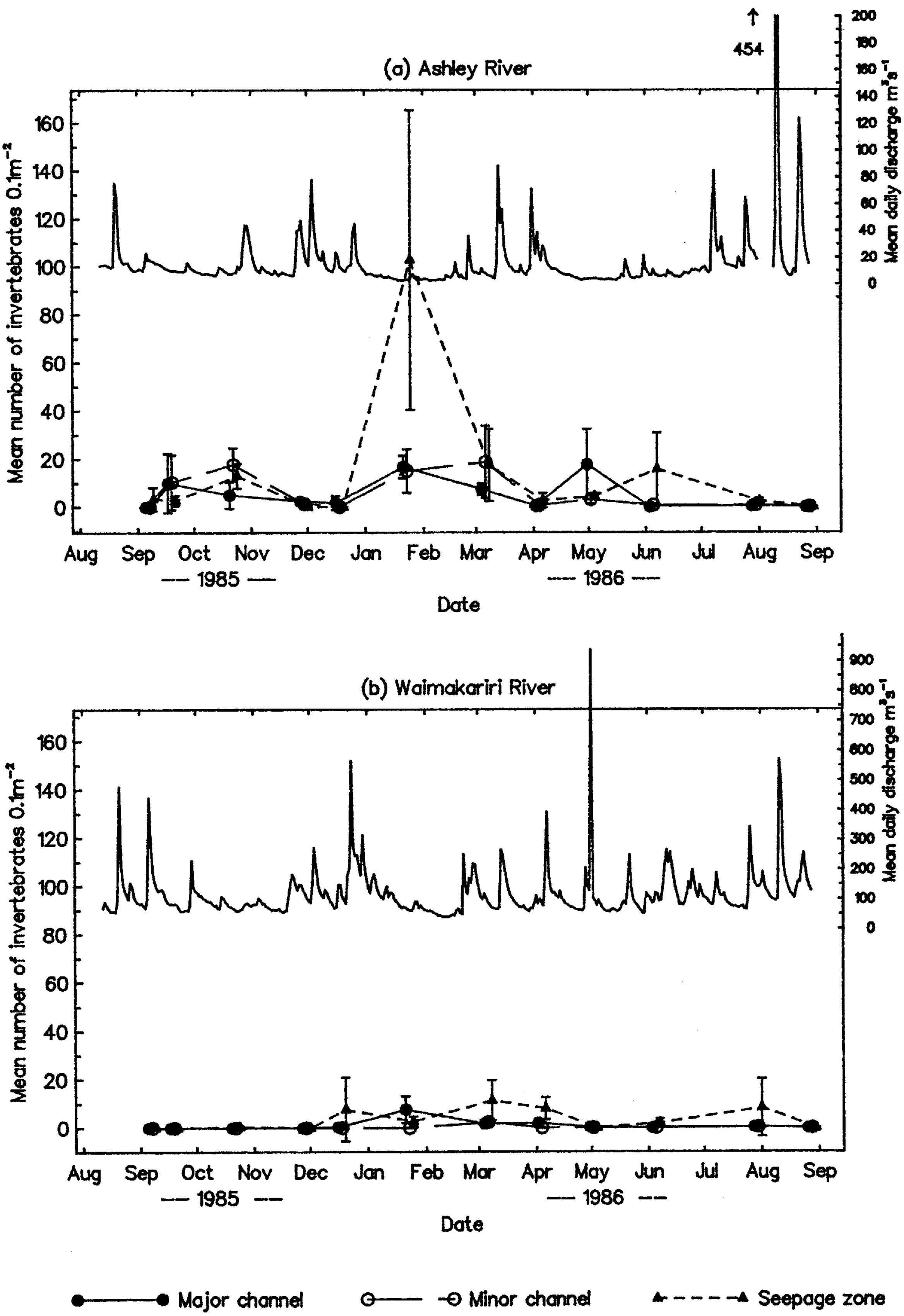


Figure 10 : Dry weight of benthic invertebrates (x ± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily mean discharges: *Hydropsychidae* spp.

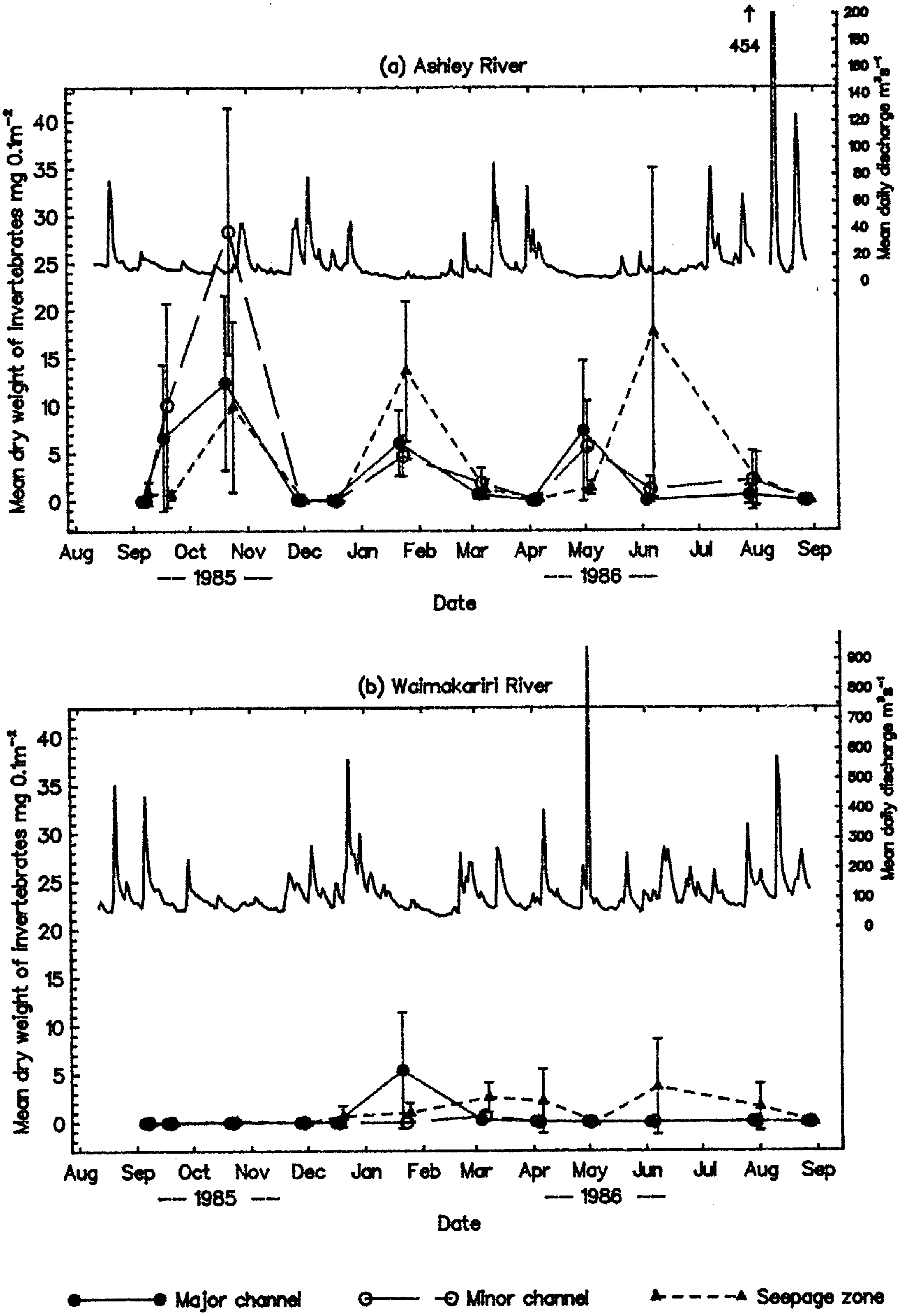
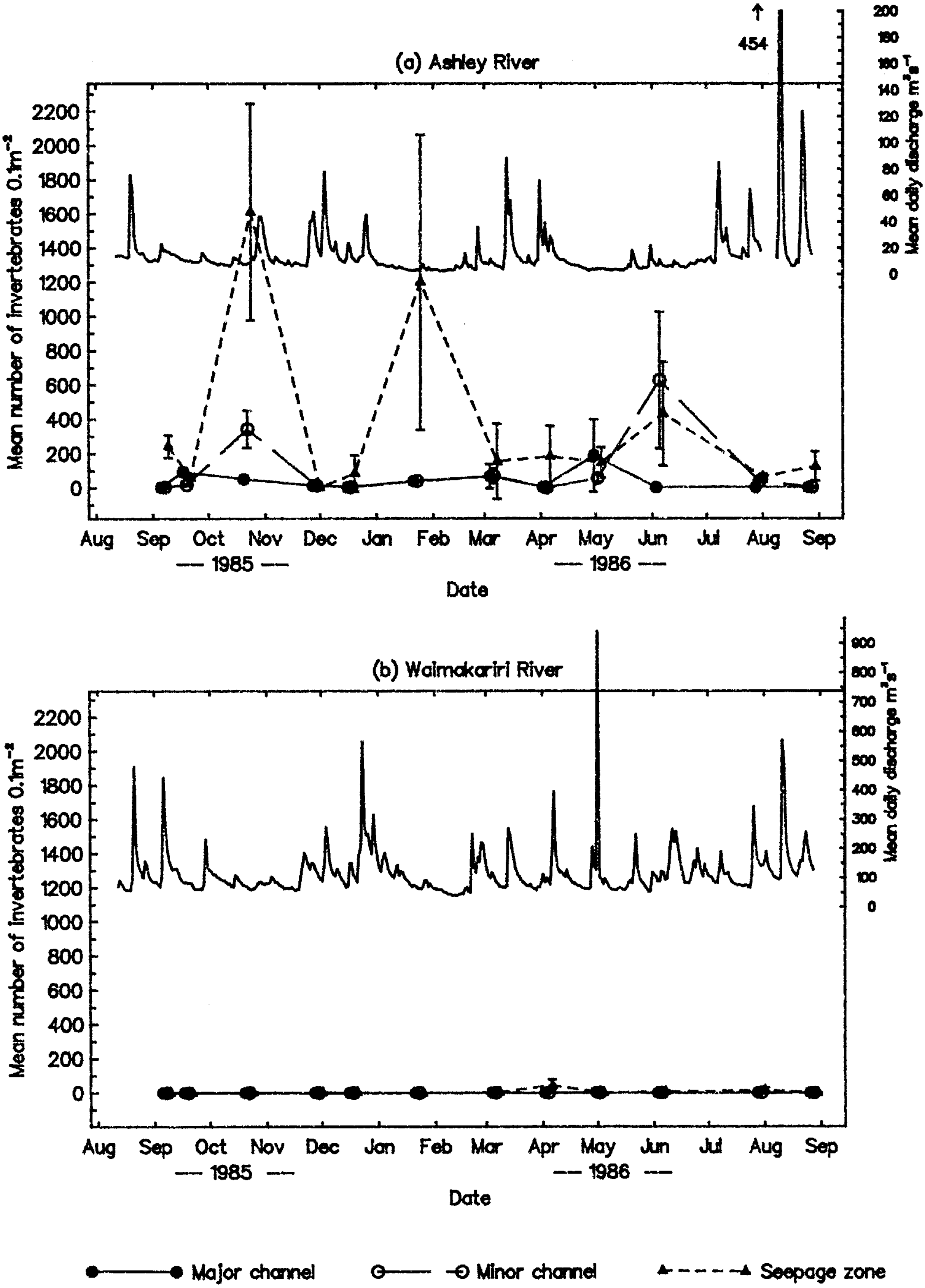


Figure 11 : Density of benthic invertebrates (x ± 1SE) in samples from Ashley and Waimakariri rivers 4 September 85 - 28 August 86 compared with daily mean discharges: Elmidae.



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