ACT PARKS and CONSERVATION SERVICE

DISTRIBUTION AND RELATIVE ABUNDANCE OF FISH IN THE NAAS-GUDGENBY CATCHMENT

H.A. JONES, T. RUTZOU AND K. KUKOLIC

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ABSTRACT

A survey of fish in the streams of the Naas–Gudgenby catchment, Namadgi National Park, was carried out between 12 December 1986 and 12 February 1987. There was a need to monitor fish populations in smaller streams to understand better their distributions, relative abundances and limiting factors. The relationships between the native and introduced species was of particular management interest.

Three species of fish were found. Brown trout were restricted to the larger and deeper channel sections of the Gudgenby system. Rainbow trout extended further upstream than brown trout into the middle upper reaches of the creeks. However, they did not occur in the smaller headwater streams and tributaries.

Galaxids had a widespread but fragmented distribution, probably due to competitive and predatory interactions with trout. There was a negative correlation of trout and galaxid abundance. It is probable the galaxids would have a continuous distribution throughout the catchment in the absence of trout because suitable habitat occurs in all sections of the system.

Recommendations for future work are made.

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INTRODUCTION

The distribution of fish species in the major rivers and impoundments of the ACT is well known (Greenham, 1981; Robinson, 1982; Dept of Territories, unpubl. data). In the larger creeks and smaller feeder streams, however, the fish fauna is poorly known and reported. The NCDC (1984) compilation of available data contains no specifics on fauna distributions in these streams.

It was known from casual observation and past incidental sampling that at least two introduced species (brown trout, *Salmo trutta* and rainbow trout, *S. gairdneri*) and one native species (mountain galaxid, *Galaxias olidus*) occurred in the Naas–Gudgenby catchment. Other species which were suspected included the threatened river blackfish (*Gadopsis* sp.), and the mosquito fish (*Gambusia affinis*).

The distributions, relative abundances and factors limiting populations of fishes in these streams was unknown. Particularly, there was a need to understand better the relationships between the native and introduced species, and habitat conditions influencing the fish fauna. Baseline information on the distribution and relative abundance of fish species present is essential for the effective management of the fishery within Namadgi National Park.

Published stream surveys generally have concentrated on larger systems such as the Seven Creeks system, Victoria (Cadwallader, 1979) and the Finniss River system, Northern Territory (Williams and Jeffree, 1975). These surveys employed a variety of sampling methods most of which were not suitable for use in the small streams of this study. The present study was the first stage of an overall status survey of fish of the upper catchment streams in the ACT.

Significant sections of a draft of this report were presented by Martin *et al* (1988) in their response to a National Capital Development Commission brief.

STUDY AREA

The Naas–Gudgenby catchment (72,000 ha) is drained by the Gudgenby, Orroral and Naas rivers. The Gudgenby River joins the Murrumbidgee River approximately one kilometre south of Tharwa, 600 m above sea level. The drainage pattern varies in accordance with the faulting in the Murrumbidgee batholith, a complex of granite rocks. The major streams in the eastern section flow in a north–easterly to northerly direction with major tributaries in the western section flowing south–easterly. The Naas and Gudgenby Rivers are dissected by the Booth and Billy Ranges. The catchment is bounded in the east by the Clear Range and in the south by the Boboyan Divide (Fig 1).

Mean annual discharges of the Orroral River at the road crossing and the Gudgenby River at Naas and at Mt Tennent are 13.6 MCUM (1967–1985), 49.9 MCUM (1962–1985) and 72.4 MCUM (1964–1985) respectively. Seasonal variations in discharge reflect the rainfall pattern, maximum discharges occurring in October then declining sharply over the summer months to minimum levels in March (Fig 2). Many tributaries, including sections of the Naas River, cease to flow during late summer either drying completely or forming a series of pools.

The Gudgenby River system has soft, alkaline waters of low conductivity. The streams have little colour, low turbidity and low phytoplankton levels. Streams in the catchment are thought to have water quality characteristics similar to those of the Gudgenby River (Table 1).

Most of the area within the Naas–Gudgenby catchment is mountainous and covered by a mosaic of vegetation types (NCDC 1984). Wet sclerophyll forest (*Eucalyptus dalrympleana – E. dives – E. pauciflora – E. viminalis*) dominates much of the catchment except for a large section of the Naas River which is dominated by savannah woodland (*E. bridgesiana – E. dives – E. viminalis*). Subalpine woodland (*E. pauciflora*) occurs on the higher ridges

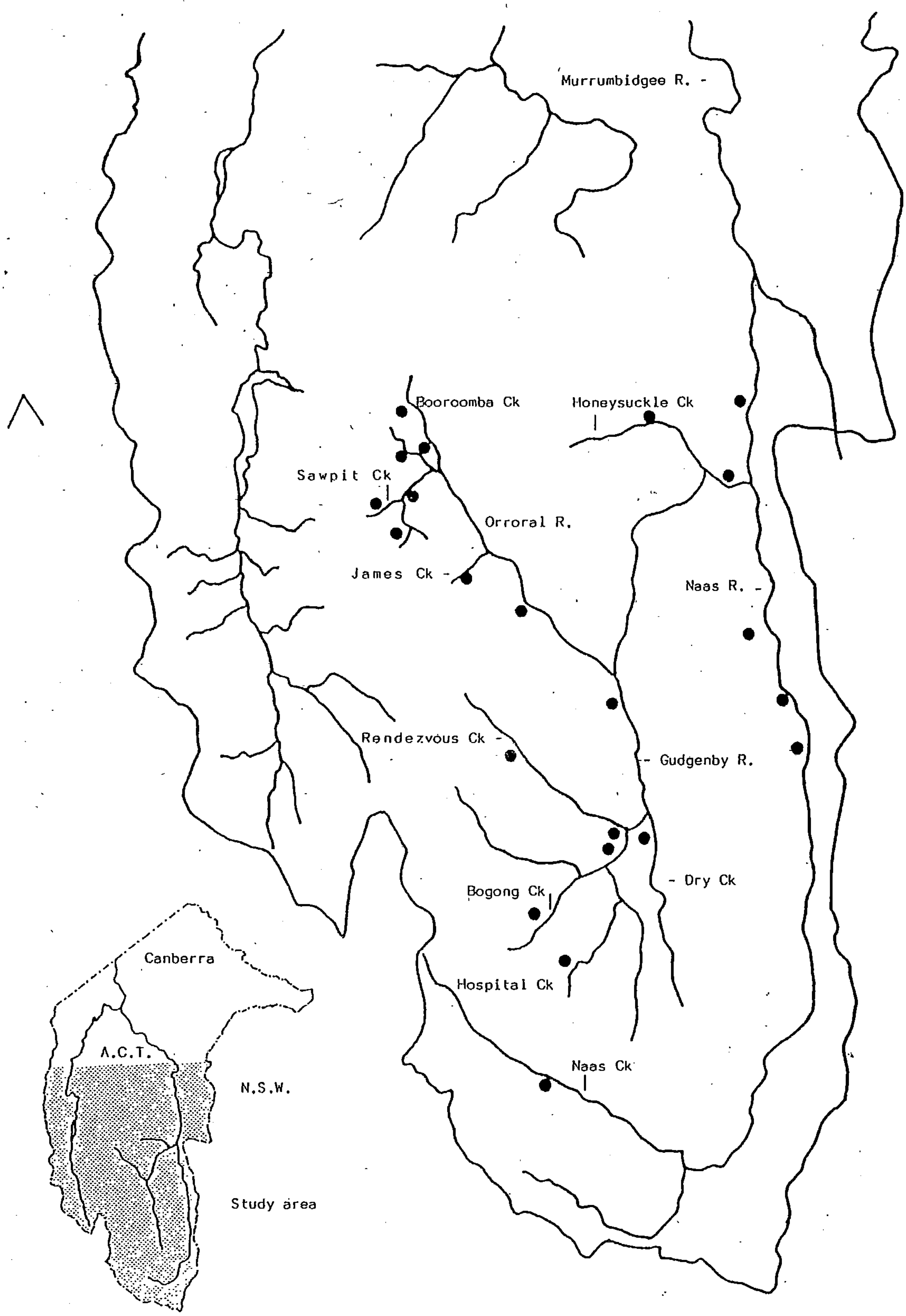


Fig 1. Map of Study Area Sample sites

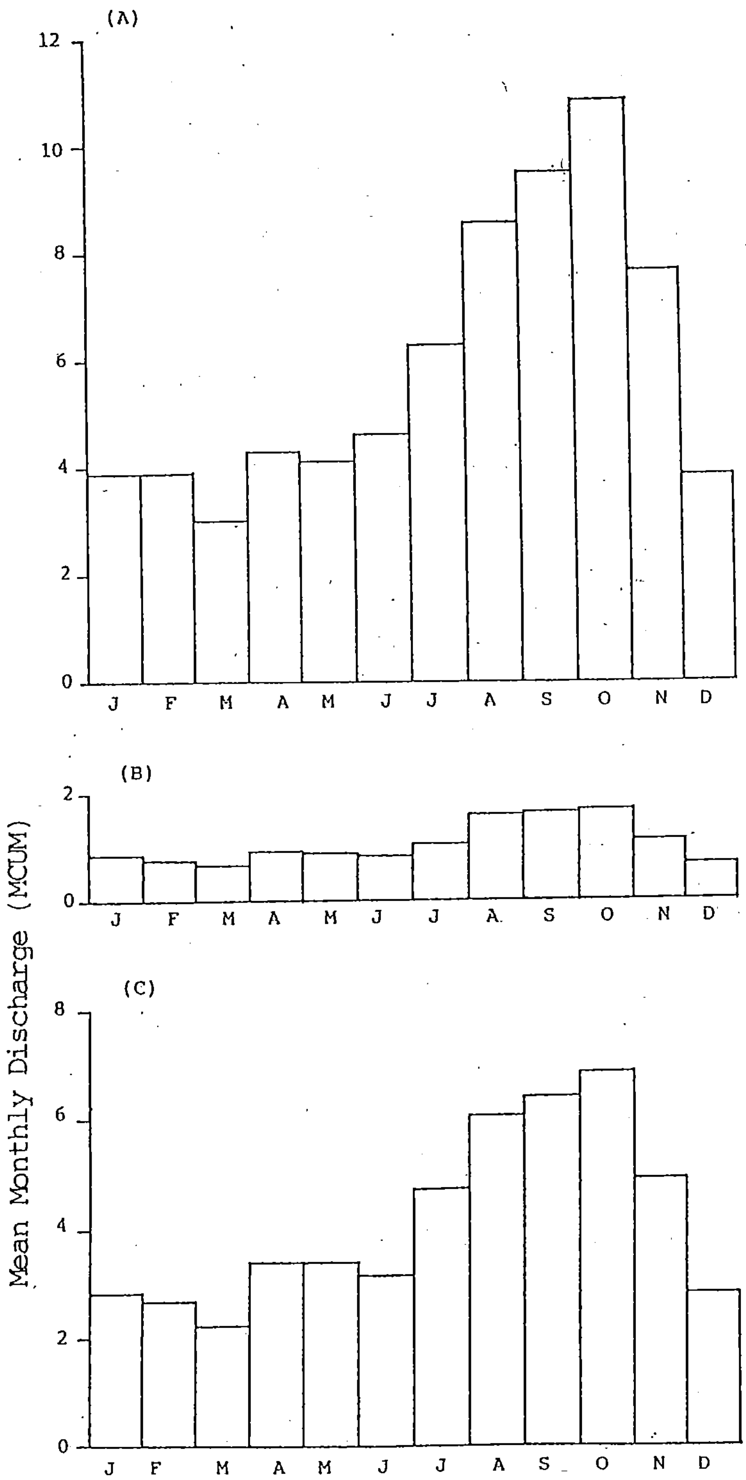


Fig 2. Mean monthly discharge data for three localities in the Naas–Gudgenby catchment. (A) Gudgenby River at Tennent, (B) River at Crossing, (C) Gudgenby River at Naas.

Table 1. Summary of water quality analyses of samples taken from the Gudgenby River at Tennent Gauging Station between 1/1/85 and 1/3/87. Data supplied by Hydrographics Section, Dept. Territories; units are mg l^{-1} unless specified otherwise.

PARAMETER	MINIMUM	MAXIMUM	MEAN
pH	7.7	8.3	8.1
Specific Conductance (uS/cm)	66.0	147.0	109.0
Apparent Colour (Pt-Co)	35.0	90.0	47.9
Turbidity (NTU)	1.1	13.0	4.3
Suspended Solids	0.9	8.6	2.6
Total Hardness	26.9	39.8	35.5
Calcium Hardness, as $CaCO_3$	17.1	22.8	20.9
Total Alkalinity, as $CaCO_3$	31.6	68.0	54.1
Dissolved Salts	79.1	115.7	104.4
Chloride	3.0	6.1	4.2
Fluoride	0.08	0.28	0.15
Sulphate	N.D	0.15	0.07
Calcium	6.88	9.16	8.41
Sodium	9.48	14.10	12.00
Potassium	1.03	1.75	1.37
Magnesium	2.40	4.13	3.55
Total Iron	0.51	1.09	0.80
Total Manganese	0.01	0.08	0.05
Total Phosphorus, as P	0.02	0.06	0.03
Nitrite & Nitrate	0.001	0.01	0.004
Kjeldahl Nitrogen	0.29	0.30	0.30
Chlorophyll a (ug/l), methanol method	0.70	1.80	1.08
Escherichia coli Density (no/100 ml)	16.0	430.0	156.6

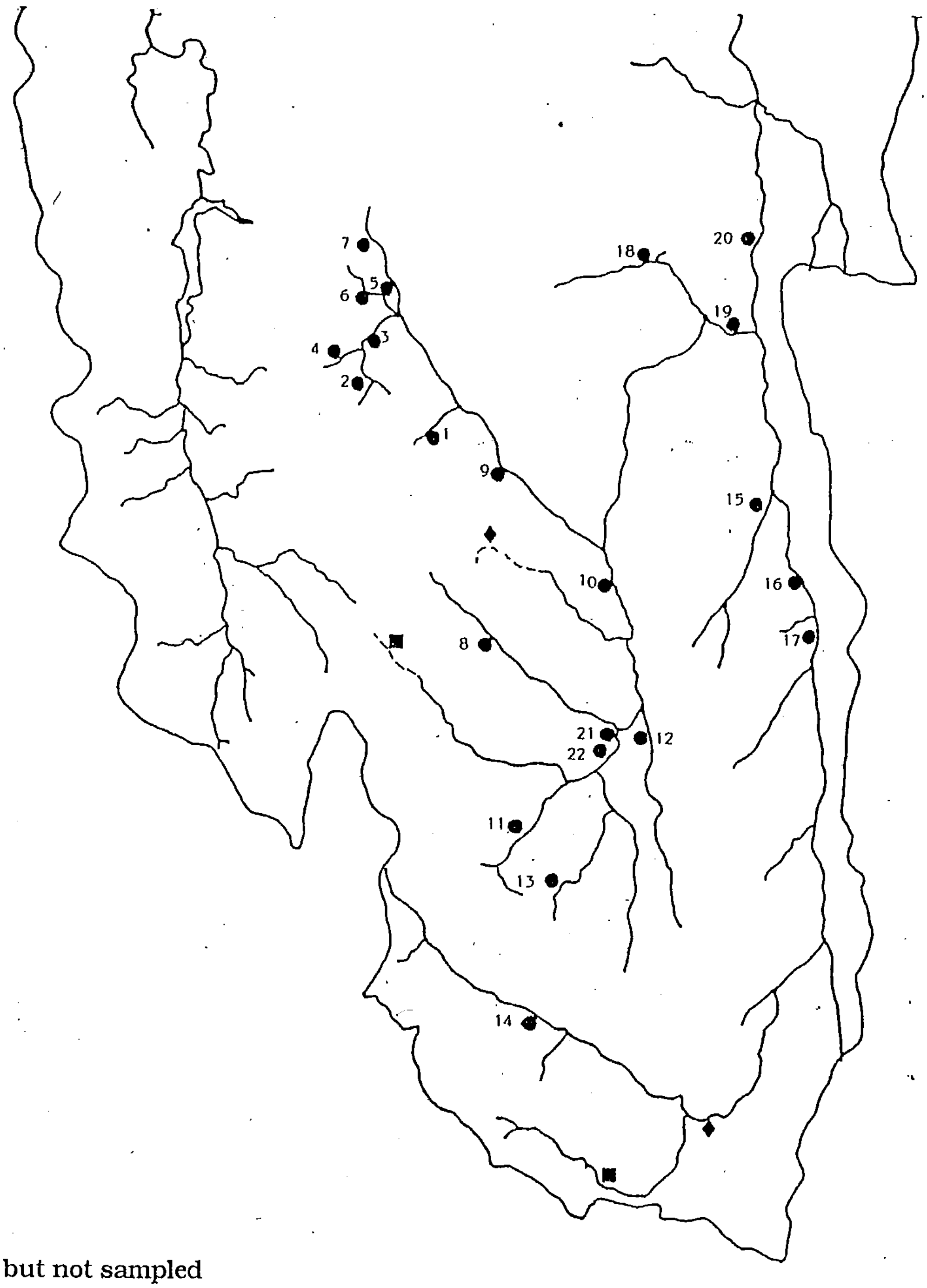
N.D., not detectable

whereas a mixture of savannah woodland (*E. pauciflora – E. stellulata*), tablelands grassland (*Poa* spp.) and fen alliance (*Carex gaudichaudiana*) is found in the higher valleys (NCDC 1984). These areas are conserved in Namadgi National Park except for the vegetational communities of the lower reaches of the catchment which have been highly modified by pastoral practices.

MATERIALS AND METHODS

Fish were collected at 22 stations throughout the Naas–Gudgenby catchment (Fig 3) between 12 December 1986 and 12 February 1987 either by using the chemical rotenone or by a combination of electrofishing and rotenone. Rotenone was added to the upstream end of a sampled stream section together with a fluorescent dye for marking. The oxidant potassium permanganate in crystal form was added to the water at a stop–net placed at the downstream end of the sampled section. A 240 V electrofisher was used for one run along a few of the stream sections. However, rotenone proved to be the most efficient sampling method (Appendix 1) and was used at all stations. Details of width, depth, current velocity, water temperature, substrate type, cover, riparian and aquatic vegetation, shade, length of stream sampled and the grid reference of each station were recorded. Cover refers to objects such as logs and boulders in addition to aquatic macrophytes and undercut banks, all of which provide shelter for fish. Shade was described by the presence of trees, shrubs, aquatic macrophytes and boulders. The gradient and stream order (Horton 1945 in Whitton 1975) for each station were determined from 1:25,000 topographic survey maps. Gradient was calculated by dividing the altitudinal difference between the nearest upstream and downstream contour intervals by the distance between them.

All sampled fish were taken to a laboratory where the length to the caudal fork (LCF) was measured to the nearest millimetre. Fish then were weighed on a Mettler P160 balance or, for fish over 150 g, a set of Salter T237 scales. Samples of all species were fixed in



● Sites

■ Observed but not sampled

◆ Previously sampled

Fig 3. Sites sampled or observed in the Naas-Gudgenby Survey.

10 per cent formalin for later stomach content analysis and scales and otoliths were taken for aging.

RESULTS

Site descriptions and length frequency distributions for fish species caught during the stream survey of the Naas-Gudgenby catchment have been described in detail (Jones, Rutzou and Kukolic 1990). Water temperatures varied greatly over the study period ranging from 12.5 °C in Sawpit Creek (Station 4) on 17 December 1986 to 31.0 °C in the Gudgenby River (station 20) on 9 February 1987.

Fish Distributions

Three fish species were found in the Naas-Gudgenby catchment: The mountain galaxias, rainbow trout and brown trout. The river blackfish, of which there are unconfirmed reports from the Naas-Gudgenby system (NCDC 1984), was not detected. Distribution of species varied with stream order (Table 2).

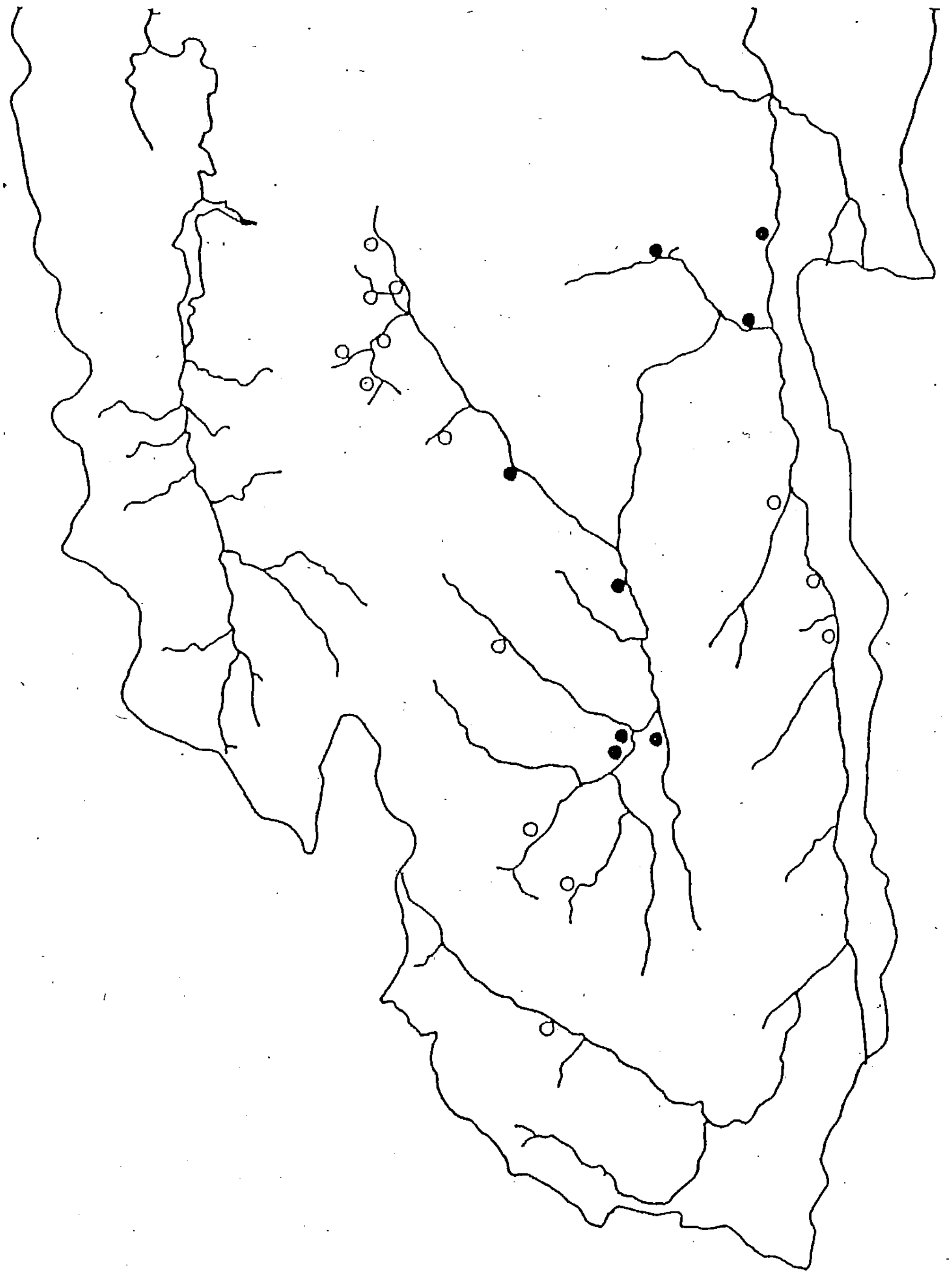
Salmo trutta.

Brown trout were confined principally to the main creek and river channels of the system except for the Naas River (Fig 4). These were primarily fourth and fifth order streams (Table 2).

Typically, brown trout inhabited the larger pool and riffle stretches with shingle or rock substrates. These areas were well-shaded by trees, shrubs and high, vertical or undercut banks and boulders. Good cover was available in most areas and was provided by boulders, debris and overhanging teatrees (*Leptospermum* sp.).

Table 2. Relationship between species and stream order. The number of stations sampled of each stream order are enclosed in parentheses.

SPECIES\ STREAM ORDER	2(1)	3(6)	4(6)	5(6)	6(3)
Galaxias	1	5	2	6	3
B. trout	0	0	2	3	3
R. trout	0	1	5	3	2



● Collected fish

○ Sampled but no fish

Fig 4. Sites at which brown trout (*Salmo trutta*) were present during the survey of the Naas–Gudgenby catchment.

Salmo gairdneri.

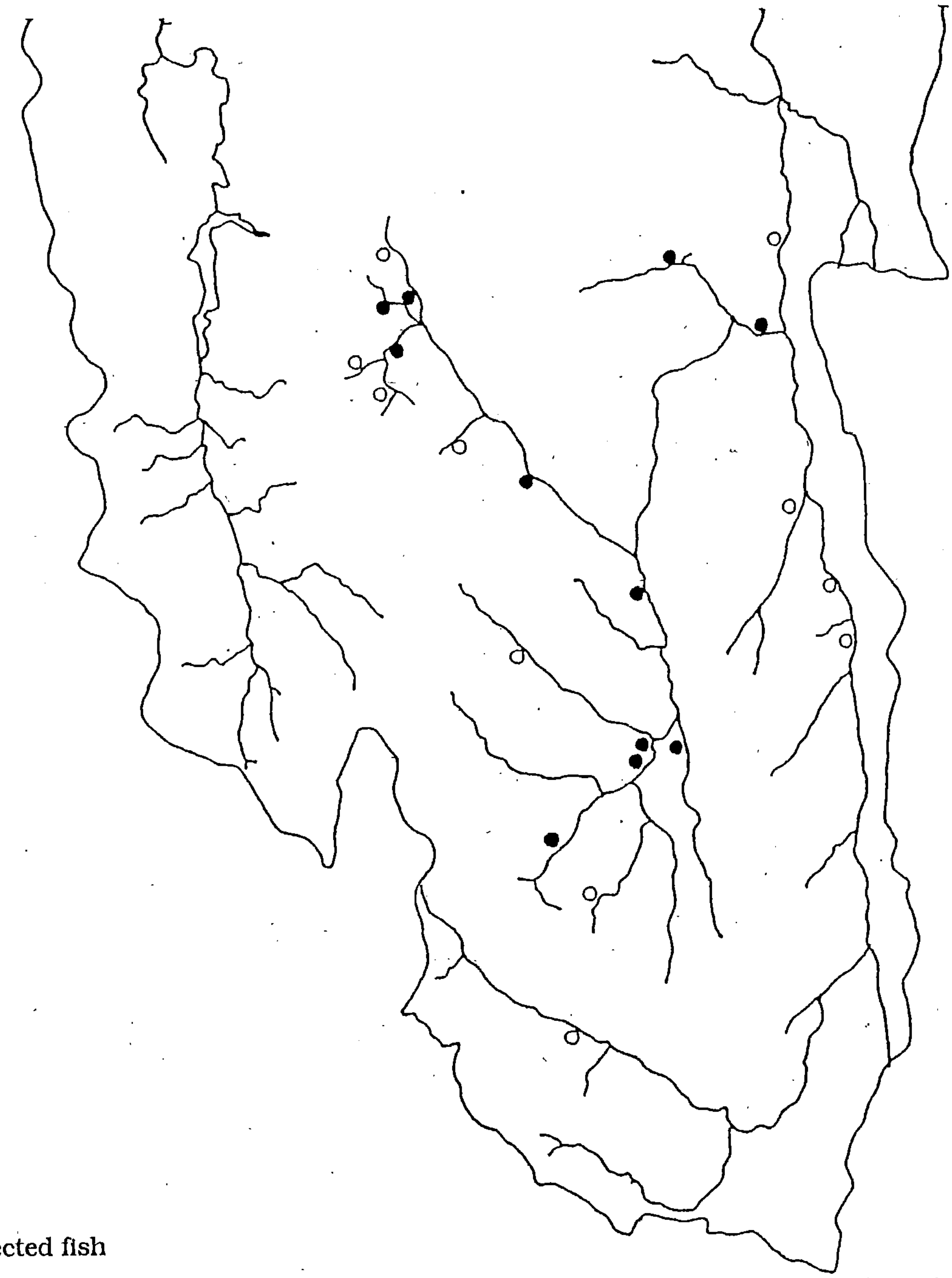
Rainbow trout were more widely distributed than brown trout (Fig 5, Table 2) extending further into the smaller reaches of the creeks and rivers. These narrow, shallow creeks with gravel bottoms and a moderate current were third, fourth and fifth order streams. Rainbow trout were sometimes the only species present (Table 3). The vertical, undercut banks were fringed with *Poa* tussocks and *Carex* which overhung the stream. Cover was relatively scarce and there was little aquatic vegetation. These streams flowed through open woodland, tussock grassland and fen which provided only a moderate amount of shade. Rainbow trout were slightly less abundant than brown trout in habitats where the two species coexisted. Two unidentified fish, possibly rainbow trout, were observed at stations 13 and 17.

Galaxias olidus.

Mountain galaxias have a widespread but fragmented distribution throughout the drainage system (Fig 6). They were present at 17 of the 22 survey stations (Table 3) and were most abundant in the smaller headwater streams and the minor tributaries.
The habitats where they occurred were of two major types:

1) Headwater streams which flowed through wet sclerophyll forest and were fringed with woolly teatree, *Leptospermum lanigerum*, which provided shade and good cover. Logs, detritus and boulders provided additional cover but there was little aquatic vegetation. Water velocity was moderate.

2) Standing pools which occurred as backwaters in creeks and in the main creek channels. Characteristically, these had abundant cover provided by aquatic macrophytes



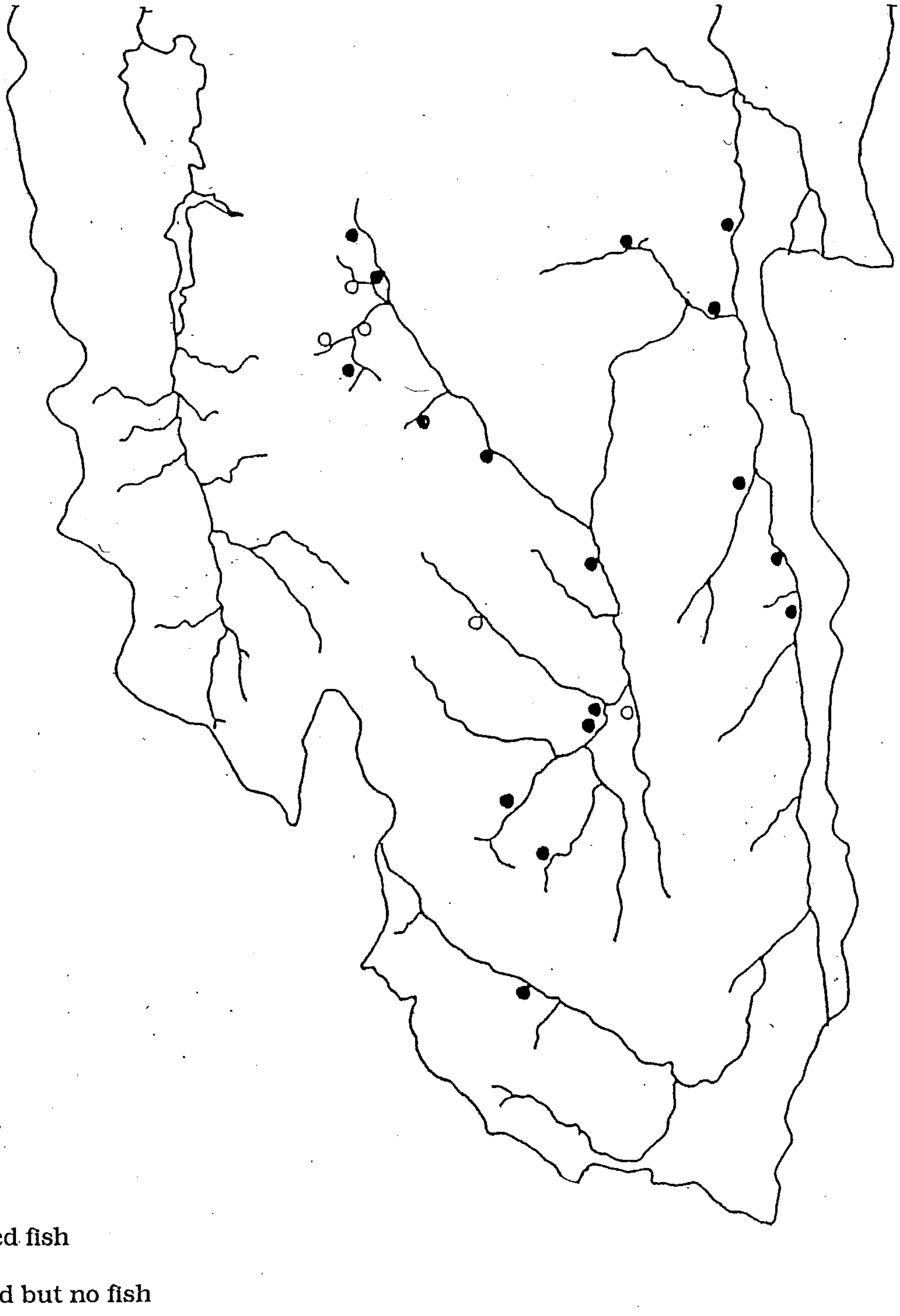
● Collected fish

○ Sampled but no fish

Fig 5. Sites at which rainbow trout (*Salmo gairdneri*) were present during the survey of the Naas–Gudgenby catchment.

Table 3. Summary of the distribution of fish species in the Gudgenby catchment.

SPECIES	STATION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	FREQ. OCCUR (%)
Galaxias	x	x			x		x		x	x	x		x	x	x	x	x	x	x	x	x	x	77
B. Trout									x	x		x						x	x	x	x	x	36
R. Trout			x		x	x		x	x	x	x	x						x	x		x		50



● Collected fish

○ Sampled but no fish

Fig 6. Sites at which galaxids (*Galaxias olidus*) were present during the survey of the Naas–Gudgenby catchment.

(esp. *Myriophyllum propinquum*), overhanging streamside vegetation (*Poa* and *Carex*) combined with undercut banks and sluggish water velocities.

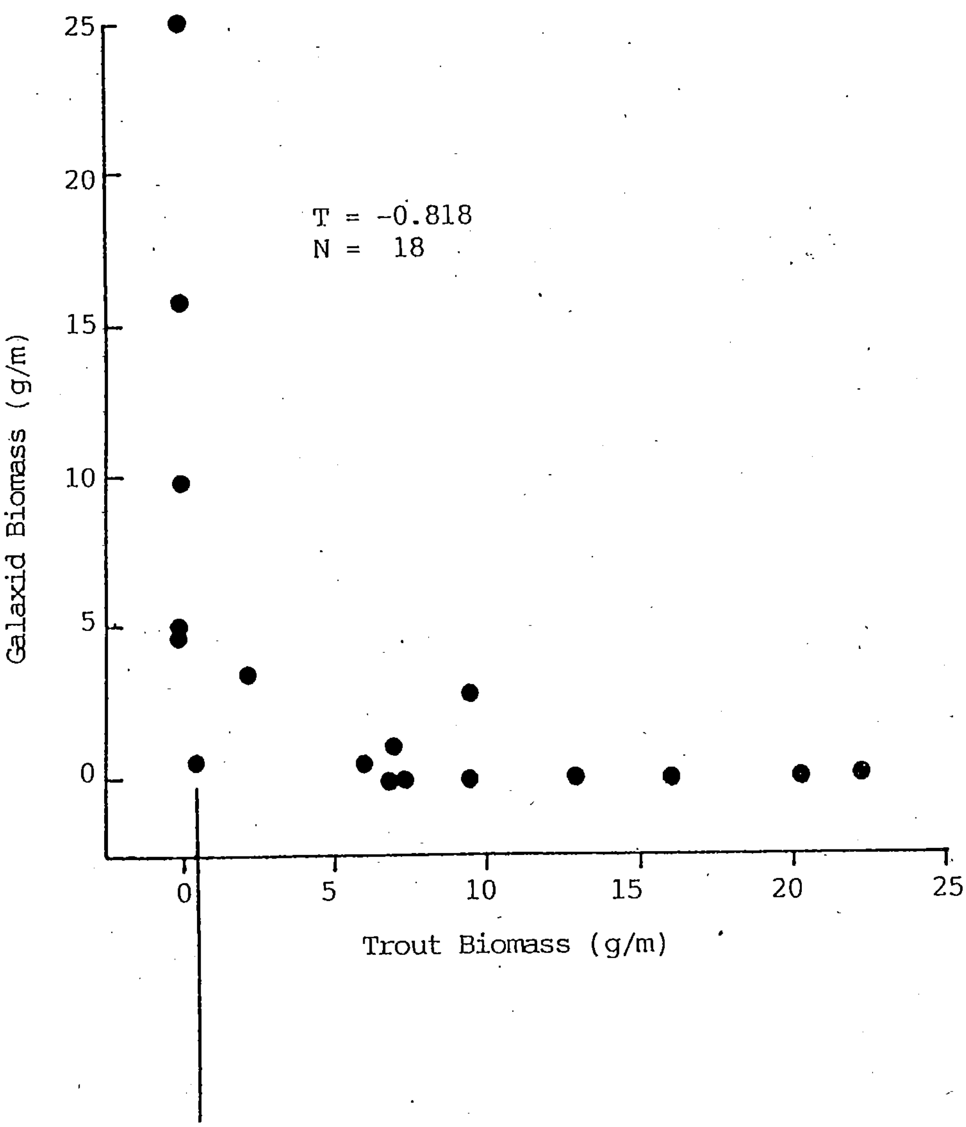
Galaxids, however, were found in a variety of habitats and must experience a broad spectrum of environmental conditions since they were found in both lotic and lentic conditions. An inverse relationship existed between the size of the galaxid and trout populations (Fig 7).

The galaxid population was extremely high in the Naas Creek (14.9 fish per metre) and trout were absent. The high galaxid density probably was due to the low water level forcing the galaxids to concentrate in the deeper sections of the creek.

DISCUSSION

As would be expected, a significant trend (Spearman's rank correlation coefficient, $r=0.433$, $P<0.05$) of increasing species richness with increasing stream order was observed (Fig 8).

An increase in habitat diversity with increasing stream size may result in reduced competition between species because of greater availability of refuges for galaxids. In some stream sections containing trout, galaxids were found at the edges among debris and overhanging teatree. Habitat partitioning was obvious at some stations (eg. station 11) in which galaxids were abundant in sluggish backwaters and the trout were confined to the flowing mainstream sections. The smaller streams with a simple community structure, such as the middle to upper section of the Orroral River and Rendezvous Creek, were inhabited only by rainbow trout. The absence of galaxids from this stream type may have been due to increased competition and greater predator/prey interactions in the less complex habitat (Gause 1935; Huffaker 1958). The adverse influence of trout on galaxid



Trout dying due to extreme water temperatures (31°C)

Fig 7. Relationship between trout and galaxid biomass in the Naas–Gudgenby catchment.

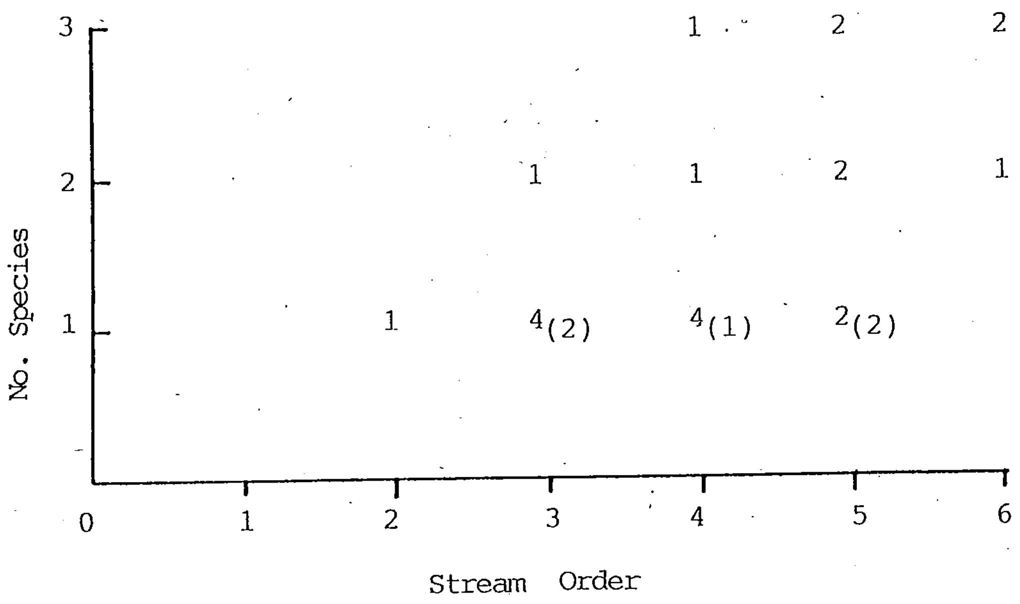


Fig 8. Relationship between species richness and stream size in the Naas-Gudgenby Catchment. (Numbers in brackets show sites with no flow at times of sampling).

populations is well documented (Frankenberg 1966; Tilzey 1976; Cadwallader 1979; Jackson and Williams 1980). The probable cause is the direct competition for food resources because of dietary overlap and behavioural similarities in feeding between young trout and galaxids (Cadwallader 1979; Jackson 1981). Predation by trout is also considered to be a major cause in the decline of galaxid populations in many areas as galaxids can be an important component of trout diets (Frankenberg 1966; Jackson 1981).

Physical factors such as high water temperatures and low dissolved oxygen levels are probably the major determinants limiting trout distribution in the system. Galaxids were abundant in the Naas River and especially in the Naas Creek, whereas trout were absent. This catchment is unsuitable for trout in the summer months because of the very low discharge and the large quantities of aquatic vegetation choking the channel. Decomposition of large amounts of aquatic macrophytes in late autumn is likely to create additional stress by reducing dissolved oxygen levels. In the lower reaches of the Gudgenby River extremely high water temperatures would cause high trout mortality. Several dead brown trout were collected at station 20 during a period when the water temperature was very high (31°C) but healthy individuals also were collected. The upper lethal limit for this species is 25.3°C for periods up to 7 days (Frost and Brown 1967). Trout may withstand temperatures in excess of this limit if the temperature falls below 21°C for several hours at night (*ibid.*; Weatherley, unpubl.).

Brown trout occurred only in the larger main channels. Egglishaw and Shackley (1982) found a positive correlation between brown trout density and stream depth. Cadwallader (1979) noted that this species typically occupied the main channel of the Seven Creeks system in Victoria.

The impermanency of many of the streams in the catchment may be a factor restricting the distribution of trout within the system (Weatherley, unpubl.). Galaxids appear to be better adapted to drought conditions (Merrick and Schmida 1984) and may survive in refuge areas in these streams.

River blackfish prefer clear, flowing streams with abundant cover such as logs, boulders and undercut banks (Cadwallader and Backhouse, 1983). Jackson (1978) found blackfish only in flat (mean depth 40–80 cm) and pool (mean depth 80–140 cm) water types with mean current velocities of 10–60 cm sec^{-1} and a negative correlation of blackfish with increasing current velocity. This type of habitat occurs in the main channel of the Gudgenby River and the lower reaches of the Orroral River, though no blackfish were detected in these areas.

RECOMMENDATIONS FOR FURTHER WORK

The present study describes basic distributions of the three fish species identified in the system. It requires several follow-up studies to clarify the reasons for the distributional patterns and how the fish species may be affected by land management actions/practices. Studies needed include:

1. Examination of the stream zones where trout and galaxids coexist and where trout are not found.
   - Does the zone move seasonally or between years?
   - What habitat characteristics permit co-existence?
   - What prevents trout from moving further upstream?

2. More detailed survey of streams to locate possible sub-populations of other species, eg. river blackfish.

ACKNOWLEDGEMENTS

This work is the result of earlier stream fish survey planning by Kruno Kukolic. The assistance of Jenny Lawrence with the subsequent initiation of this study is appreciated. Dr Mike Braysher commented on earlier drafts of the manuscript and Dr Keith Williams edited and finalised the report. Roslyn Saillard and Craig McArthur prepared the figures and assisted with the preparation of the report.

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APPENDIX I

Before a comparison of the population densities between sampling stations could be made it was necessary to estimate

i) the efficiency of each of the sampling methods and

ii) the variation between streams in the efficiency of each sampling technique.

Efficiency is defined as the proportion of the absolute population collected by the sampling method.

The upstream and downstream boundaries of the sampling station were blocked by seine nets. The station was first sampled by electrofishing and all fish returned to the stream after fin clipping. The stream was sampled again by rotenone poisoning. The number of fish marked and released (n), the number of recaptured fish (r) and the total number of fish in the sample (a) were recorded.

The simple Lincoln Index was used to estimate the total population P within the enclosed length of stream (Southwood 1966, p. 78):

$$P = a.n/r$$

The efficiency E of each method was calculated as:

E = (no. fish captured by each method) x 100/P

Station 3 - Lower Sawpit Creek

a = 3 n = 2 r = 2

P = 3x2/2 E (electrofishing) = 66.7%

= 3 E (rotenone) = 100%

Station 5 - Booroomba Creek

a = 29 n = 5 r = 5

P = 29x5/5 E (electrofishing) = 17.2%

= 29 E (rotenone) = 100%

The habitat characteristics of the streams at these two stations were very similar; both stations providing small amounts of cover. Rotenone poisoning collected all fish within the transect whereas electrofishing was less efficient. Electrofishing was an ineffective method for sampling small fish. At station 5, for example, 20 of the 29 fish were less than 100 mm LCF but all of the 5 fish caught by electrofishing were greater than 100 mm LCF. These results corroborate the findings of similar studies (Boccardy and Cooper 1963, Jacobs and Swink 1982).

The variation in the efficiency of the sampling methods between different stations was not examined due to the restricted amount of time available to carry out the survey. Boccardy and Cooper (1963) suggested that differences in the efficiency of capture at different stations were attributable to variations in the amount of cover. If this is the case then the efficiency of rotenone sampling may have been less than 100% at stations 2, 11, 14 and 22.