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AN EVALUATON OF THE RELATIVE SUCCESS OF NATURALIZED BROOK CHARR *Salvelinus fontinalis* (Mitchill), POPULATIONS IN SOUTH DUCK RIVER AND COWAN CREEK, DUCK MOUNTAIN REGION, MANITOBA

by

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The naturalized populations of brook charr, Salvelinus fontinalis in Cowan Creek and South Duck River, Manitoba showed markedly different densities. The streams are geologically similar, but the hydrological regime of Cowan Creek has been modified by beaver activity within the study area. The diets of the two populations were similar and the streams provided abundant invertebrate food resources. Cowan Creek fish, at lower density, grew faster and had a greater mean size than South Duck River fish. The differences in the two populations appeared to correlate with differences in winter conditions and beaver activity on the streams. The development of solidly frozen reaches of Cowan Creek with subsequent overflowing of its waters, sometimes out of the stream channel, could have had significant effects on the suitability of much of the stream for over-winter survival, limiting brook charr mainly to beaver ponds during winter. This ice condition was not common on most of South Duck River. Consequent effects on spawning and incubation success could explain the differences in density between the streams, as well as growth and size differences. Although both populations are marginally successful, successive cold dry winters could result in extirpation of either or both of them.

Keywords: population density; survival; introduced species.

RESUME

Franzin, W.G., and S.M. Harbicht. 1985. An evaluation of the relative success of naturalized brook charr, Salvelinus fontinalis (Mitchill), populations in South Duck River and Cowan Creek, Duck Mountain Region, Manitoba. Can. Tech. Rep. Fish. Aquat. Sci. 1370: iv + 21 p.

Les populations naturalisées d'omble de fontaine, Salvelinus fontinalis, dans le ruisseau Cowan et la rivière South Duck, au Manitoba, ont affiché des densités remarquablement distinctes. Les cours d'eau se ressemblent sur le plan géologique, mais le régime hydrologique du ruisseau Cowan a été modifié par les activités de castors dans la région étudiée. Les régimes alimentaires des deux populations étaient semblables et les cours d'eau offraient une source abondante de nourriture d'invertébrés. La population du ruisseau Cowan était moins dense que celle de la rivière South Duck mais les spécimens étudiés se développaient plus rapidement et avaient une dimension moyenne plus grande que ceux de la rivière South Duck. Les différences établies entre les deux populations semblaient liées aux écarts climatologiques hivernaux et aux activités des castors observé près des cours d'eau. Le gel solide de certains tronçons du ruisseau Cowan, accompagné du débordement des eaux qu'il entraîne, et ce parfois en dehors du lit du ruisseau, pourrait avoir contribué de façon déterminante à rendre le ruisseau sur une bonne partie de sa longueur plus ou moins apte à assurer la survie de l'omble fontaine pendant l'hiver, ce qui aurait pour effet de la confiner principalement aux étangs de castor pendant les mois d'hiver. Cette accumulation de glace n'a pas été observée sur l'ensemble de la rivière South Duck. Les incidences de ces conditions sur le taux de succès de la fraye et de l'incubation pourraient expliquer les différences de densité constatées entre les populations des deux cours d'eau; il en est de même pour les différences de croissance et de dimension. Bien que les deux populations ont un taux de succès marginal, des hivers froids et secs répétés pourraient entraîner la disparition de l'une des populations ou des deux.

Mots-clés: densité de population; survie; espèces introduites.

INTRODUCTION

Brook charr, Salvelinus fontinalis (Mitchill), have been introduced into many small streams in the Manitoba escarpment to provide sportfishing opportunities. Some of these introductions have resulted in self-sustaining naturalized populations. In this study, the naturalized brook charr populations inhabiting South Duck River and Cowan Creek, two small spring-fed streams that drain heavily forested eastern slopes of the Duck Mountains (Fig. 1) were investigated. Although brook charr have been introduced into apparently satisfactory habitats in all three of the large hilly areas forming the Manitoba escarpment, as well as elsewhere on the Prairies, (MacCrimmon and Campbell 1969), the success of the introductions seldom has been evaluated. The populations reported on in this paper are near the northern limits of introduced brook charr populations. Cowan Creek and South Duck River were stocked mainly with fingerling brook charr during the years 1961-1973 (Table 1). No further stocking took place from 1973 up to and including the time of this work. The purpose of this study was to determine the relative success of these two populations and the degree of similarity of their responses to the rigorous and outwardly similar environments of the two streams.

MATERIALS AND METHODS

Fish populations of the streams were sampled with backpack electroshocker, seines, dipnets, gillnets and by angling. In both streams, the electroshocker was most effective except in beaver ponds where gillnets and angling were most successful. Dipnets and seines were useful only minimally in riffles and small pools.

Cowan Creek and South Duck River fishes were sampled throughout the open water season of 1980 but only during July of 1981. All species of fish caught were identified and their capture locations recorded. All brook charr were measured in fork length, weighed, sexed and sampled for otoliths, pectoral fin rays, scales and their digestive tracts for later determination of age and diet respectively. Ovaries removed from mature female charr were preserved in Gilson's solution for fecundity analysis.

Stream temperatures were recorded during the entire study at two locations on South Duck River and three locations on Cowan Creek using Ryan submersible strip chart recorders.

RESULTS

Eleven species of fish were collected from 11 stations on Cowan Creek. Station locations are shown in Fig. 2. Details of species taken, by station, are shown in Table 2. The greatest numbers of species were taken at stations in the lower reaches of the stream (C5, C8, C10, C11) which mainly were slow moving run and pool habitats. The upper reaches (C1, C2, C3, C4) contained mainly brook charr and occasionally mottled sculpin (Cottus bairdi), brook stickleback (Culaea inconstans) and blacknose dace (Rhinichthys atratulus) (Table 2). Beaver ponds, which were common in Cowan Creek, (C6, C7, C8, C9) yielded only brook charr in gillnet and angler catches but probably harboured a few of the small species of fishes as well. Brook charr were found at all but the two lowest stations (C10, C11) which were channelized areas of the stream.

Table 3 shows the numbers of each of the four species of fish captured at seven locations on South Duck River (Fig. 3). In addition one white sucker (Catostomus commersoni) was sighted but not captured at station SD6. Brook charr were collected at all seven stations on South Duck River.

The segment of South Duck River that was sampled, by habitat and stream characteristics, compared with only a portion of the habitat sampled on Cowan Creek. The portion of South Duck River between SD1 and SD7 was more or less comparable to the portion of Cowan Creek between C1 and a point between C4 and C5. On the other hand, there was far less beaver activity on the portion of South Duck River sampled than in the sampling area of Cowan Creek. These two factors doubtless affected the distribution of brook charr in the two streams as well as the fish communities in general.

The presence of groundwater flow into the streams probably was an important regulator of water temperature in both streams. Examples of the temperature regimes recorded in the two streams are shown in Fig. 4 (a and b). Both streams exhibited monthly mean temperatures below 1°C from November, 1980, to April, 1981, at all recorder stations. Monthly mean temperatures at C4 and SD3 correlated well ($R^2 = 0.99$) and analysis of variance comparing monthly means at these stations revealed almost no difference ($F = 0.12$, 1, 22 df). There were similar and parallel differences in seasonal warming and cooling at different elevations in the two streams (Fig. 4a,b). It was suspected that water temperature might play an important role in the distribution of brook charr in the streams particularly in mid-summer and mid-winter. Observations of stream temperatures and habitat types were not sufficient to confirm or deny such a correlation. Additional information on habitats and temperature records at main stations are contained in Friesen et al. (1983).

These two populations were compared in terms of growth, age composition, reproduction, diet and relative density.

Growth: Tables 4 and 5 present data on length, weight and condition factor by sex and maturity status of 114 Cowan Creek and 399 South Duck River brook charr respectively. Condition factor was calculated from the formula

$$K = \frac{W \times 10^4}{L},$$

a multiple of Fulton's condition factor (Ricker 1975). Mean length of the sample of mature brook charr from Cowan Creek was greater (♀♀, 190.4 mm, ♂♂ 185.4 mm) than that of the South

Duck River charr (♀♀ 136.5 mm; ♂♂ 139.1 mm). Length frequencies of all brook charr collected are shown in Fig. 5. Length: weight relationships were calculated for the samples of all fish from each stream. Regression equations describing these relationships were for Cowan Creek charr; $Log_{10}W = 2.9702 (Log_{10}L) - 4.8567$ (Fig. 6) and for South Duck River charr; $Log_{10}W = 3.0458(Log_{10}L) - 5.0078$ (Fig. 7). Analysis of covariance of log length on log weight was significant both in terms of slope and intercept when all fish from each location were included in the analysis. However there were many more 0+ fish in the South Duck River sample than in the Cowan Creek sample. Removal of 0+ fish from both samples prior to analysis of covariance resulted in no significant difference between the samples, i.e. the length:weight relationships of the two populations were the same. The adjusted regression lines were: South Duck River; $Log_{10}W = 2.9930 (Log_{10}L) - 4.8952$ and Cowan Creek; $Log_{10}W = 2.9487 (Log_{10}L) - 4.8077$. All four regression lines fit the data very well; $R^2 \geq 0.98$. The growth in weight with increasing length of these fish compared favourably with computed relationships from other studies of non-anadromous brook charr populations (Fig. 8).

Scales provided the clearest indication of age in the two samples of brook charr. Some degree of validation of this method was provided by differences in length of fish as they progressed from 0+ to 1+. However no attempt was made to validate age of older fish by mark and recapture of individuals. Analysis of covariance of log length at scale age revealed that Cowan Creek brook charr grew significantly faster than South Duck River charr (Fig. 9) but factors such as sampling error, differences in stream habitat and population density may have contributed to this result, a point discussed later.

REPRODUCTION

Both populations apparently have reproduced successfully in recent years as indicated by the age structure of our samples (Fig. 10). Spawning was observed in both streams in late September, 1980 by which stream temperatures had fallen to the 5-10°C range. Two spawning areas were located on Cowan Creek; one just upstream of a beaver pond at C1 and one just upstream of undercut bank pools near C4. Spawning charr were located in South Duck River in only one area; in riffles and at the shallow upstream ends of pools near SD1. In all cases the redds were located in sand to gravel substrates. Estimates of fecundity were obtained from egg counts of thirty-one Cowan Creek and six South Duck River brook charr respectively (Table 6).

Ripe Cowan Creek females ranged in scale age from 2+ to 3+ and in fork length from 155 to 284 mm with egg counts in the range 190 to 1348. South Duck River females ranged in scale age from 1+ to 2+ and in fork length from 148 to 195 mm with egg counts in the range 132 to 430. Two individuals, one from each stream, apparently were partially spent when captured and fell well outside of a regression of egg number on fork length for the combined data of both samples (Fig. 11). The data were combined because of the small numbers of South Duck River samples and their apparent fit into the scatter of the Cowan Creek sample. The combined fecundity curve compared well with that of Allen (1956) for an introduced Wyoming mountain brook charr population but the Duck Mountain populations had lower fecundity in the smaller size classes than was found in Quebec lake populations (Vladykov 1956) or in native anadromous populations of the lower Nelson River area of Manitoba (Gaboury 1978).

DIET

Brook charr food habits were determined from examination of the preserved stomach contents taken from 109 Cowan Creek and 187 South Duck river specimens. These data are presented in terms of the importance of each order of organisms in the overall diet of the two populations (Fig. 12) as well the frequency of occurrence in fish stomachs of individual orders of food organisms (Fig. 13). Diptera and Trichoptera together accounted for more than 50% of the diet in both populations (Fig. 12) but their respective order of importance within that portion of the diet was reversed. The relative importance of other food groups did not differ markedly between the populations (Fig. 12). Empty stomachs were encountered infrequently and were not a significant factor in the analysis.

POPULATION DENSITIES

Relative population densities, provided by comparisons of catches per unit of electrofishing effort during the 1980 season (Table 7) indicated that brook charr were about one and a half times more abundant in riffle/pool areas of South Duck River than in similar areas of Cowan Creek. The data from electroshocking effort only were used as a basis for a reasonable comparison of densities because of gear selectivity of the fish habitat. This restriction in the comparison eliminated only 3% of brook charr captured in South Duck River but 31% of those captured in Cowan Creek where many charr (42) were collected by other types of gear. In comparable habitats (e.g. C4 and SD4) many more charr were collected in South Duck River than in Cowan Creek (Tables 2,3) suggesting that the differential found in electroshocker CPUE data was real. The total biomass of brook charr collected from the two streams was remarkably similar (SDR ≃ 10.5 kg; CC ≃ 8.5 kg) despite the large difference in numbers captured (SDR=399; CC=114).

DISCUSSION

The purpose of this investigation was to examine the relative success of brook charr in these two streams. If one defines success at the population level as the ability of a species to persist in space and time, then both populations are indeed successful; they have reproduced and become established in these streams since their introduction to them 10 to 20 years ago. However it is noteworthy that the response of brook charr to apparently similar summer habitats is quite different in terms of density and mean size. The winter environments of the two streams provide an answer to this. Cowan Creek, in winter, restricts fish primarily to beaver ponds due to the formation of large areas of ever-thickening ice and overflowing water in most of the riffle and pool areas. The complete filling of the stream bed with ice and a shift of stream water out of the channel was noted in some areas during the winter of 1980-81. An additional effect of this is to limit recruitment by freezing out any incubating eggs in many areas potentially suitable for spawning prior to ice formation. Those fish that remain in beaver ponds are able to take advantage of an abundant food supply come spring and renewal of a good supply of invertebrate drift and therefore grow very well. Large areas of ice-filled stream channel were not seen in South Duck River and presumably, therefore, many of the riffle/pool areas of the stream remained as suitable overwintering habitat. Many investigators have suggested that overwintering habitat is of critical importance to stream salmonids, replacing in importance summer competition for food and feeding position (Chapman 1966; Hunt 1969a; Glova and Mason 1977 and others). Brook charr, particularly the younger year classes, typically shelter under stones within the stream channel. Recent work (Rimmer et al. 1984) has shown that juvenile Atlantic salmon which seek similar types of shelter remain in these areas during winter. These authors suggest that this observation may be more generally applicable to juvenile stream dwelling salmonids. If this is true for brook charr, in small streams such as South Duck River and Cowan Creek, winters of extreme cold coupled with poor snow cover could cause severe mortality of brook charr overwintering in rocky pools and riffles. The winter of 1980-81 in this area was just such a winter and followed an unusually hot dry summer. The net effect of low fall flows from surface springs and thick ice formation was a catastrophic decline in the abundance of all year classes of brook charr in South Duck River by early 1981. Thus, even in these ideal summer feeding conditions, the winter environment appears to be a critical determinant of the survival of these populations. Several cold, unusually dry winters in succession possibly could eliminate either or both of these populations. Cowan Creek charr, which primarily survive winters in beaver ponds, still may suffer severe mortality of eggs and larvae in the redds located in riffle areas. It appears that there are few if any remedial measures that one could take to enhance survival of brook charr in these streams. The kinds of habitat improvements such as the addition of instream boulders or logs and artificial bank cover shown to increase numbers and biomass of brook charr (Hunt 1969b, 1971) and other salmonids (Gilbert 1978) probably would offer no amelioration of the combined effects of lowered stream discharge and cold, low snowfall winters. Given the vagarous climate that the Duck Mountain region experiences both in terms of summer and winter conditions of precipitation and temperature, one might expect to see reasonably strong fluctuations in abundance of individual year classes. The fact that the populations have persisted in both streams attests to the capacity of brook charr to occupy habitat unsuitable to many less adaptable species. However one could only describe the success of these populations of brook charr as marginal and the streams as near the limits of suitable habitat for this species.

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Table 1. Stocking records for brook charr introduced to Cowan Creek and South Duck River. Data from Annual Reports, Province of Manitoba, Departments of Mines and Natural Resources (to 1971); Mines, Resources and Environmental Management (1971-75).

	Cowan Creek	South Duck River
1961		8000F
62		
63		
64		
65		2000F
66	1000F*	1000F
67		
68		
69		
70		500F
71		
72	1000Y**	500F
73	2000Y	500F

* F = Fingerling
**Y = Yearling

Table 3. Relative abundances of fish species captured at stations on South Duck River during 1980-81.

Species	Station Number						
	SD1	SD2	SD3	SD4	SD5	SD6	SD7
Brook charr (*Salvelinus fontinalis*)	24	5	187	195	21	19	8
Brook stickleback (*Culaea inconstans*)		2					
Blacknose dace (*Rhinichthys atratulus*)		5	21	10			2
Longnose dace (*Rhinichthys cataractae*)				4			
White sucker (*Catostomus commersoni*)						*	
No. of species present	1	3	2	3	1	2	2

* = Visual observation

Table 2. Relative abundances of fish species captured at stations on Cowan Creek during 1980-81.

Species	Station Number										
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
White sucker (*Catostomus commersoni*)					25			41		1	5
Brook charr (*Salvelinus fontinalis*)	6	11	3	67	1	3	24	12	1		
Creek chub (*Semotilus atromaculatus*)					13			16		31	14
Blacknose dace (*Rhinichthys atratulus*)				9	28			25			11
Pearl dace (*Semotilus margarita*)					1			4			
Finescale dace (*Phoxinus neogaeus*)								5			
Longnose dace (*Rhinichthys cataractae*)					10						
Fathead minnow (*Pimephales promelas*)					4			1			1
Brook stickleback (*Culaea inconstans*)				2	1					3	6
Mottled sculpin (*Cottus bairdi*)			2	6	5						
Johnny darter (*Etheostoma nigrum*)								5			
No. of species present	1	1	2	4	9	1	1	8	1	3	5

Table 4. Length, weight and condition of Cowan Creek brook charr 1980-81.

Sex	N	Fork length (mm)				Weight (g)				K Fact	
		Mean	Min	Max	SD	Mean	Min	Max	SD	Mean	SD
Immature	26	73.7	49.0	108.0	15.4	5.5	1.2	15.0	3.6	0.1223	0.0112
Female	54	190.4	93.0	284.0	53.4	97.3	9.1	262.0	64.9	0.1165	0.0120
Male	34	185.4	110.0	284.0	45.0	92.6	16.6	281.8	64.4	0.1259	0.0146
Total*	114	162.3	49.0	284.0	65.8	75.0	1.2	281.8	68.1	0.1206	0.0132

Total* = Females + Males + Immatures
SD = Standard deviation

Table 5. Length, weight and condition of South Duck River brook charr in 1980-81.

Sex	N	Fork Length (mm)				Weight (g)				K Factor	
		Mean	Min	Max	SD	Mean	Min	Max	SD	Mean	SD
Immature	151	79.6	45.0	136.0	23.5	8.1	0.9	34.3	7.1	0.1217	0.0131
Female	155	136.5	61.0	220.0	32.3	36.4	2.9	147.2	26.9	0.1214	0.0127
Male	93	139.1	61.0	237.0	31.8	38.9	2.8	146.8	27.9	0.1252	0.0106
Total*	399	115.6	45.0	237.0	40.5	26.2	0.9	147.2	26.1	0.1224	0.0125

* = Males and Females and Immatures
SD = Standard deviation

Table 6. Fecundity of brook charr from South Duck River and Cowan Creek in fall 1980 by intervals of length frequency.

Location	Fork Length (mm) Intervals	No.	Range	Mean No. of Eggs	SD
South Duck River	141 - 160	2	145- 230	188	60.1
	161 - 180	1	430	430	-
	181 - 200	2	334- 429	382	67.2
Cowan Creek	141 - 160	1	190	190	-
	161 - 180	3	331- 489	390	86.0
	181 - 200	4	433- 739	546	139.8
	201 - 220	3	598- 808	738	121.2
	221 - 240	8	686-1014	806	104.3
	241 - 260	9	725-1321	966	212.2
	261 - 280	1	1157	1157	-
	281 - 300	1	1348	1348	-

SD = Standard deviation

Table 7. Electroshocking catch per unit of effort (CPUE) in riffle and pool areas only of South Duck River and Cowan Creek in 1980.

	Catch	Shocking Time (min)	CPUE
South Duck River	316 (97%)	284	0.899 (53.9/h)
Cowan Creek	78 (68%)	135	0.578 (34.7/h)

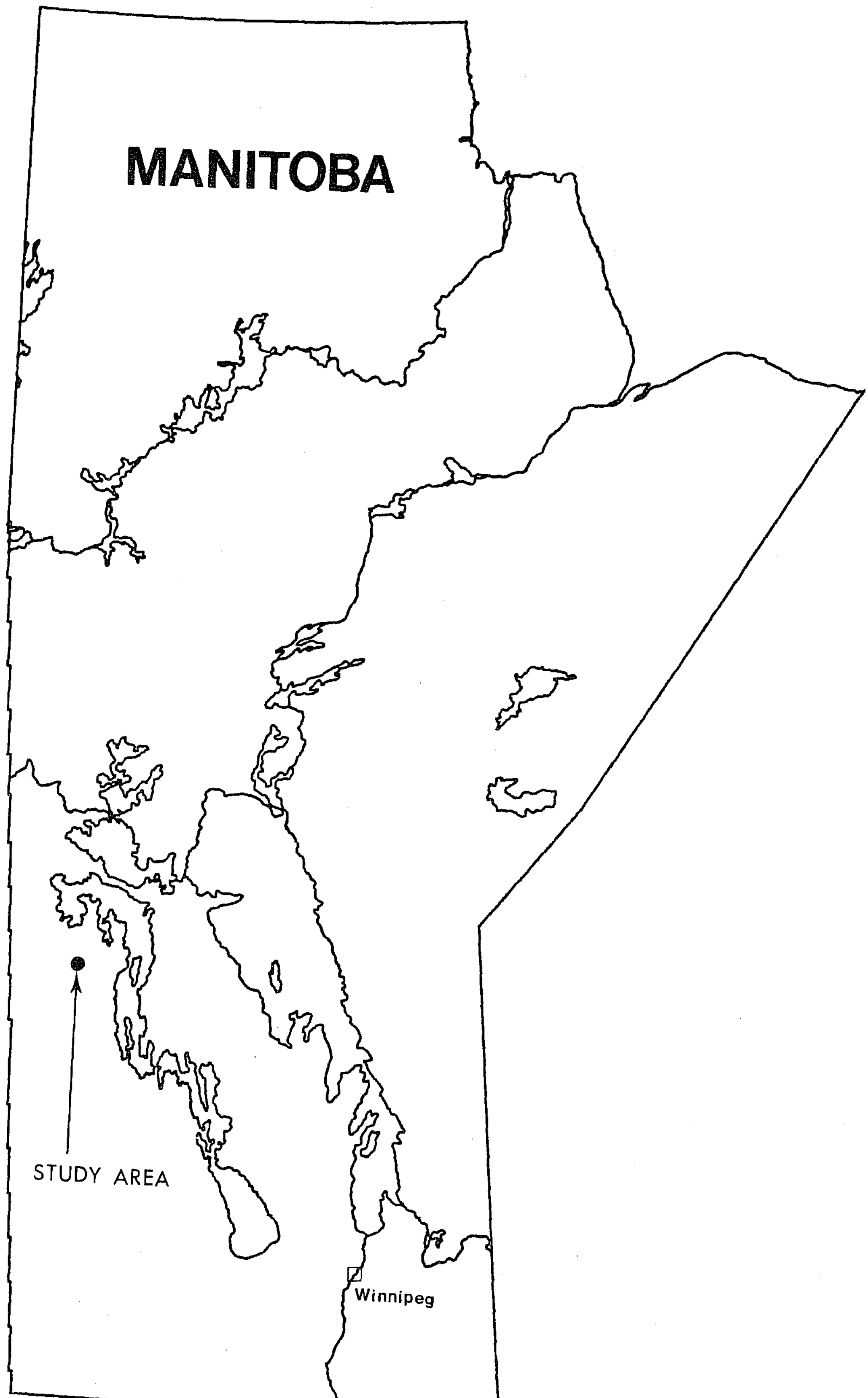


Fig. 1. Map showing location of the study area.

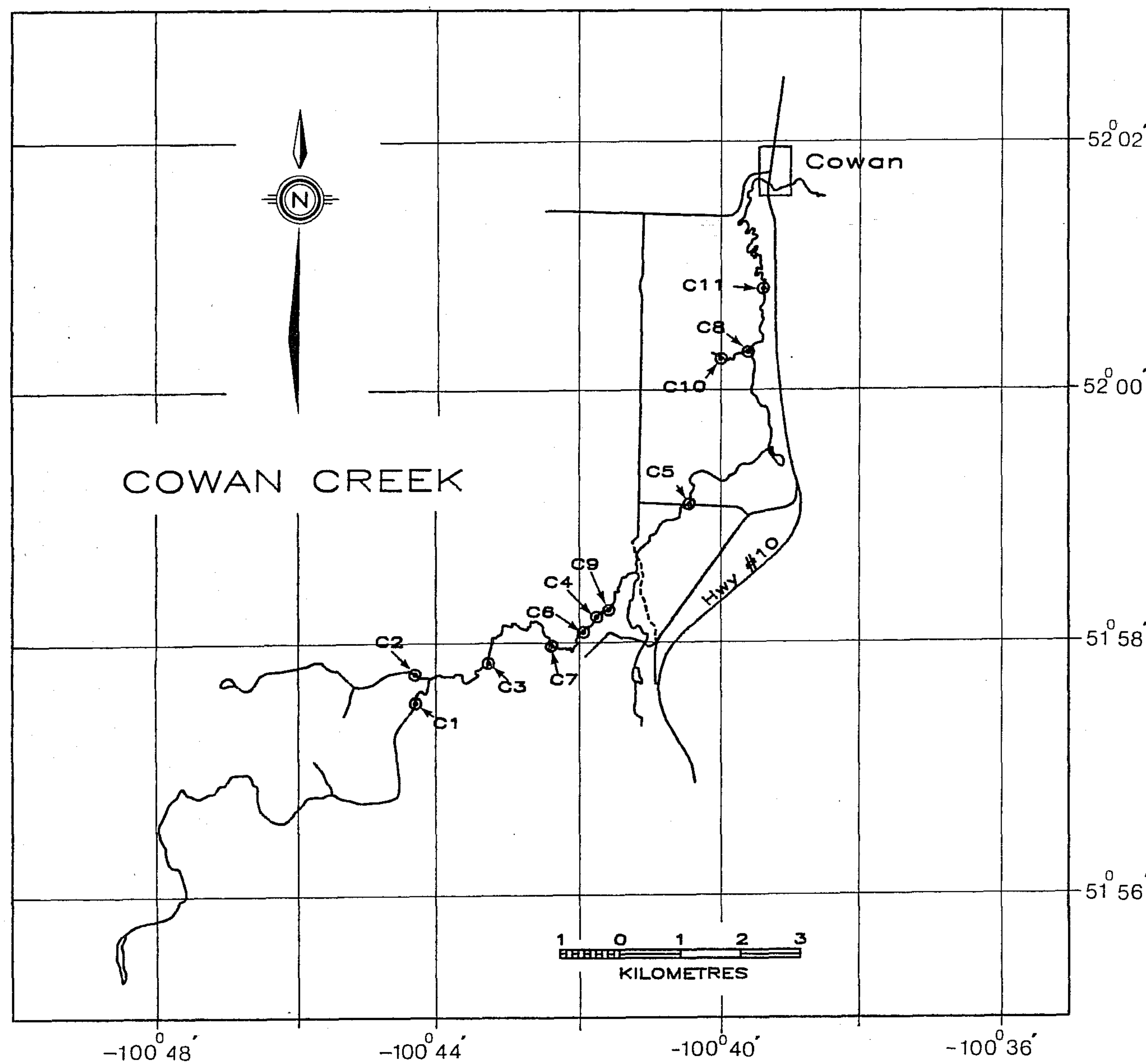


Fig. 2. Map showing the location of sampling stations on Cowan Creek.

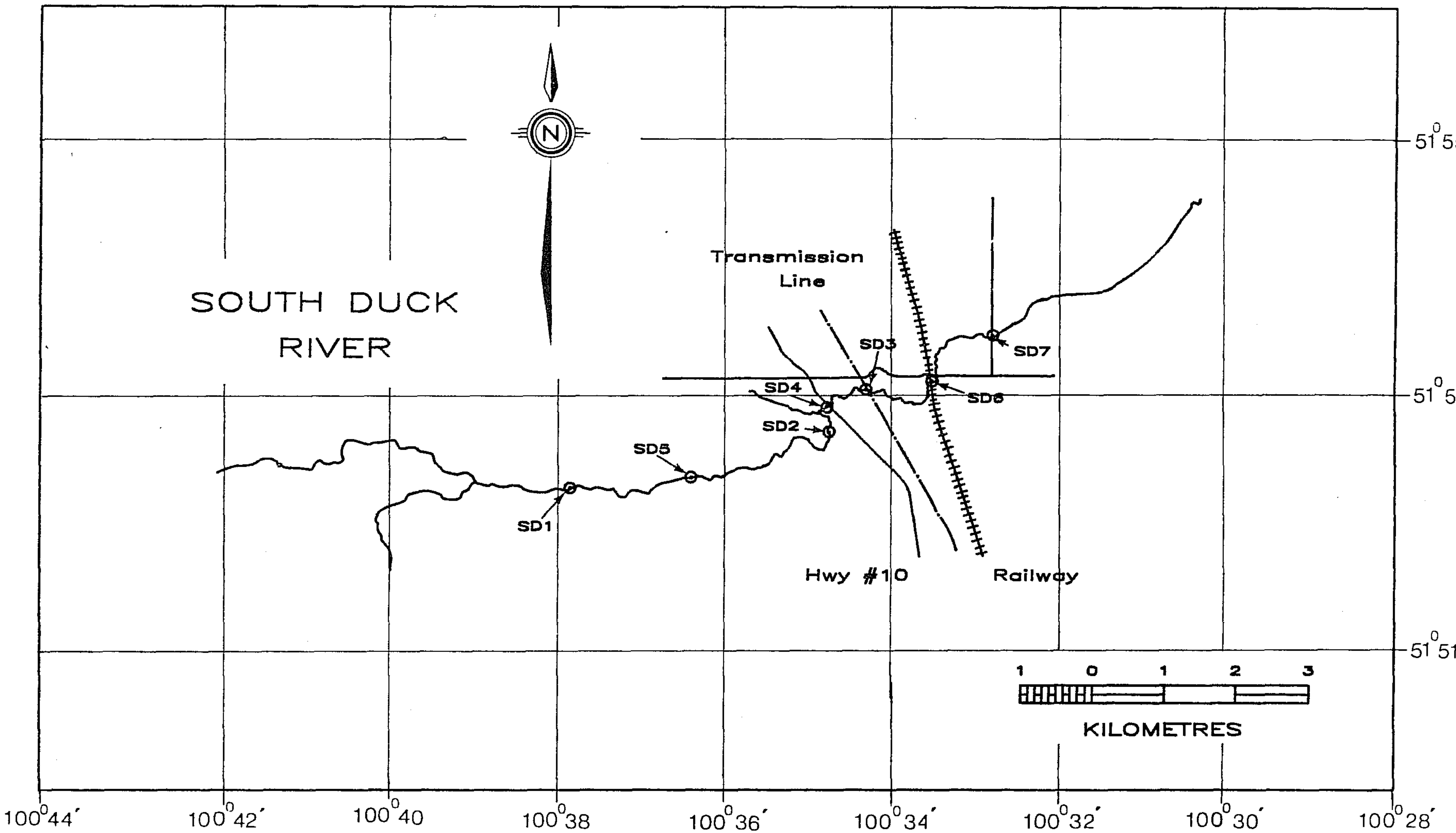


Fig. 3. Map showing the locations of sampling stations on South Duck River.

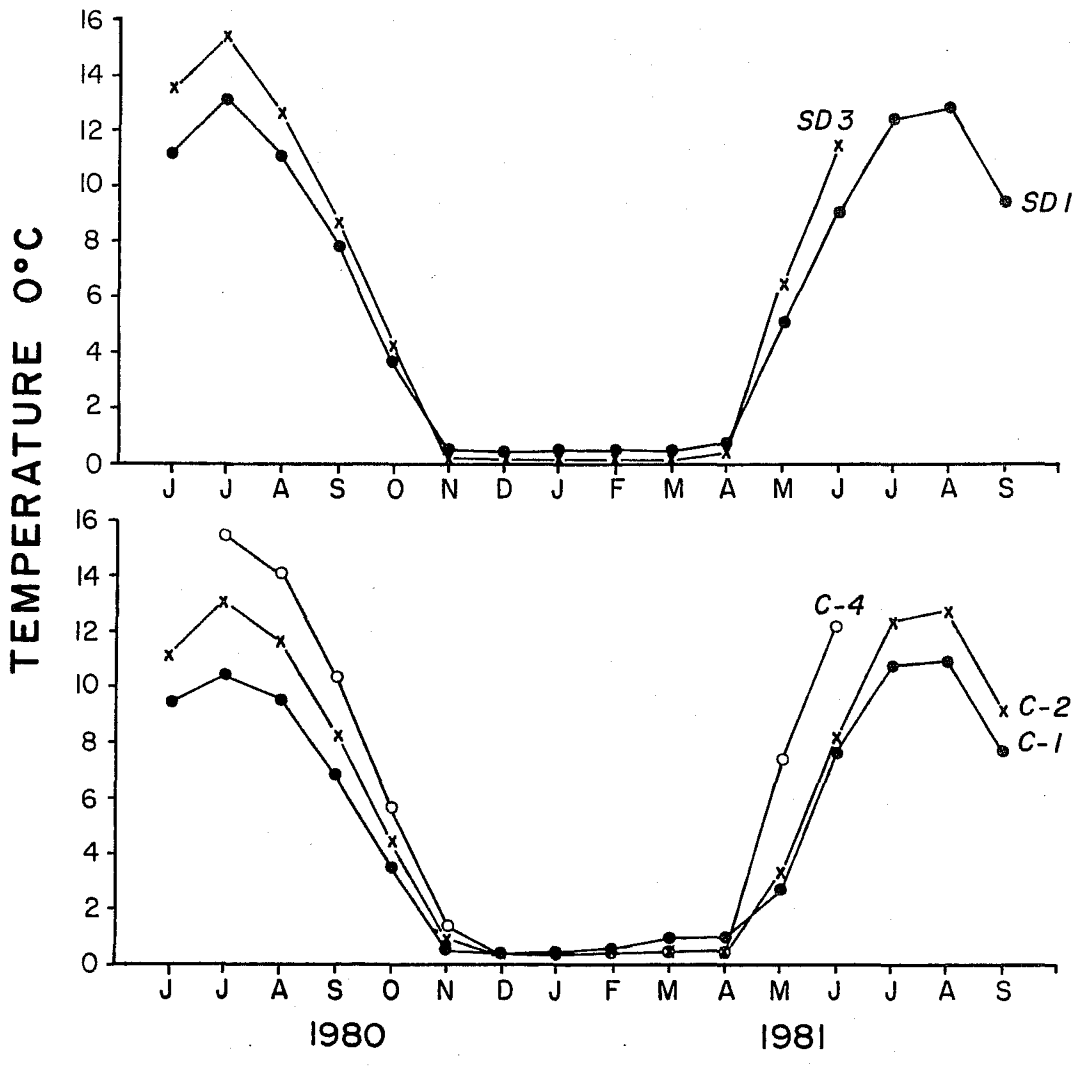


Fig. 4a. Records of monthly mean temperatures for stations SD1 and SD3, South Duck River, 1980-81.

4b. Records of monthly mean temperatures for stations C1, C2 and C4, Cowan Creek, 1980-81.

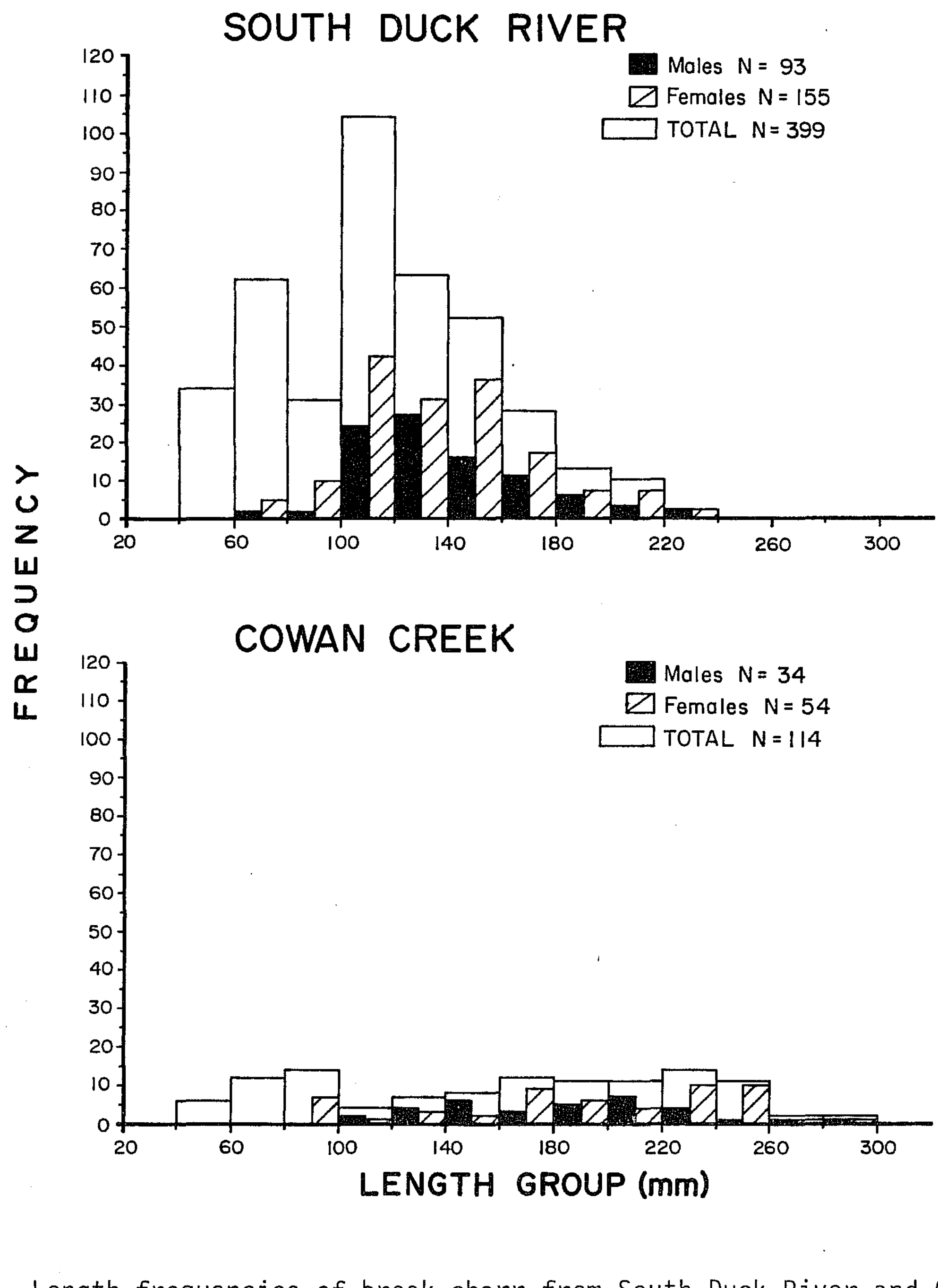


Fig. 5. Length frequencies of brook charr from South Duck River and Cowan Creek 1980-81. Totals include 151 and 26 fish respectively of undetermined sex.

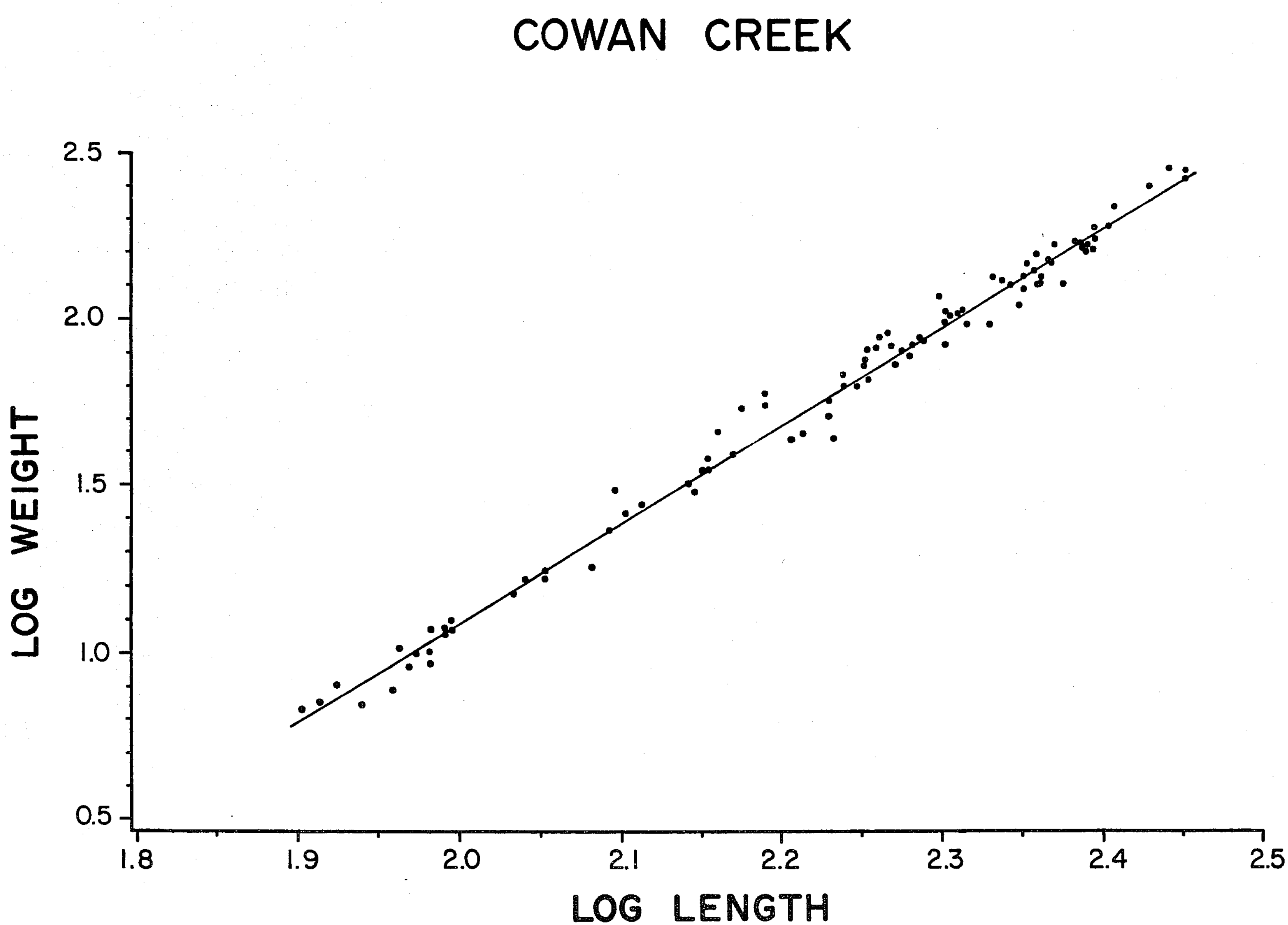


Fig. 6. Regression of log weight on log length for Cowan Creek brook charr in 1980-81.

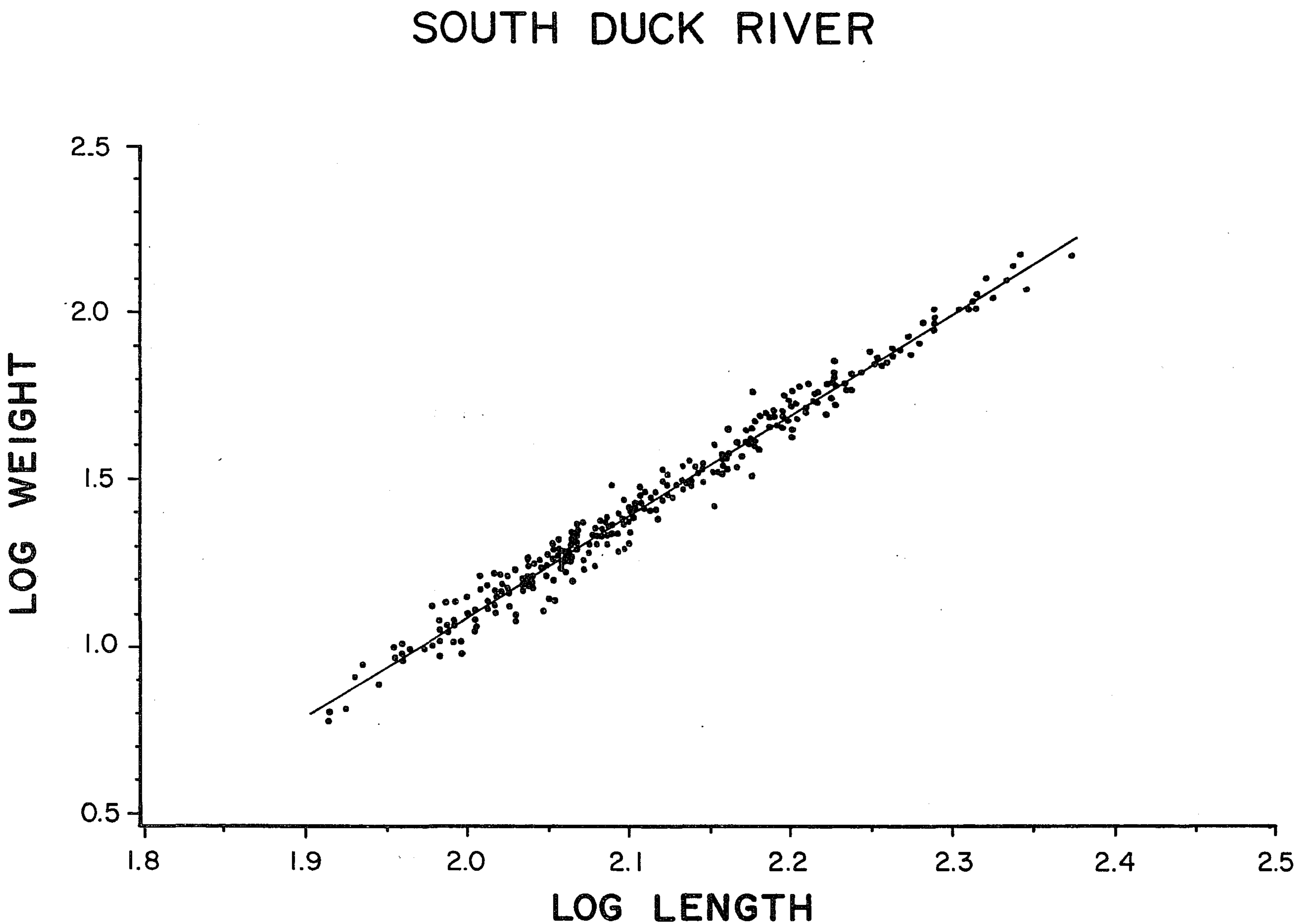


Fig. 7. Regression of log weight on log length for South Duck River brook charr in 1980-81.

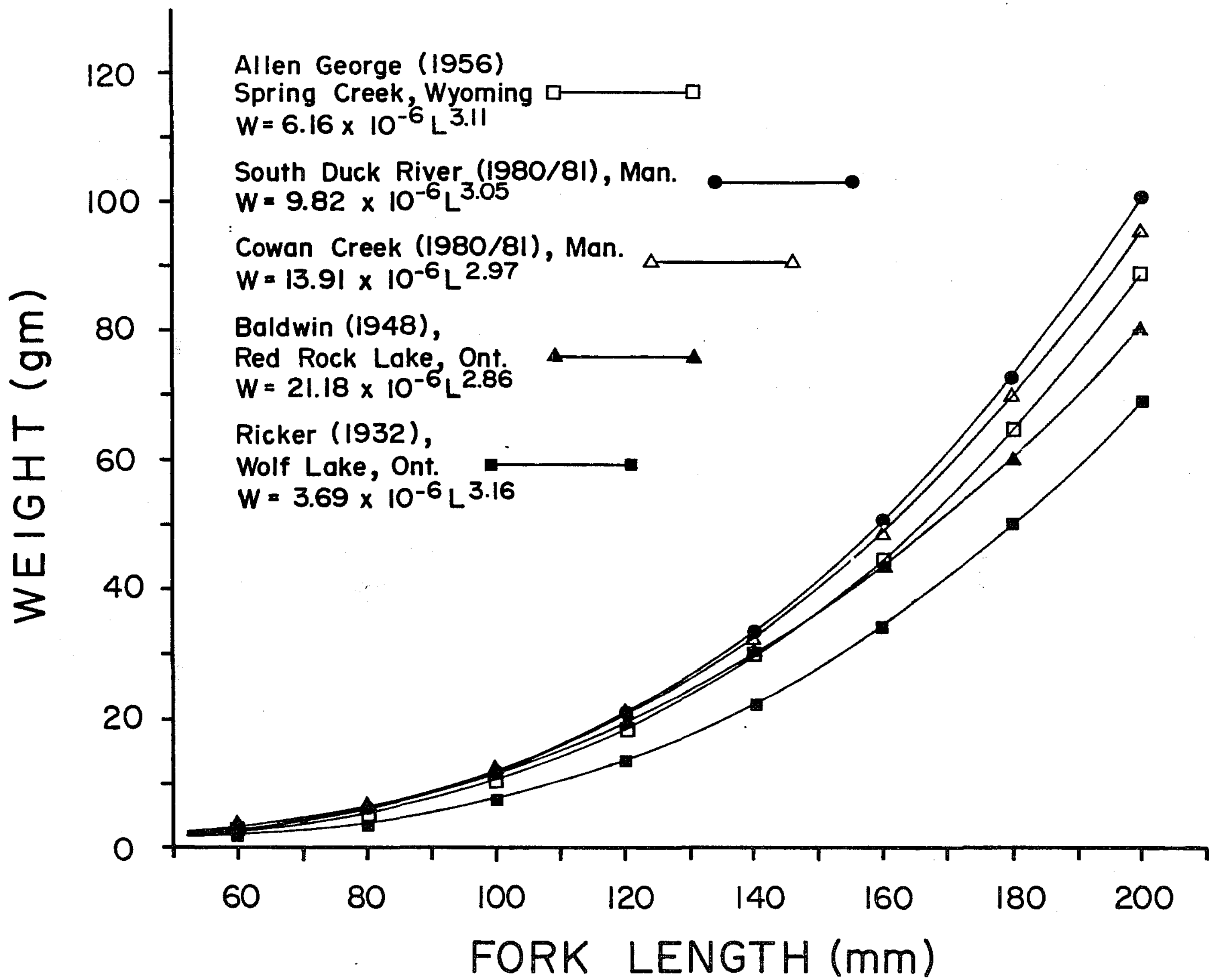
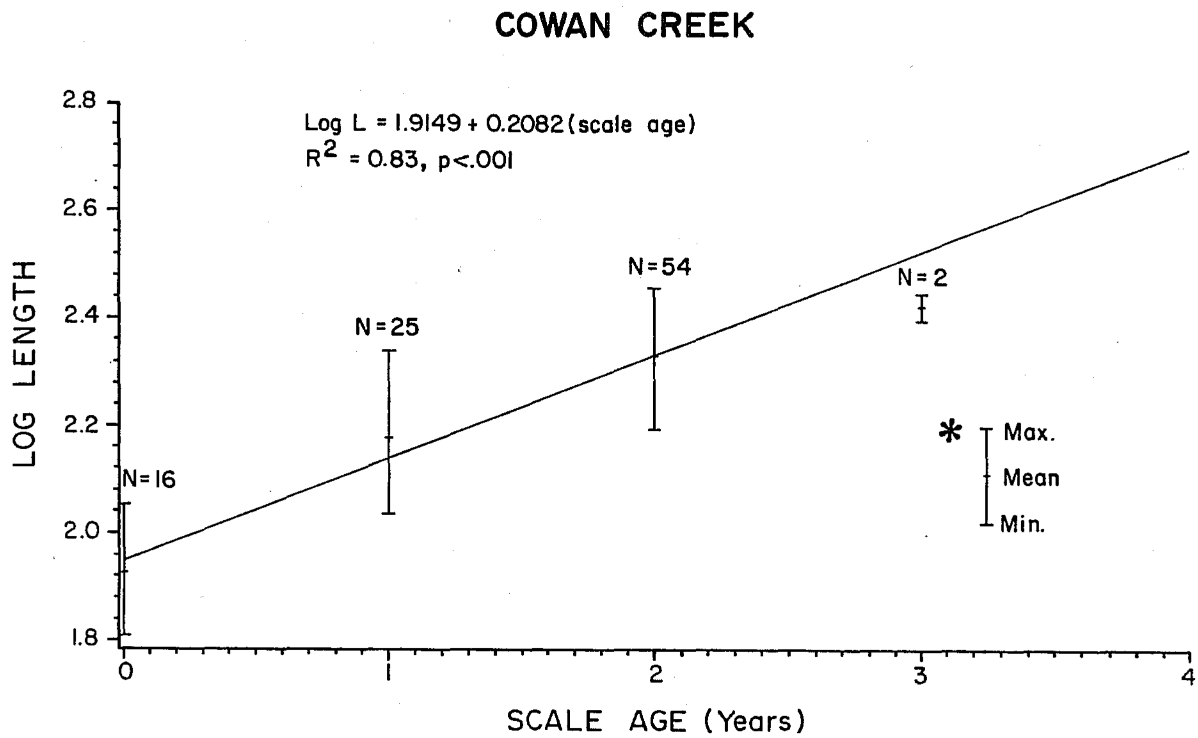


Fig. 8. Comparison of length:weight relationships for brook charr from South Duck River and Cowan Creek with Wyoming and Ontario Populations.



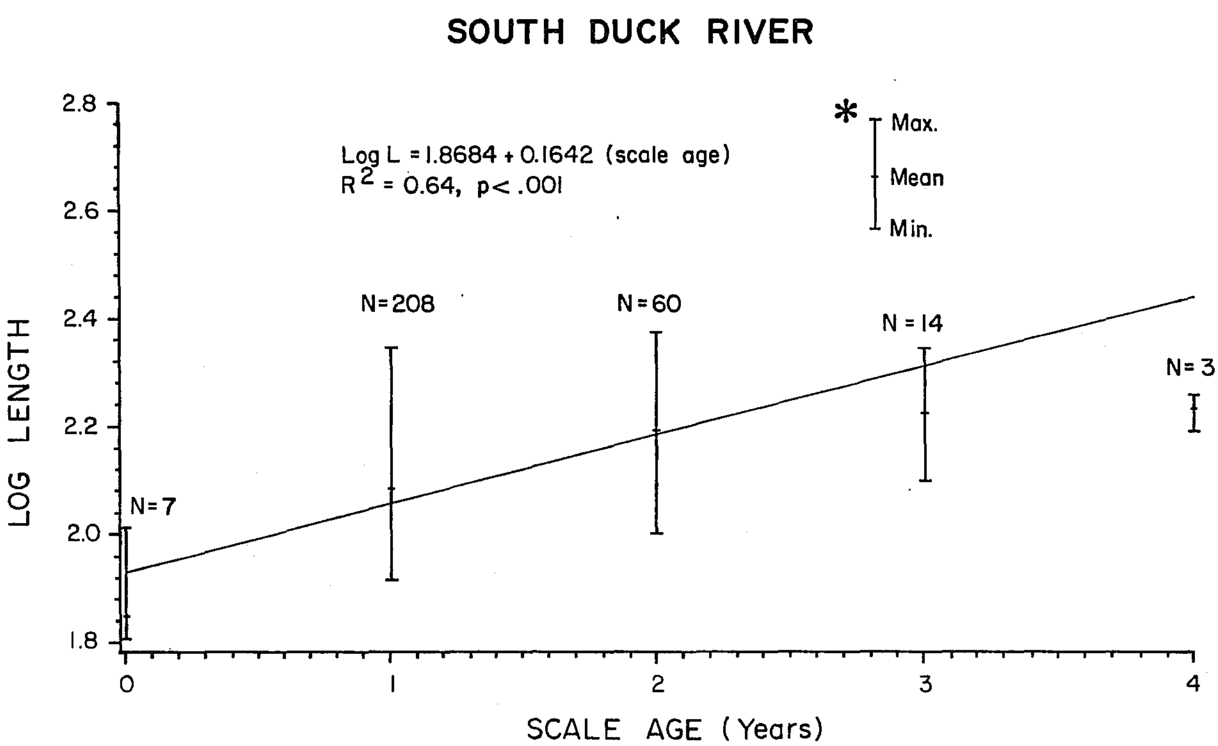


Fig. 9. Regressions of log length at scale age of brook charr from South Duck River and Cowan Creek, 1980-81.

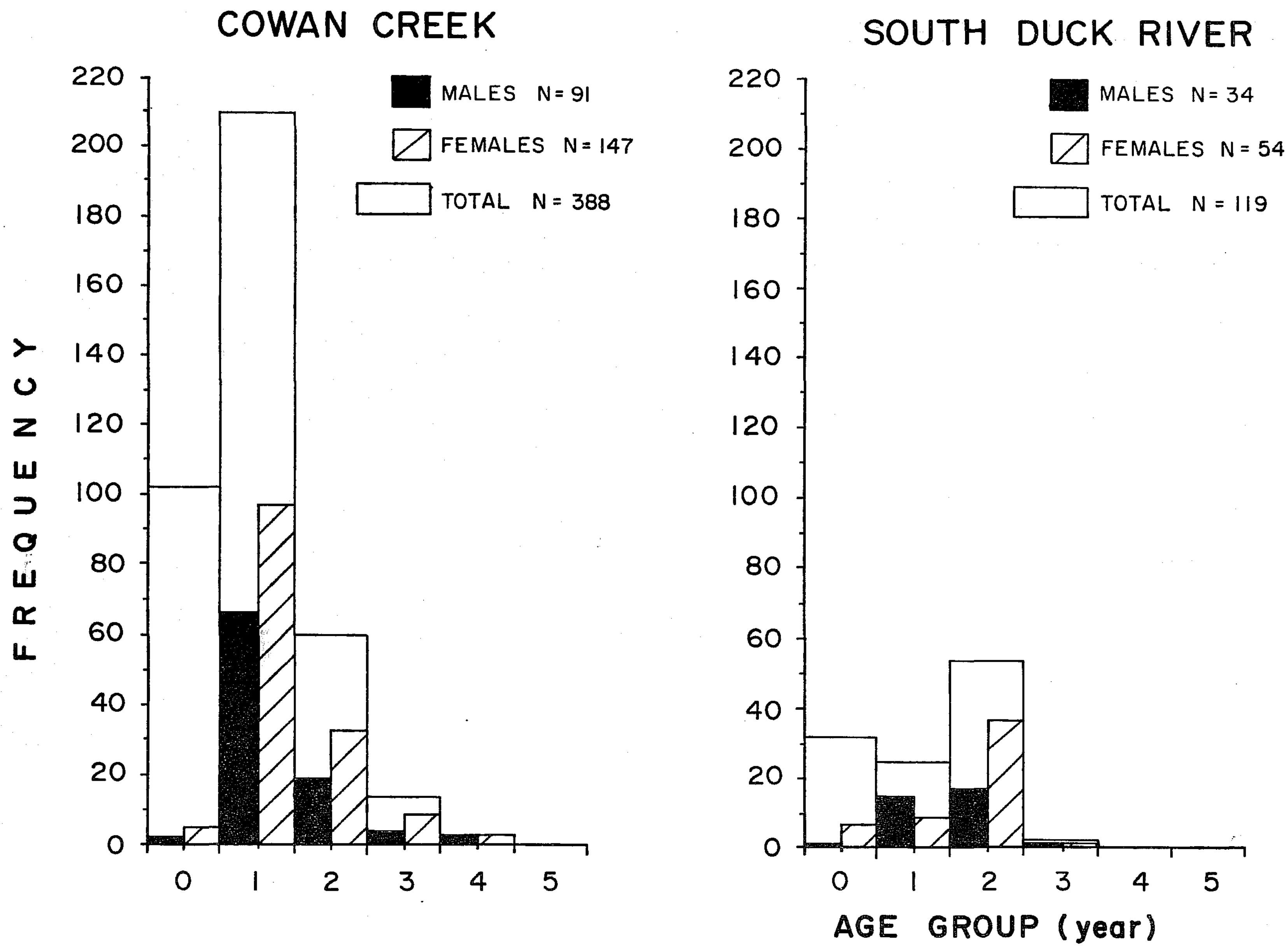


Fig. 10. Age frequency histograms of South Duck River and Cowan Creek brook charr, 1980-81. Totals include 150 and 25 fish respectively of undetermined sex.

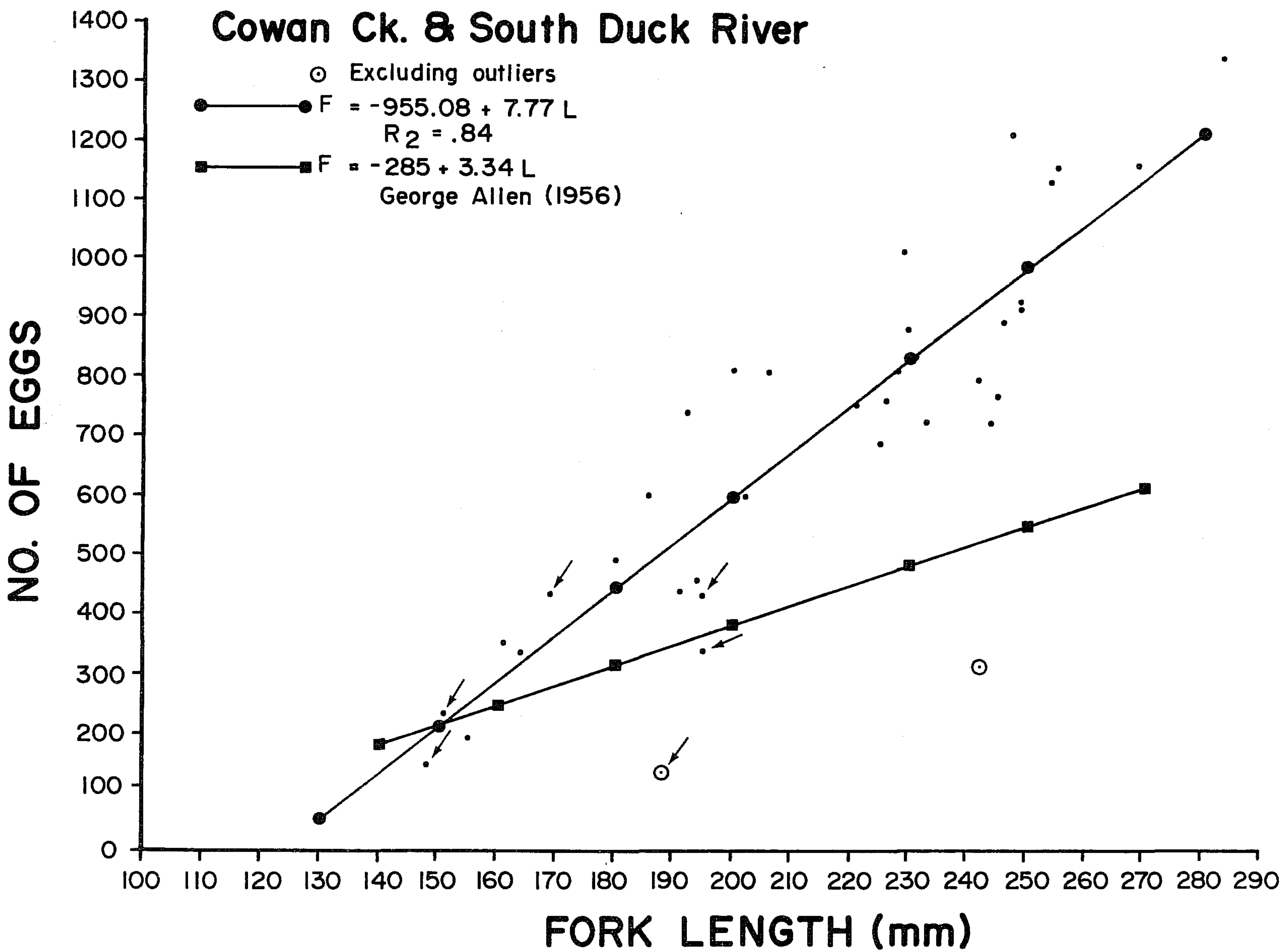
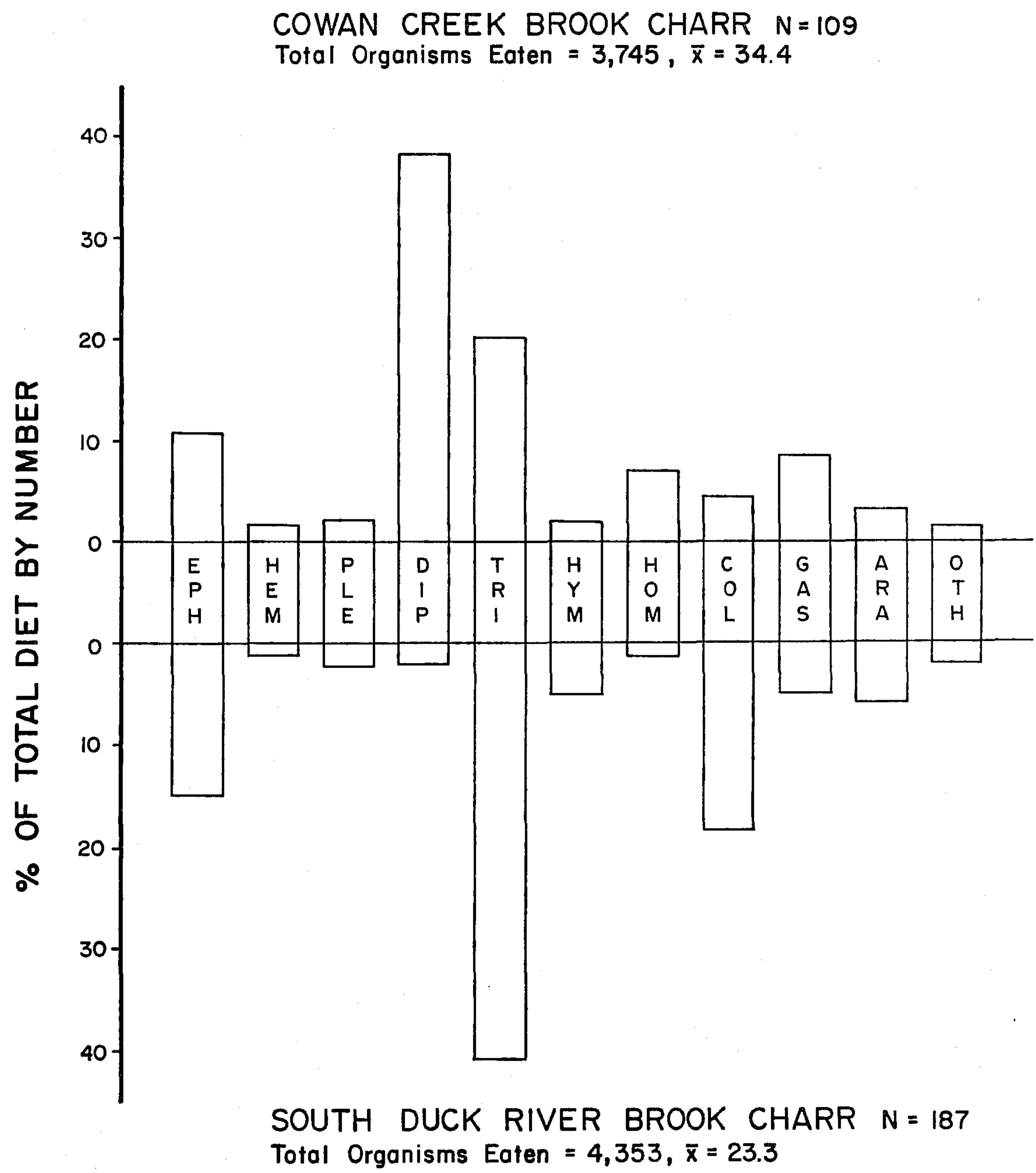


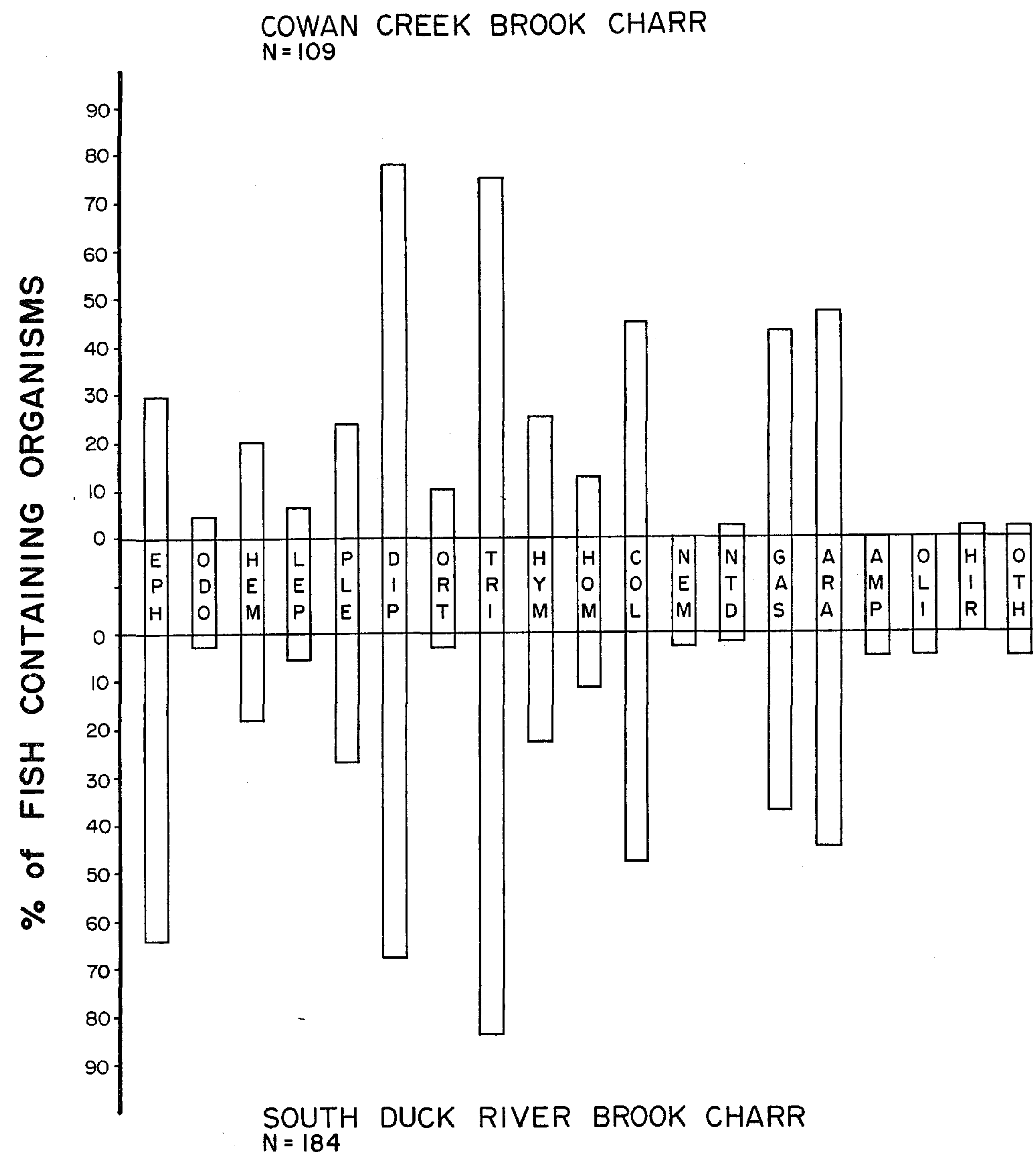
Fig. 11. Comparison of regressions of fecundity per mm fork length of combined Cowan Creek and South Duck River brook charr data with data from an introduced Wyoming population. South Duck River samples indicated by arrows.



EPH=Ephemeroptera; HEM=Hemiptera; PLE=Plecoptera; DIP=Diptera; TRI=Trichoptera; HYM=Hymenoptera; HOM=Homoptera; COL=Coleoptera; GAS-Gastropoda; ARA=Arachnida; OTH=Others (Less than 1%).

Others - includes; Odonata, Lepidoptera, Orthoptera, Nemptomorpha, Collembola, Diplopoda, Nematoda, Amphipoda, Ostracoda, Oligochaeta, Cladocera, Hirudinea.

Fig. 12. Histograms showing the percentage contribution of invertebrate taxa to the diets of South Duck River and Cowan Creek brook charr in 1980-81.



EPH=Ephemeroptera; ODO=Odonata; HEM=Hemiptera; LEP=Lepidoptera; PLE=Plecoptera; DIP=Diptera; ORT=Orthoptera; TRI=Trichoptera; HYM=Hymenoptera; HOM=Homoptera; COL=Coleoptera; NEM=Nematomorpha; NTD=Nematoda; GAS=Gastropoda; ARA=Arachnida; AMP=Amphipoda; OLI=Oligochaeta; HIR-Hirudinea; OTH=Others (Less than 1%).

Others - includes; Diplopoda, Collembola, Cladocera, Ostracoda.

Fig. 13. Histograms showing the percentage of South Duck River and Cowan Creek brook charr that contained organisms from various invertebrate taxa.