



University of Montana

Department of Zoology • Missoula, Montana 59812 • (406) 243-5122

January 12, 1984

Dr. Robert J. Behnke
Department of Fishery and Wildlife Biology
Colorado State University
Fort Collins, Colorado 80523

Dear Bob:

Thanks for the manuscript on artic charr. I certainly agree with you that Nyman's conclusions drawn from a single esterase locus are farcical at best. I really cannot understand how he was able to get such conclusions published.

I have enclosed a copy of the galleys for the hybrid manuscript. Our limited data from bull trout populations indicates that in contrast to brook trout the bull trout apparently have low amounts of intraspecific genetic variation. Thus, you might want to revise this point in your manuscript.

This past summer we collected a fish that was undoubtedly the progeny from a brook trout-bull trout hybrid x brook trout mating. This conclusively demonstrates that some of these hybrids are fertile, although it appears that only a very small percentage are. Our data indicate about one percent.

We are working on a manuscript describing the heritabilities of eight meristic characters in a rainbow trout population. Many of these have unusually high heritabilities, greater than 0.80. I will send you a copy as soon as the manuscript is ready to submit for publication.

Sincerely,

Robb Leary

RL/cs
Encl.



University of Montana

Department of Zoology • Missoula, Montana 59812 • (406) 243-5122

June 13, 1986

Robert Behnke
Fish and Wildlife Biology
Colorado State University
Fort Collins, Colorado 80523

Bob:

At long last here are the Salvelinus electrophoretic data. The samples were obtained from the following locations with sample sizes in parentheses: Bull trout, S. confluentus - South Fork Lolo Creek, Montana (34); Dolly Varden, S. malma - Bear Lake (1), Fox River (12), and Mystery Creek (1) from the Kenai Peninsula, Alaska; Arctic Char, S. alpinus - Clam Lake (1), Dolly Varden Lake (4), East Finger Creek (4), and Moose Lake (1) from the Kenai Peninsula, Alaska and a single specimen from an unknown source in Sweden; Brook trout, S. fontinalis - Harriman Trout Company, St. Ignatius, Montana (14), Lake trout, S. namaycush - Lewis Lake strain maintained at the Jackson National Fish Hatchery, Jackson, Wyoming (50).

We determined the genotype of each individual at 42 protein encoding loci (Table 1) and of these 18 can be used to differentiate among the taxa (Table 2). Most of these loci, however, distinguish the brook trout and lake trout from the other three species. Only two loci, Me2 and Sod unambiguously differentiate the bull trout from the Dolly Varden and Arctic char. These latter two species share alleles at all loci examined and thus cannot be distinguished with these data.

In Table 3, we have listed the allele frequencies at those loci that showed evidence of inter and intraspecific genetic variation in these samples with sample sizes greater than one plus the Swedish char. The inclusion of the Swedish char is justified based on the work of Nils Ryman and his colleagues. In an extensive survey of Swedish char they found that all populations analyzed clustered together at a Nei's genetic distance of 0.01. This indicates that there is relatively little electrophoretically detectable genetic differentiation among these fishes and thus a single specimen can be considered a valid representation of them.

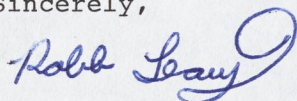
Considering the Arctic char, the allele frequencies in Table 3 have a couple of noteworthy points. At Aat1, the Swedish and Alaska char are completely divergent. The Swedish char have the allele common to the Dolly Varden while the Alaskan char have the allele characteristic of the bull trout. Although we did not detect the Gpi3(108) allele in the two samples of Alaskan char included in Table 3, we did detect this allele in the other two Alaskan specimens. Thus the allele frequencies at this locus are widely divergent

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among populations of Arctic char. The 108 allele being common in Swedish populations the 103 allele common in some Alaskan populations, and both alleles apparently being common in other Alaskan populations.

We calculated Nei's genetic distance between all pairs of samples in Table 3. The dendrogram (Fig. 1) produced by cluster analysis of the genetic distance matrix (Table 4) shows rather nicely the confusing nature of the data. Note that the Swedish char clusters with Dolly Varden before it clusters with the Alaskan char. This indicates that there is as much electrophoretically detectable genetic divergence among Arctic char included in our samples as there is between the Arctic char and Dolly Varden. In contrast to this mess, the bull trout, lake trout, and brook trout are clearly distinct from each other as well as from the Arctic char - Dolly Varden complex. The available data, therefore, support the specific status of the bull trout.

Sincerely,



Robb Leary

Enclosures

RL:sf

TABLE 1

Enzymes and loci examined in samples of Salvelinus

Enzyme	Loci	Tissue
Adenylate kinase	Adk1,2	M
Alcohol dehydrogenase	Adh	L
Aspartate aminotransferase	Aat1,2 Aat(3,4)	L M
Creatine Kinase	Ck1,2 Ck3	M E
Glucose phosphate isomerase	Gpi1,2,3	M
Glyceraldehyde-3-phosphate dehydrogenase	Gap(3,4)	E
Glycerol-3-phosphate dehydrogenase	G3pl,2	L
Glycyl-leucine peptidase	G11,2	E
Isocitrate dehydrogenase	Idh1,2 Idh(3,4)	M L
Lactate dehydrogenase	Ldh1,2 Ldh3,4,5	M E
Leucyl-glycyl-glycine peptidase	Lgg	E
Malate dehydrogenase	Mdh1,2 Mdh(3,4)	L M
Malic enzyme	Mel,2,3 Me4	M L
Phosphoglucomutase	Pgml,2	M
6-Phosphogluconate dehydrogenase	6Pg	M
Sorbitol dehydrogenase	Sdh	L
Superoxide dismutase	Sod	L

Note: E = eye, L = liver, M = muscle. The pairs of loci listed in parentheses are electrophoretically indistinguishable in at least one taxon so they are considered to be single tetrasomic loci in all analyses.

TABLE 2

Loci that can be used to distinguish among members of the genus Salvelinus. Allelic mobilities are relative to the common allele at the homologous locus in rainbow trout, Salmo gairnderi.

Taxa and alleles					
Locus	Bull	Dolly Varden	Arctic Char	Brook	Lake
Aat1	54	100,54	100,54	100	100, null
Adk2	100	100,20	20	100	100
Ck1	85	85	85	100	85
Ck2	86	86	86,100	100	86
Gpi1	100	100	100	100	108
Gpi3	108	103,108	103,108	108	108
Ldh1	54	54	54	0	0
Ldh2	91	91	91	91	88
Ldh4	76	76	76	28	76
Mdh1	145	145	145	110	145
Mdh3,4	86	86	86	86,93	53,86
Me1	145	145	145	56	127
Me2	145	175	175	145	125
Me4	95,97	95	95	97	97
Pgml	100	100,138	75,100	100,null	100
Sdh	120	120	120	200	120
Sod	190	177,142	177	97	190,177

Note: When more than one allele is observed at a locus within a species the most common allele is listed first.

TABLE 3

Allele frequencies at those loci that showed evidence of genetic variation in sample of the genus Salvelinus.

		Taxa and allele frequencies											
		Bull		Dolly Varden		Arctic Char				Brook		Lake	
Locus	Alleles	S.F.Lolo	Fox Rvr	East Finger	Crk	Dolly Varden	Lake	Sweden	Harriman	Lewis	Lake		
Aat1	54	1.000	0.208	1.000		1.000		--	--	--			
	100	--	0.792	--		--		1.000	1.000	0.684			
	null	--	--	--		--		--	--	0.316			
Aat3,4	60	1.000	1.000	0.563		0.688		1.000	0.679	0.500			
	100	--	--	--		--		--	--	0.495			
	80	--	--	--		--		--	0.321	0.005			
	40	--	--	0.437		0.312		--	--	--			
Adk2	100	1.000	0.708	--		--		--	1.000	1.000			
	20	--	0.292	1.000		1.000		1.000	--	--			
Ck1	85	1.000	1.000	1.000		1.000		1.000	--	1.000			
	100	--	--	--		--		--	1.000	--			
Ck2	86	1.000	1.000	0.875		0.500		1.000	--	1.000			
	100	--	--	0.125		0.500		--	1.000	--			
Gap3,4	125	1.000	0.979	1.000		1.000		1.000	1.000	1.000			
	100	--	0.021	--		--		--	--	--			
G3p1	105	1.000	1.000	0.500		0.750		1.000	0.679	1.000			
	89	--	--	0.500		0.250		--	0.321	--			
Gpi1	100	1.000	1.000	1.000		1.000		1.000	1.000	--			
	108	--	--	--		--		--	--	1.000			
Gpi3	108	1.000	0.042	--		--		1.000	1.000	1.000			
	103	--	0.958	1.000		1.000		--	--	--			
Idh1	200	0.853	1.000	1.000		1.000		1.000	1.000	1.000			
	333	0.147	--	--		--		--	--	--			
Idh3,4	106	1.000	1.000	1.000		1.000		1.000	0.375	1.000			
	135	--	--	--		--		--	0.465	--			
	82	--	--	--		--		--	0.125	--			
	null	--	--	--		--		--	0.035	--			
Ldh1	54	1.000	1.000	1.000		1.000		1.000	--	--			
	0	--	--	--		--		--	1.000	1.000			

TABLE 3 -- Continued

Ldh2	91	1.000	1.000	1.000	1.000	1.000	1.000	--
	88	--	--	--	--	--	--	1.000
Ldh3	135	1.000	1.000	1.000	1.000	1.000	0.750	1.000
	95	--	--	--	--	--	0.250	--
Ldh4	76	1.000	1.000	1.000	1.000	1.000	--	1.000
	28	--	--	--	--	--	1.000	--
Ldh5	100	1.000	0.583	1.000	1.000	1.000	1.000	1.000
	95	--	0.417	--	--	--	--	--
Mdh1	145	1.000	1.000	1.000	1.000	1.000	--	1.000
	110	--	--	--	--	--	1.000	--
Mdh3,4	86	1.000	1.000	1.000	1.000	1.000	0.839	0.005
	93	--	--	--	--	--	0.161	--
	53	--	--	--	--	--	--	0.995
Me1	145	1.000	1.000	1.000	1.000	1.000	--	--
	127	--	--	--	--	--	--	1.000
	56	--	--	--	--	--	1.000	--
Me2	145	1.000	--	--	--	--	1.000	--
	175	--	1.000	1.000	1.000	1.000	--	--
	125	--	--	--	--	--	--	1.000
Me4	95	0.941	1.000	1.000	1.000	1.000	--	--
	97	0.059	--	--	--	--	1.000	1.000
Pgm1	100	1.000	0.833	--	--	--	0.750	1.000
	138	--	0.167	--	--	--	--	--
	75	--	--	1.000	1.000	1.000	--	--
	null	--	--	--	--	--	0.250	--
Pgm2	100	0.971	0.833	1.000	1.000	1.000	1.000	1.000
	122	--	0.167	--	--	--	--	--
	90	0.029	--	--	--	--	--	--
Sdh	120	1.000	1.000	1.000	1.000	1.000	--	1.000
	200	--	--	--	--	--	1.000	--
Sod	190	1.000	--	--	--	--	--	0.950
	177	--	0.917	1.000	1.000	1.000	--	0.050
	142	--	0.083	--	--	--	--	--
	97	--	--	--	--	--	1.000	--

TABLE 4

Nei's genetic distance between members of the genus Salvelinus

	Arctic Char					
	Bull	Dolly Varden	East Finger	Dolly Varden	Sweden	Brook
Arctic Char						
Dolly Varden	0.109	--				
East Finger	0.159	0.051	--			
Dolly Varden	0.158	0.050	0.005	--		
Sweden	0.143	0.047	0.068	0.066	--	
Brook	0.342	0.406	0.497	0.471	0.412	--
Lake	0.238	0.288	0.399	0.400	0.318	0.386

Permanaged

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Figure 1 -- Dendrogram produced by cluster analysis of the Nei's genetic distance matrix.

Genetic Distance

0.5
0.4
0.3
0.2
0.1
0.0

East Finger Char

Dolly Varden Char

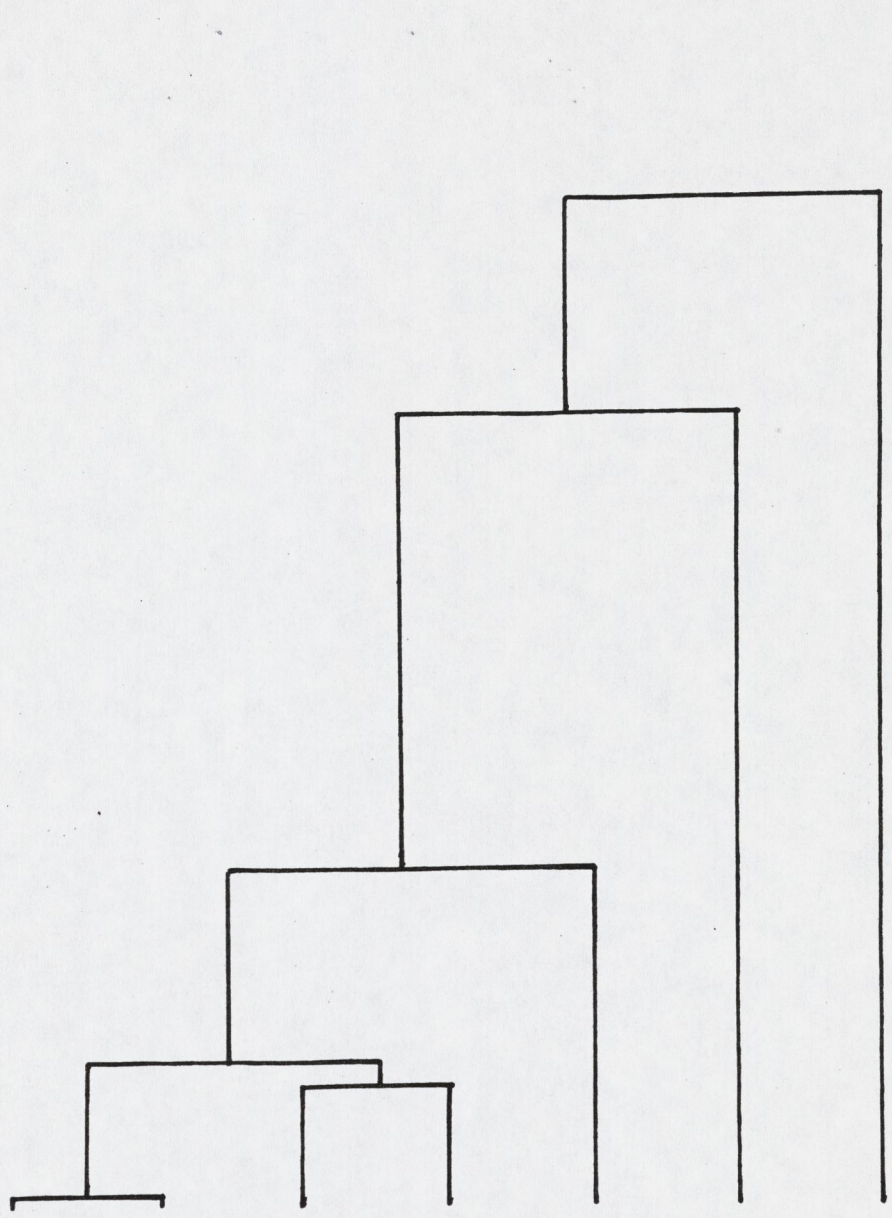
Dolly Varden

Swedish Char

Bull

Lake

Brook



Robb heavy
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FIRST CLASS

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