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DEPARTMENT OF ANIMAL SCIENCE

DAVIS, CALIFORNIA 95616

Dr. R. J. Behnke
Dept. of Fish. & Wildlife Bio
Colorado State University
80523

Dear Dr. Behnke:

Enclosed is a draft of a manuscript Gary Thorgaard and I are preparing on karyotypic comparisons of S. clarki subspecies. I believe this represents the first karyotype of S. c. bouvieri and S. c. lewisi since Simon's original description. I think you will find it very interesting. We would value your opinions and welcome suggestions.

I find it very gratifying that proteins, chromosomes, and morphology all tell a similar story within this particular problem in Salmo clarki taxonomy. I have not yet seen Allendorf's results but understand from your letter to C. Busack and a communication ~~from~~ between G. Thorgaard and D. Campton that S. c. clarki and S. c. lewisi cluster at I = .95 and that S. c. bouvieri join these at I = .90. Karyotypes support this idea. However I agree with you that the divergence of S. c. bouvieri before divergence of S. gairdneri is highly unlikely and is in disagreement with the karyotypes we present, and zoogeography. The karyotype of

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~~[illegible]~~ S. c. bouvieri suggests a recent divergence from a Great Basin ancestor. This is consistent with my electrophoretic work; under this rational gross electrophoretic divergence and low electrophoretic variability is the result of founder effect and drift. This seems most logical to me in view of recent glacial activity.

At the present time I am a post-doctoral research geneticist at U.C.-Davis with G.A.E. Gall. I am continuing my work with Salmo clarki using chromosomes, electro & morphology. This summer I am collecting S. c. lewisi (Gallitin River headwaters) and S. c. bouvieri from Yellowstone National Park; S. c. henshawi and S. c. humboltensis from Nevada; and S. c. pleuriticus from Wyoming. Previously I compared serum proteins ~~and~~ from S. c. bouvieri and S. c. pleuriticus and they were quite different. But I feel further analysis using chr. and many geneloci is necessary to clarify the situation.

Based on chromosomes and zoogeography my current idea is that Salmo clarki is composed of at least 2 major groups; a Great Basin group which includes S. c. seleniris, S. c. humboltensis, S. c. henshawi, S. c. alvordensis, S. c. utah and S. c. bouvieri + un-named Snake River fine-spot; and

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a northwest group which includes S. c. clarki and S. c. lewisi and potentially others such as S. c alpestris which are in question. I don't know if S. c. pleuriticus S. c. stomias & S. c virginalis belong to the Great Basin group or represent a third distinct lineage.
Any comments you wish to make on this scheme are welcome.

Sincerely,
Eric J Loudenslager
Eric J. Loudenslager

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July 31, 1978

Dr. R. J. Behnke
Cooperative Fisheries Unit
Colorado State University
Fort Collins, Colorado 80523

Dear Dr. Behnke:

Thank you very much for your generous outpouring of materials and suggestions. I had heard from a number of people that you were a conscientious correspondent, and am delighted to be able to personally verify these reports.

I should have explained to you that Eric Loudenslager is now a post doctural researcher with us. He will be doing a study of 12-16 Nevada cutthroat populations. I am sure he would appreciate the list you mentioned of collection sites for humboldtensis.

I should also have explained the appendices of my thesis. Both were intended for a specific audience: the Threatened Trout Committee headed by Steve Nicola. Steve and Jim Ryan had asked us some time before for a statement regarding the purity of the Independence Lake trout. I personally feel as you do about quibbling over nuances of purity; I like to see unique populations preserved, regardless of their ancestry, and this would certainly include Independence Lake. But I felt I had to be as objective in this matter as possible.

The appendix regarding hybridization was written because I felt the biologists on the committee, who accept without reservation the idea that the western Salmo readily hybridize, should be aware of the lack of experimental data supporting this notion. You will be interested to know, if you don't already know, that Don Campton is planning a very thorough study of steelhead x coastal cutthroat crosses at the University of Washington. This summer at Davis we are doing some golden female x rainbow male crosses. Although there is a substantial amount of circumstantial data suggesting the western trouts hybridize without difficulty, I find it hard to believe the F_1 fish are fully fertile, if the parents differed in chromosome number. A cytological study of F_2 embryos might go a long way toward resolving the problem.

To a point I agree with your criticism of my interpretation of the population structure in Silver King Creek. I definitely went too far in implying that an equilibrium exists; I undoubtedly sampled a dynamic process. But I will still argue that there is reproductive isolation between the populations. There are two possibilities consistent with the data: migration from unspotted to spotted, with virtually no migration in the other direction, and virtually no migration in either direction. The important question is, what will happen to the situation if CDFG and USFS stop artificially impeding the expansion of the spotted population? Based on the historical evidence, it is a fair assumption that the spotted population would greatly increase in number. Given migration situation #1, the spotted population might well absorb the unspotted; given situation #2, the unspotted population might be driven to extinction through competition. Or perhaps the isolation will break down and the unspotted population would be lost. I could make a long list of possible outcomes, based on different regimes of ecological and ethological isolation.

But isn't it possible that the populations would remain distinct, although perhaps the unspotted population might become very small? Can we say with certainty that this was not the situation in Silver King at the time of the 1964 treatment? The presence of two isolated popualtions in the creek, even in this decidedly non-equilibrium situation, suggests to me that non-trivial equilibria are possible. A close look at streams where hybrid swarms exist may reveal some of these equilibria.

At present my plans are to divide the thesis material into two papers:

1) a condensation of the basic study, presenting all the findings as they pertain to the situation in the creek.
2) a short paper dealing with the relative merits of electrophoresis and meristics in examining hybrid trout swarms. This would include the information on genetic and euclidean distances, and measures of genetic variability.

I plan to submit both to JFRBC, although I have thought about submitting #2 to Systematic Zoology. I would appreciate your opinions on this.

As you requested, I am enclosing a copy of the thesis to exchange for a copy of Terry Hickman's thesis. Thank you for your time.

Sincerely,

Craig Busack

Craig Busack

Department of Fishery and Wildlife Biology

Colorado State University
Fort Collins, Colorado
80523

16 August 1978

Mr. Eric Loudenslager
Department of Animal Science
University of California, Davis
Davis, CA 95616

Dear Eric:

Many thanks for a copy of the manuscript on westslope cutthroat karyotypes--it looks like a significant breakthrough. The idea that S. c. lewisi is intermediate between the coastal and yellowstone cutthroat nicely agrees with my view on the evolution of interior cutthroat trout, except I could not decide which branch--S. c. bouvieri or S. c. lewisi was the more primitive. I was tending toward the bouvieri side on the basis of zoogeography, but I'll modify my opinion now.

The ms. was timely. I am in the midst of writing a monograph for federal agencies on western trouts and will make reference to your paper. I have a draft completed on about half of the monograph and promised to send a copy to Don Campton, Univ. Washington. I'll request he bring it along when he comes to Davis so you can all have a look at it. The style and complexity of my monograph has been changing with reviews and comments from the agencies. They claimed the early parts are too technical and scientific for their administrators to understand. I'm afraid the revisions they want will result in something more suitable for Ranger Rick magazine rather than a definitive tome on western trouts.

I'll provide a rough outline on my scheme of interior cutthroat evolution and you can design some of your research to "falsify" my notions. The lewisi line of evolution probably did not give rise to any of the other subspecies, but one must keep an open mind on this matter because in pleuriticus, stomias, and virginalis, intense coloration is developed in excess of any other subspecies. Only lewisi comes close to developing such colors. The bouvieri group and all of the Great Basin cutthroats evidently lost the genes for expressing bright golden, red, and orange colors. On zoogeographical grounds their large, round spots, the cutthroat trout of the Colorado, South Platte and Rio Grande basins should be derived from the bouvieri line, but if so, the ancestor must have carried the genetic basis for the brilliant colors which was subsequently lost in bouvieri and its Great Basin derivatives.

The question of who came first, the Great Basin cutthroat trout or the "Yellowstone" trout of the Snake River can't be answered with any certainty at present. There is no doubt that morphologically, S. c. henshawi is the most divergent subspecies of S. clarki, but this may not be due to evolutionary antiquity but rather to more rapid change under the selective pressures of a large, lacustrine environment. S. c. utah of the Bonneville basin, conversely, shows little in the way of lacustrine selection and I suspect it was not subjected to such a long period of lacustrine selection--it probably didn't get into the Bonneville basin until the Bear River changed its course from the Snake River to the Bonneville (which eventually led to the filling and overflow of L. Bonneville back to the Snake). S. c. utah appears hardly differentiated from S. c. bouvieri of the upper Snake. Recognition as a separate subspecies is purely a practical matter.

The Alvord cutthroat, like the Lahontan, consisted of two distinct kinds. One was native to the Trout Creek drainage (Alvord sump) and one to Willow and Whitehorse Creeks. Willow and Whitehorse Creek may never have directly connected to Lake Alvord because they lack the peculiar chub, Gila alvordensis, so prevalent in Trout Creek. The native trout of Trout Creek is now probably extinct (I found only rainbow trout in all of the headwaters in the Trout Creek Mtns.). It was similar to S. c. henshawi and could have been the result of S. c. henshawi invading the Trout Creek drainage from an overflow of Summit Lake. The Willow and Whitehorse Creek trout have some evidence of a lacustrine influence in their evolutionary history (average of 21 gill-rakers) and closely resemble S. c. humboldtensis. But this similarity is more likely the result of convergent or parallel evolution. Did the ancestor of the Willow and Whitehorse Creek trout come from the Lahontan basin or from the Columbia? Do you think you can get the answer from gene loci?

If you will be collecting in Yellowstone Park, the "purest" S. c. lewisi is found in Cougar Creek. Specimens from the E. Fork Specimen Creek and the headwaters of Grayling Creek also look good.

If you can make progress on the interior cutthroat relationships discussed above, there is still the question on the origin and relationships of the native cutthroat of the Columbia River basin which occurs sporadically in isolated and disjunct localities. Evidently the redband trout displaced the cutthroat from areas where they came into contact. S. c. alpestris may be a composite, but the type specimens do have many more scales than either bouvieri or lewisi. The two ancestral lines must have come together after the last glacial period. I examined a specimen from a tributary of the John Day River, Oregon with 217 scales. Is this alpestris?

Re. the manuscript. The distribution of lewisi also includes the headwaters of the South Saskatchewan drainage (Hudson Bay watershed). In the Snake River drainage, lewisi evidently is native only to the Salmon and Clearwater drainages. I can't explain this anomaly of distribution. In the discussion on p. 5, Schultz, 1933 is cited but the citation is not in lit. cite. Do you mean Schultz 1935, Pac. Sci. Cong. Proc.? Actually, I believe Schultz was wrong here. There is no evidence I know of that coastal cutthroat trout distribution overlapped that of lewisi and intergrades occur. I once asked Schultz about this but he was quite elderly and his memory was hazy. You might have Don Campton search the University of Washington's collection and see if Schultz' specimens from east of the Cascades are there. Interior resident redband trout can look like various combinations of cutthroat intergrades. The collections of Evermann and Gilbert of the 1890's from around Spokane and Wallowa are bouvieri type of cutthroat. It also seems inescapable that glacial Lake Missoula must have played a role in the speciation and distribution of lewisi.

Reinitz found the GPI gene locus to be distinct between lewisi and rainbow trout, but rainbow trout and coastal cutthroat trout are not distinct at this locus. What type of GPI does bouvieri have?

I checked Ray Simon's Ph.D. thesis. His Lauri Lake specimens should have been lewisi, but the polymorphism could be from hybridization. The specimens from Leavenworth National hatchery, Washington were probably Yellowstone trout, but hatchery stocks are always suspect. His specimens from the Jackson, Wyoming hatchery must have been the fine-spotted Snake River cutthroat.

If you can get some good karyotypes from pleuriticus, some insight into their origin (along with stomias and virginalis) should be possible.

Sincerely,

Robert Behnke

Department of Fishery and Wildlife Biology

Colorado State University
Fort Collins, Colorado
80523

16 August 1978

Mr. Craig Busack
Department of Animal Science
University of California, Davis
Davis, CA 95616

Dear Craig:

A copy of Terry Hickman's thesis on Bonneville trout should be sent to you from the Salt Lake City office of the Bureau of Land Management where it is being duplicated.

I recently received a letter from Don Campton and will send him a copy of part of a draft I am writing on western Salmo. I'll request he take it to Davis and show it to you and Eric Loudenslager.

In the golden trout x rainbow trout crosses being made--are pure parental crosses, using eggs and sperm from the same fish being made? If not, any lack of fertility can be attributable to the quality of the eggs or sperm. From a practical point of view, any reduction in fertility is of little consequence for golden trout management. For 50 years they have been widely stocked and there is not a single instance where they have maintained reproductive isolation from rainbow trout or cutthroat trout if sympatric and natural reproduction occurs. I know of two streams, Red Canyon, Colorado, and Bull Creek, Wyoming, where the trout populations represent an amalgamation of gairdneri, clarki and aguabonita.

Again, I would appeal to common sense to arrive at the simplest answer to the spotted and unspotted trout in Silver King Creek. When I first examined spotted fish in the early 1960's it was obvious to me that they must carry rainbow trout chromosomes. When spots were obvious, gillraker counts and scale counts were lower and basibranchial teeth usually absent. Unspotted fish were typical of seleniris. Each year the spotted (hybrid) fish made up a larger proportion of the population (hybridization was spreading). If the original rainbows planted in 1949 hybridized with the Paiute trout and could not maintain reproductive isolation, how can you expect hybrids to become isolated from either of the parents? There are very few examples where introduced rainbow trout and native interior cutthroat trout coexist, and it is always in large environments where niche diversity would favor maintenance of the species (Yellowstone River below falls in Yellowstone Park, Buffalo Bill Reservoir, Wyoming)--I can not envision rainbow and cutthroat trout coexisting in Silver King Creek, much less hybrids and cutthroat.

I would urge you to submit manuscripts for publication. The paper on techniques would be better suited to Systematic Zoology. I expect that the editors of either the journal of the Fisheries Research Board on Systematic Zoology would send them to me for review, in which case, you would hear more from me on reproductive isolation in Silver King Creek.

I recently received the manuscript by Loudenslager and Thorgaard. The karyotype of S. c. lewisi is exciting news and agrees with my interpretation of the evolution of interior cutthroat. I am writing Eric a letter on this paper.

Sincerely,

Robert Behnke

KARYOTYPIC AND EVOLUTIONARY RELATIONSHIPS OF THE YELLOWSTONE AND WEST-SLOPE CUTTHROAT TROUT

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and

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INTRODUCTION

The systematics of inland populations of cutthroat trout (*Salmo clarki*) remain unclear despite previous investigations (Miller, 1950; Needham and Gard, 1959; Behnke, 1965). Several factors have contributed to the confusion: the introduction of rainbow trout (*Salmo gairdneri*) and non-native cutthroat trout (oten the Yellowstone cutthroat) has reduced and complicated identification of pure native populations; recent geological events have complicated our understanding of the dispersal and present zoogeography of the existing subspecies; and the range of meristic and morphological variability may be as great within a region as between regions. In spite of these difficulties it is important to determine systematic and zoogeographic relationships among the remaining stocks in view of their declining numbers and continued habitat loss from man's activities (Behnke, 1971; Binns, 1977; Reinitz, 1977).

Inland cutthroat trout of the upper Columbia River drainage and the headwaters of the Missouri and Yellowstone Rivers form one of the confusing groups. The designation *Salmo clarki lewisi* has sometimes been applied to all of these cutthroat trout in the past (Schultz, 1933; Behnke, 1965). More recently the cutthroat trout of Yellowstone Lake and River and the large-spotted cutthroat trout of the Snake River above Shoshone Falls have been considered a separate subspecies and designated *S. c. bouvieri* (Yellowstone cutthroat trout) (Behnke, 1973, 1975, and per. comm.). The designation *S. c. lewisi* (west-slope cutthroat trout) now applies only to native cutthroat trout in the Missouri and upper Columbia River system (with the exception of the Snake River above Shoshone Falls) (Behnke, 1973, 1975). The early association of Yellowstone cutthroat trout with *S. c. lewisi* is partly responsible for its wide propagation and introduction throughout much of the range of west-slope cutthroat trout from 1900-1950. Thus it is important to evaluate the evolutionary relationships among these subspecies in order to understand the possible genetic consequences of past mixing and hybridization.

Miller (1972) and Gold (1977) suggest that detailed comparative studies of karyotypes may clarify the origins and relationships among western *Salmo*. Previously (Simon, 1964; Gold et al., 1977) karyotype differences have been described between coastal and inland cutthroat trout. In this report we describe the karyotypes of the Yellowstone and west-slope cutthroat trout, and discuss their systematic implications.

MATERIALS AND METHODS

Yellowstone cutthroat trout were sampled from Le Hardy's Rapids (Yellowstone River) and Pelican Creek within the Yellowstone drainage and from Dime Creek and the Snake River near the Jackson Hole Biological Research Station within the Snake River drainage. West-slope cutthroat trout were obtained from the Jocko River State Trout Hatchery, Arlee, Montana. This stock originated from the Hungry Horse drainage (Flathead River system), Montana and is beleived to represent pure west-slope cutthroat trout.

Chromosome preparations of Yellowstone cutthroat trout followed the method of Gold (1974) with modification. Briefly, homogenized anterior head kidney was treated with a 0.075 N KCl hypotonic solution and fixed in Carnoy's solution (3:1 methanol:glacial acetic acid). One or two drops of the fixed cell suspension was dropped onto cold, wet (dH_2O) microscope slides which were then plate dried. Chromosome preparations of west-slope cutthroat trout were prepared from white blood cell cultures as previously described (Thorgaard, 1976). Slides were stained in dilute (4-6%) Giemsa in phosphate buffer or C-banded using the $Ba(OH)_2$ technique (Salamanca and Armendares, 1974).

RESULTS

Chromosome number and morphology of 51 Yellowstone cutthroat trout from 4 locations, and 5 west-slope cutthroat trout from the Jocko River Trout Hatchery were determined (Table 1).

Of the 305 cells of Yellowstone cutthroat trout analyzed, 63% (194) were modal with 2n=64, 26% (80) were hypomodal, and 11% (31) were hypermodal. This variation is within the range of error typically observed for salmonid chromosome preparations (Thorgaard, 1976; Gold, 1977; Gold et al., 1977), and is attributed to chromosome loss during preparation and counting errors caused by early chromatid separation. All individuals were modal with 2n=64, and approximately equal numbers of cells were counted per individual. The modal karyotype (fig. 1) is characterized by 38 chromosomes with approximately median centromeres, two of which often have satellites (M; pairs 1-19), 2 small chromosomes with submedian centromeres (SM; pair 20), 0 chromosomes with subterminal centromeres (ST), and 24 chromosomes with acrocentric or approximately terminal centromeres (A; pairs 21-32). The chromosome arm number (NF) is 104. This karyotype is indistiguishable from the karyotype of the Alvord cutthroat trout, *S. c. alvordensi*, and similar to the Lahontan cutthroat trout, *S. c. henshawi* (Table 2).

Of the 59 cells analyzed from west-slope cutthroat trout 80% (47) were modal with 2n=66, 16% (10) were hypomodal, and 4% (2) were hypermodal. All individuals were modal with 2n=66. The modal karyotype (fig. 2) is characterized by 34 chromosomes with approximately median centromeres (pairs 1-17), 4 small chromosomes with submedian centromeres (pairs 18 & 19), 12 chromosomes with subterminal centromeres (pairs 20-25), and 16 chromosomes with acrocentric or approximtely terminal centromeres(pairs 26-33). Using the criteria that only chromosomes with median and submedian centromeres are scored as biarmed, the NF is estimated to be 104. This karyotype has not previously been described for any *Salmo*, but closely resembles the coastal cutthroat trout (*S. c. clarki*) karyotype because of the many subtelocentric chromosomes and higher chromosome number (Table 2).

C-banded preparations of both Yellowstone and west-slope cutthroat trout revealed only centric constitutive heterochromatin. Thus the minor elements on the ST chromosomes do not appear to be constitutive heterochromatin, which usually accounts for polymorphisms of this type in small mammals such as *Peromyscus* (Murray and Kitchin, 1976) and *Thomomys* (Patton and Yang, 1977).

The karyotypes of west-slope cutthroat trout from the Jocko River Trout Hatchery and Yellowstone cutthroat trout differ by a diploid chromosome number of two, without a change in arm number. The simplest explanation for this is the fusion or fission of acrocentric or subtelocentric chromosomes, termed a Robertsonian rearrangement. There is also a difference in the number of small submetacentric chromosomes. West-slope cutthroat trout are characterized by 12 subtelocentric chromosomes, including one distinctive long pair (pair 20), but there are none in the Yellowstone cutthroat trout karyotype. Even if it is assumed that subtelocentric chromosomes were involved in the Robertsonian rearrangement there remains a difference between the two groups of 8 chromosomes with minor short arms.

Because attempts to G-band trout chromosomes have thus far failed, there is no way to assess additional chromosomal homologies between west-slope and Yellowstone cutthroat trout. However, these gross karyotypic differences suggest that substantial chromosomal differentiation is present between west-slope and Yellowstone cutthroat trout.

DISCUSSION

A comparison of Yellowstone and west-slope cutthroat karyotypes to those available for other S. clarki subspecies (Table 2) suggests some very interesting affinities. The Yellowstone karyotype is similar to that of two Great Basin subspecies, the Alvord cutthroat trout and the Lahontan cutthroat trout. The west-slope karyotype, although unique, is most easily derived from that of the coastal cutthroat trout. These karyotypic similarities thus suggest that two separate cutthroat lineages are present in the upper Columbia River system.

The evolutionary affinity suggested between Yellowstone and Great Basin cutthroat trout because of their karyotypic similarity agrees with geological and glacial events. Shoshone Falls of the Snake River was formed by lava flows 30,000 to 60,000 years ago, isolating the upper Snake River from the rest of the Columbia drainage (Dr. D. Love, U.S.G.S., Laramie, WY). The Bear River, which now drains into the Bonneville Basin, has alternately been a tributary to the upper Snake River and Bonneville Basin and could provide a transfer of fish from one system to another. Behnke (1975) proposes that the ancestral large-spotted cutthroat trout isolated above Shoshone Falls was also the ancestral large-spotted cutthroat trout isolated in the Bonneville Basin. It was not until about 6,000 years ago that the Yellowstone plateau was free of glacial ice. At that time cutthroat trout migrated over Two Ocean Pass into the headwaters of the Yellowstone River above Yellowstone Lake (Jordan, 1891; Behnke, 1975).

The west-slope cutthroat trout we karyotyped was one of the stocks used to electrophoretically characterize west-slope cutthroat trout (Reinitz, 1977), and the karyotype we present should be representative of this subspecies. Although further studies may detect chromosome polymorphisms within west-slope cutthroat trout, the many subtelocentric chromosomes and higher chromosome number demonstrate karyotypic similarities with coastal cutthroat trout. Historically coastal cutthroat trout inhabited the Columbia drainage as far upstream as Spokane, and overlapped the range of west-slope cutthroat trout east of the Cascade Mountains in Washington, where intergrades between the two subspecies were identified (Schultz, 1933). Thus the geographic proximity and chromosome similarities suggest potential evolutionary affinities between these two subspecies. It is possible that west-slope cutthroat trout are the result of an early inland invasion and differentiation of coastal cutthroat trout in the upper Columbia River system. – glacial L. Missoula

This evolutionary scheme is consistent with Behnke's (1973) suggestion that the confusion in the taxonomic status of Columbia River system cutthroat trout is due to post glacial dispersion of two differentiated stocks. It is interesting that these morphologically (Behnke, 1973) and karyotypically differentiated subspecies may also be electrophoretically different. Reinitz (1977) electrophoretically characterized the west-slope cutthroat trout and detected malate dehydrogenase, muscle protein, lactate dehydrogenase, phosphoglucomutase, and tetrazolium oxidase polymorphisms, while aspartate amino transferase was monomorphic. Loudenslager (1978) electrophoretically characterized the Yellowstone cutthroat trout and only detected an aspartate amino transferase polymorphism. Thus a comparison of these accounts suggests that biochemically these subspecies may be quite distinct and warrant further electrophoretic study.

GPI locus (rainbow, coastal cutt)

Because introductions of non-native trout and habitat loss have reduced most native cutthroat trout populations to a few isolated headwater streams, much of the original diversity characteristic of Salmo clarki has been lost (Behnke, 1971). Presently programs are underway to identify unique populations which may be remnants of the original stocks and of use in fish restoration efforts. This report demonstrates that this is best acomplished using cytogenetic and biochemical genetic methods in conjunction with morphological analyses.

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TABLE I. Chromosome numbers in somatic cells of Yellowstone and west-slope cutthroat trout.

Population	Common Name	# Ind.	cells with 2n= 58-	59-	60-	61-	62-	63-	64-	65-	66-	67-	68-
Le Hardy's	Yellowstone	3	--	--	2	--	5	1	23	2	11	--	--
Pelican Creek	Yellowstone	7	--	1	1	1	1	3	46	2	6	--	--
Snake River	Yellowstone	21	3	--	11	--	18	1	83	1	8	--	--
Dime Creek	Yellowstone	10	9	--	11	--	7	5	42	--	1	--	--
Jocko Hatchery	West-slope	5	--	4	--	--	1	2	--	3	47	--	2

TABLE 2. A comparison of karyotypes of Salmo clarki subspecies.

Subspecies	2n	NF	M	SM	ST	A	Source
S. c. alvordensi	64	104	38	2	0	24	Wilmot, 1974
S. c. henshawi	64	104	36	4	0	24	Gold et al., 1977
S. c. bouvieri	64	104	38	2	0	24	This Study
S. c. clarki	68	104	36	0	18	14	Gold et al., 1977
S. c. clarki	70	106	38	0	32	0	Simon, 1964
S. c. lewisi[1]	64	106	42	?	?	22	Simon and Dollar, 1963; Simon, 1964
S. c. lewisi	66	104	34	4	12	16	This Study

1. Simon and Dollar (1963) and Simon (1964) combined metacentric and submetacentric chromosomes together as metacentric and subtelocentric and acrocentric together as acrocentric.

Our findings are not totally inconsistent with Simon and Dollar (1963) and Simon (1964). The apparent discrepancy in chromosome number may be because Simon could have karyotyped Yellowstone cutthroat which at that time were considered part of the S. c. lewisi subspecies. However Simon (1964) observed cutthroat trout with 64, 65, and 66 chromosomes from Lauri Lake, Montana so the possibility for a chromosome polymorphism within west-slope cutthroat does exist. His observation provides further evidence of individuals with 66 chromosomes in populations of cutthroat trout in the upper Columbia system.

The arm number discrepancy could result from difficulties in centromere placement in Simon's embryo squashes as discussed by Gold et al. (1977). Furthermore, Simon (1964) reported observing differences in chromosome morphology among inland cutthroat trout but beleived an analysis of these differences beyond the scope of his study.

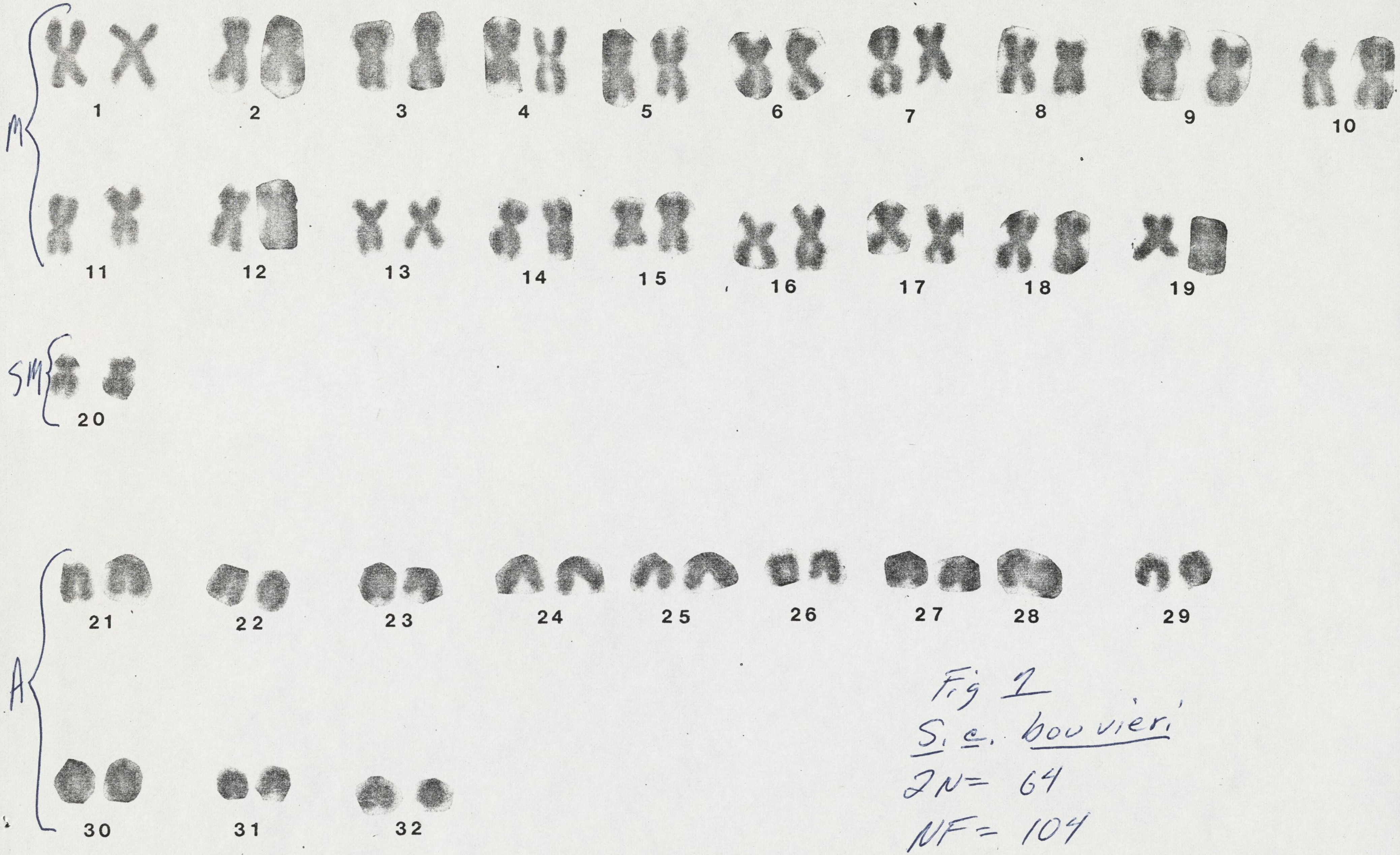

Fig 1
S. c. bouvieri
2N= 64
NF= 104

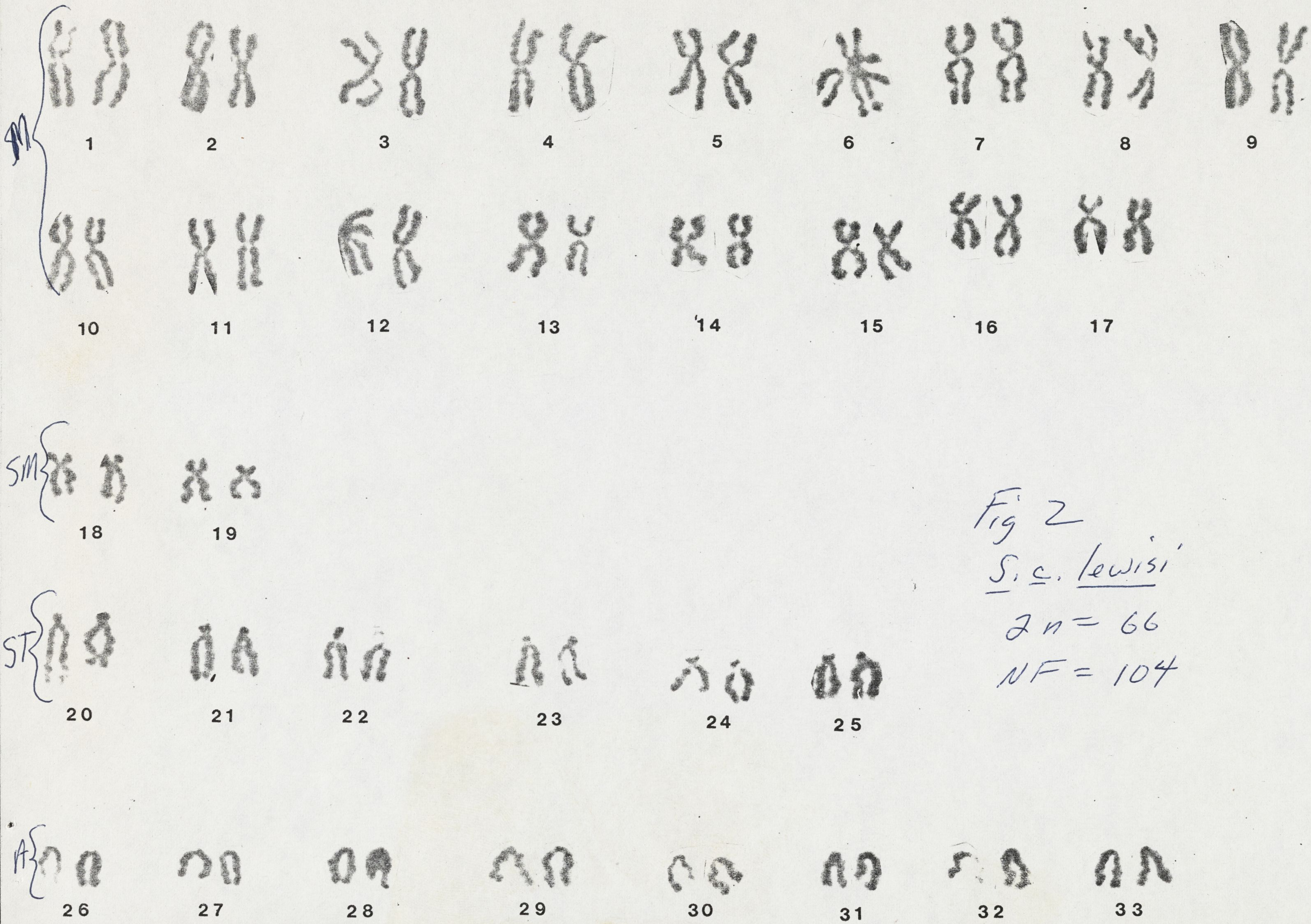

Fig 2
S. c. lewisi
2n = 66
NF = 104