REPORT ON COLLECTIONS OF CUTTHROAT TROUT
FROM NORTH-CENTRAL NEW MEXICO

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May 1980

ABSTRACT

Examination of 401 specimens of 28 samples of trout revealed that 24 samples represent good or very good populations of *Salmo clarki virginalis*, two populations have more obvious hybrid influence, but are predominantly cutthroat trout, and two populations are predominantly rainbow trout. Data from several characters were analyzed in a principal component computer program. The interpretation of the data provided a basis to rank the samples according to purity from grade A to grade F. Comments are made on management implications of the study for the Rio Grande cutthroat trout.

INTRODUCTION

The Rio Grande cutthroat trout, *Salmo clarki virginalis*, is rare throughout its once large range in Colorado and New Mexico. Although theses and reports on Rio Grande cutthroat trout have been written by Colorado State University graduate students (Wernsman 1973, Stork 1975, Propst 1977) and I have written several reports on this trout for federal and state agencies, virtually no information on the taxonomy or biology of *S. c. virginalis* can be found in the published literature. In a monograph on the native trouts of western North America, written for the U.S. Fish and Wildlife Service, I presented an update on information on Rio Grande cutthroat trout (Behnke 1979a).

A total of 401 specimens from 28 sites were examined to evaluate the purity of the populations from which the samples were taken. Most of the samples are from Taos County. Three samples are from the Canadian River drainage and 25 samples are from the Rio Grande drainage.

Most of the samples examined are identified as *S. c. virginalis* (75% to 100% *virginalis* genotype). Only two samples (Sawmill Creek and Latir Creek) are predominantly rainbow trout. Some samples indicate a hybrid influence from non-native cutthroat trout, probably originating from introductions of the "cutthroat" trout formerly propagated at the Seven Springs state hatchery.

METHODS AND MATERIALS

The specimens were received preserved in isopropyl alcohol. They were in excellent conditions. I express my gratitude to all concerned for their care and expertise in the collection, preservation, and handling of specimens.

Collections from the same stream frequently were in more than one container. If the transect data of collection sites were identical, the collections were combined into one sample. If transect sites differed, the collections were considered as separate samples.

Several meristic and morphometric characters were counted and measured for each specimen as a basis to evaluate hybrid influence from rainbow trout and from non-native subspecies of cutthroat trout. The following characters were used in a computer program to group samples according to similarities and differences: gillrakers, upper, lower and total numbers on anterior and posterior side of first left gill arch; scales above the lateral line and scales in the lateral series (counted two rows above the lateral line); basibranchial teeth; pyloric caeca; left and right branchiostegal rays; dorsal, anal, pectoral and pelvic fin ray counts; dorsal fin depressed length and caudal peduncle depth expressed as a percentage of the standard length. Data for each specimen were recorded and transformed on computer punch cards for a multivariate principal component analysis. Mr. Steve Culver, a graduate student studying computer-aided techniques for handling trout taxonomic data, performed the computer analysis. A computer printout positions each sample in two and three dimensional layouts based on the "mean of means" for all characters of the sample. Thus, the first component segregates the samples along a horizontal axis using seven characters. The second component segregates along a vertical axis using five additional characters. The third component is horizontal but at a right angle to the first component (envision a box in three dimensions: the first and third components form the horizontal bottom of the box at a right angle to each other and the second component is the vertical height of the box. The samples are represented as stalks rising from the bottom of the box in various spatial relationships to the three axes). This spatial arrangement is based on the overall values of the taxonomic characters. The computer printout of the visual arrangement of samples from principal component analysis and printouts with the ranges, means, and standard deviations of all characters of all samples are enclosed with the original of this report.

Also, every specimen of all samples was examined for spotting pattern and each sample was evaluated in relation to hybrid influence of the spotting pattern.

A grading system from A to F was designed to rank the relative purity of the samples. Grade A is given to those samples with no evidence of hybridization and believed to be pure or more than 90% pure *S. c. virginalis*. Grade B samples show some evidence of hybridization, but phenotypically closely resemble *S. c. virginalis*. Grade B is assumed to represent from about 75-80% to about 90-95% purity. Grade C samples show more pronounced evidence of hybridization but have more than 50% *S. c. virginalis* genes in the genotype. Grade D would be very obvious hybrids with 25% to 50% *virginalis* genes. Grade F reflect an overwhelming hybrid influence with 25% or less *virginalis* heredity. The classification based on spotting pattern agrees with the computer printout based on morphological and meristic data. Two samples rated F and two samples rated C have clearly recognizeable hybrid spotting patterns and they are well segregated from all other samples in the printout. All other samples are rated as A or B.

CHARACTERIZATION AND CLASSIFICATION

I recognize about 15 subspecies of cutthroat trout, *Salmo clarki*. All subspecies can be grouped into three major phyletic lines within the species. The coastal cutthroat trout, *S. c. clarki*, has small, irregularly shaped spots distributed all over the body and has 68-70 chromosomes. The "west-slope" cutthroat trout, *S. c. lewisi*, native to the headwaters of the Columbia, South Saskatchewan and Missouri river basins, has small, irregularly shaped spots concentrated posteriorly (posterior of line from the dorsal fin to the anal fin) and has 66 chromosomes. All other subspecies are derived from a common ancestor of the "Yellowstone" cutthroat trout, *S. c. bouvieri*, and are typically characterized by large, rounded spots and 64 chromosomes. The Rio Grande cutthroat trout belongs to a subgroup of three closely related subspecies. The Colorado River cutthroat, *S. c. pleuriticus*, the greenback cutthroat, *S. c. stomias*, along with *S. c. virginalis* form a close-knit evolutionary subgroup that differs from other subspecies of the "Yellowstone" group by their genetic basis to express bright coloration.

The differentiation of subspecies of cutthroat trout is similar to differentiation in the races of man, *Homo sapiens*, in regards to the time of origin of the species and their geographical races, the degree of genetic similarity, and how genetic differences are expressed. Often small genetic differences are manifested in conspicuous morphological differences. For example, a sample of Nordic people can be readily separated from a sample of Australian Aborigenes on the basis of their phenotypic expression of small genetic differences. The races of man are genetically very close and almost no consistent differences can be found between races on the basis of electrophoretic determination of the products of gene loci. I have found this also to be true of cutthroat trout subspecies. For the past few years I have compared my taxonomic evaluation of cutthroat trout subspecies with the electrophoretic studies of Dr. Eric Loudenslager and Dr. Fred Allendorf (often on the same samples of fish). It is apparent that I can typically obtain a much greater resolution and more accurate interpretation of a genotype through critical analysis of morphological and meristic characters and of spotting and coloration patterns than can be had from examination of the electrophoretic patterns of 20 or 30 gene loci. The reason is simply that a critical evaluation of morphology incorporates an enormously greater part of the genome into the study than can be examined by electrophoresis -- and morphology is governed by the regulatory part of the genome which is more subject to rapid evolutionary change.

I make this point to emphasize that although quantitative genetic studies on Rio Grande cutthroat trout may be interesting, they will find little or no consistent differences from other subspecies of the "Yellowstone" group of cutthroat trout and a slight hybrid influence from rainbow trout will be difficult to detect (*S. gairdneri* and various subspecies of *S. clarki* are electrophoretically very similar -- about 90% to 95% similarity). There is no known technique that can determine a population as 100% pure *S. c. virginalis* with certainty.

I have not worked with Rio Grande cutthroat trout as much as I have with some of the other subspecies and my previous characterization (Behnke 1979a) was based on limited material. I had assumed that a population of typical *S. c. virginalis* would average about 160 to 170 scales in the lateral series, about 40 pyloric caeca, and a concentration of medium-large "club"-shaped spots on the caudal peduncle. I had also pointed out that a differentiated form of *virginalis* is native to the Pecos River drainage characterized by larger spots and higher scale counts. The present group of specimens provides much more data on *S. c. virginalis* than available previously and has caused slight modifications of my previous views. I found samples quite typical of the "Pecos" type of *virginalis* with large spots and lateral series scale counts exceeding 180, which leads me now to believe that the slight differentiation leading to the "Pecos" type of *virginalis* originated in the Rio Grande drainage proper and was transferred to the Pecos drainage via headwater stream capture (I formerly assumed that the differentiation occurred in isolation in the Pecos drainage).

Comparing the Grade A and Grade B samples with the samples from Latir and Sawmill creeks, which are quite typical of rainbow trout, I note a reduction of about one meristic element in all characters of *virginalis*, (gillrakers, fin rays, branchiostegal rays). Also the dorsal fin length is longer and the caudal peduncle is deeper in the predominantly hybrid samples. A feature of the principal component analysis is that an additive effect from several characters is obtained to group samples according to similarities and differences even though none of the characters may exhibit statistically significant differences individually.

I would point out that the computer printout does not consistently segregate Grade A from Grade B samples. Computer analysis of taxonomic data is not as straightforward as it may seem. It takes considerable practical experience and fine tuning of the input to obtain the best output. If the input data on posterior gillrakers, basibranchial teeth, and branchiostegal rays were handled differently, I believe we could achieve better resolution of the A and B samples. Interpretation based on considerable experience is necessary to achieve the most correct results from the computer output. Biologists and administrators are often naive when it comes to applying modern technology to old problems. The computer cannot discover new characters; it cannot determine which samples are 100% pure. The computer can only work with the data put into it and the quality of the data and the way it is programmed determines the outcome -- good, bad, or indifferent. I have discussed methods and principles of salmonid taxonomy more fully in a recent publication (Behnke 1980).

Influence from rainbow trout hybridization is readily detected from changes in spotting pattern, lower scale counts, reduction and absence of basibranchial teeth, and higher counts of most meristic elements. A hybrid influence from non-native cutthroat trout is more difficult to assess. According to my notes on cutthroat trout propagation and stocking in New Mexico, cutthroat were first stocked in 1902. From 1902 to 1939, most of the cutthroat stocked probably were federal fish originating from Yellowstone Lake, Wyoming. From 1931 to 1939, besides the federal fish, the New Mexico Game and Fish Department took cutthroat eggs from Latir, Costilla, and Bonito lakes. In 1934-35, a lake was constructed to hold a cutthroat trout brood stock at Seven Springs Hatchery. Barker (1968) believed the lake at Seven Springs was originally stocked with fish from the Costilla River. R. R. Miller (Univ. Michigan) once told me that in 1961 trout from the Rio La Junta (trib. of Rio Pueblo) were also introduced into the brood stock lake at Seven Springs. In 1976, Dave Propst obtained a sample of 10 specimens of the Seven Springs brood stock. As might be anticipated from the origins of this stock, they appear to be a hybrid mixture of Yellowstone cutthroat, Rio Grande cutthroat, and rainbow trout. For detection of Yellowstone cutthroat trout hybrid influence I look for higher counts of gillrakers and basibranchial teeth (20-21 gillrakers and 20 or more teeth) and more even distribution of spots on the body. For detection of a hybrid influence of Seven Springs "cutthroat" trout I look for higher counts of basibranchial teeth, higher pyloric caecal counts and lower scale counts.

For many years it was a standard practice to "seed" headwater streams in New Mexico with cutthroat (and often rainbow trout) fry. Because this practice was so pervasive it should be assumed that no stream containing *S. c. virginalis* has completely escaped exposure to hybridization from non-native cutthroat trout and/or rainbow trout -- only that some populations have resisted hybridization to a much greater degree than others. The following section ranks 28 samples in relation to how well they have resisted hybridization.

EVALUATION OF SAMPLES

Grade A (pure or virtually pure).

Jarosa Canyon, Taos Co., T23N, R14E, S25. Not located on map -- but from transect data, if drainage is to north it is tributary to Rio Grande del Ranchos, if to south, it is tributary to Rio Pueblo. Ten specimens, standard length (SL) 108-190 (131) mm. All specimens with typical *virginalis* spotting pattern. All specimens with basibranchial teeth 4-17 (8.3); typical *virginalis* meristic characters: scales lat. ser. (LS) 179.1, above 1.1. 45.0, pyloric caeca 35.6, branchiostegal rays (BR) 8.7 (right) 9.0 (left), dorsal fin rays (D) 9.8, anal rays (A) 9.4. No evidence of hybrid influence from rainbow trout or non-native cutthroat.

Saloz Canyon, Taos Co., T23N, R13E, S25. Not located on map but assumed to be tributary to Rio Pueblo. Seven specimens 115-177 (144) mm SL (brown trout also in collection). Typical *virginalis* spotting. All specimens with basibranchial teeth 2-9 (4.1); typical *virginalis* meristic characters: scales LS 169.3, above 1-1. 43.3, caeca 37.4, BR 8.6 (R), 9.0 (L), D 9.6, A. 8.9. No evidence of hybrid influence, but only seven specimens in this sample.

Alamitos Creek, Taos Co., three samples: E. Fk., T21N, R13E, S24; 10 specimens, 79-187 (154) mm SL; Mid. Fk., T21N, R13E, S19; 18 specimens 109-171 (136) mm SL; Mid. Fk., T21N, R13E, S12; 4 specimens 65-140 (100) mm SL. The three forks of Alamitos Creek form the headwaters of the Rio Pueblo. Specimens with large spots, typical of "Pecos" type *virginalis;* scale counts high (188, E. Fk., 182, Mid. Fk.). All specimens with basibranchial teeth except 1 of 18 of Mid. Fk. sample. Meristic characters similar to Jarsosa and Saloz samples. The Rio Pueblo is a heavily stocked stream and I assume there has been abundant opportunity for hybridization of the native trout in Alamitos Creek. However, the large spots and high scale counts, typical of Pecos drainage *virginalis,* cannot be readily interpreted as a hybrid influence from any known form of introduced trout. Thus, I assume that these characters are an expression of the native genotype. Samples from the Rito la Presa, a tributary to the Rio Pueblo north of Alamitos Creek, do have a slight hybrid influence.

Palociento Creek, Taos Co., T23N, R14E, S3. Not located on map, but similar to Jarosa Canyon, if drainage to north it is tributary to Rio Grande del Ranchos, if to south it is tributary to Rio Pueblo. Sample of 22 specimens 80-178 (112) SL. All specimens with basibranchial teeth 1-11 (5.0). Specimens exhibit excellent representation of *virginalis* spotting pattern. Scales LS 174.8, caeca 37.0, BR 8.8 (R), 9.3 (L), D 9.6, A 9.2 -- typical values for *S. c. virginalis* with no evidence of hybrid influence.

Columbine Creek, Taos Co., T28N, R13E, S25, tributary to Red River (?) (not located on map). Sample of 15 specimens 130-199 (158) mm SL. Typical *virginalis* spotting pattern. All specimens with basibranchial teeth 7-26 (12.7). This number of basibranchial teeth is high for *virginalis*. The caeca count is also high for *virginalis*, 38-55 (44) which may indicate influence of Seven Springs "cutthroat" introductions. However scale counts are high (180 LS, 47 above 1.1.) and other meristic characters are typical of *virginalis*. This population is probably not pure but it is an excellent phenotypic representative of *virginalis* and can be considered as essentially pure.

San Cristobal Creek, Taos Co. Two samples: T28N, R13E, S32 (N=21, 136-215 [160] mm SL), and T28N, R13E, S31 (N=21, 94-171 [127] mm SL). San Cristobal Creek is a direct tributary to the Rio Grande between the Red River and the Rio Hondo. The samples from San Cristobal Creek are very similar to the cutthroat trout in the sample from Columbine Creek. The San Cristobal specimens have numerous basibranchial teeth -- 5-21 (12.4) in the first sample and 4-12 (7.1) in the second sample, and high scale counts -- 181 in the first sample and 190 in the second sample. Caecal counts average 41.1 and 40.5. As with the Columbine Creek sample, I doubt that the San Cristobal specimens represent a pure population of *virginalis*, but they are an excellent example of the typical *virginalis* phenotype and I cannot attribute the slightly abberant characters to any known form of introduced trout.

South Fork Rio Hondo, Taos Co. Two samples: T26N, R13E, S20 (N=13, 114-206 [166] mm SL) and T27N, 14E (N=7, 138-217 [173] mm SL). The Rio Hondo is a direct tributary to the Rio Grande. The two samples are quite similar except that the first sample has more lateral series scales (182 vs. 172). All 20 specimens with basibranchial teeth -- 2-15 (9.0) in first sample and 3-15 (8.4) in second. Meristic characters typical of *virginalis*. I find no evidence of a hybrid influence and spotting pattern ideally conforms to *virginalis*. I note that on the Carson National Forest map that the Rio Hondo is a popular recreation area with many campgrounds along the river -- suggesting heavy stocking of rainbow trout. The purity of the two samples from the South Fork, and the large average size of the specimens in comparison to other samples, indicate that the sample sites are remote, lightly fished areas and, perhaps, at least semi-isolated from the main Rio Hondo.

Grade B samples.

Tienditas Creek, Taos Co., T24N, R15E, S8. Sample of 19 specimens 91-191 (134) mm SL. Tienditas Creek is a headwater tributary to the Rio Taos. The meristic character values of this sample are typical of *virginalis*. One specimen of 19 lacks basibranchial teeth, and mean value is somewhat low (3.6). The spotting pattern of the specimens is slightly more variable than those samples ranked as A. This leads me to suspect a slight (probably 10% or less) hybrid influence. Overall in respect to the other samples, Tienditas Creek might be graded as A- or B+.

Rito la Presa, Taos Co. Two samples: T22N, R14E, S409 (N=24, 71-190 [125] mm SL plus several brown trout) and T22N, R14E, S17 (N=12, 68-167 [126] mm SL plus brown trout). The Rito la Presa is tributary to the Rio Pueblo. There is evidence of a slight rainbow trout hybrid influence in these samples. Some specimens have spots on top of the head and in anterior ventral region (rainbow trout pattern). Two of 24 specimens in first sample and 3 of 12 specimesn in the second sample lack basibranchial teeth. The higher mean value for basibranchial teeth in the first sample (5.6 vs. 3.5) as compared with the second sample also conforms to spotting variability comparisons. The first sample has more scales (172 vs. 159) and other meristic characters agree that the two samples are not drawn from a single freely interbreeding population -- the first sample has less of a hybrid influence than the second sample. I would rank the first sample about 85%+ pure and the second sample about 75-80% and award a B+ grade to sample 1 and B- to sample 2.

West Fork Rito la Presa, Mora Co. T23N, R14E, S25 and S23. Sample of 15 specimens 58-149 (110) mm SL plus brown trout. All specimens with basibranchial teeth, 1-9 (5.0). Characters typical of *virginalis* except that the spotting pattern is somewhat atypical with more even distribution of spots over sides of body. The relative purity of this sample appears to be comparable to the Rito la Presa sample from site 1.

East Fork Rito la Presa, Mora Co. T23N, R14E, S24, N=4, 70-120 (85) mm SL. The small sample size and small specimens do not allow for much interpretation. One of 4 lacks basibranchial teeth. Other characters typical of *virginalis*. Probably this population on order of 80-90% pure.

Bitter Creek, Taos Co. Two samples: T29N, R15E, S 16-21 (N=21, 93-155 [124] mm SL) and T29N, 15E, S15 (N=15, 92-153 [124] mm SL). Bitter Creek is a tributary of the Red River. These samples show a slight hybrid influence with rainbow trout. The basibranchial tooth count indicates the second sample has more rainbow trout influence than the first sample (6 of 15 specimens lack teeth [mean value 1.1] in second sample whereas 19 of 21 specimens have teeth in first sample [mean of 3.3]). However, other meristic characters are not significantly influenced by rainbow trout genes except for slightly lower scale counts (means of 157 and 162).

The spotting pattern is unusual and probably the result of rainbow trout influence. Adult specimens retain the typical juvenile *virginalis* spotting pattern with small, eliptical spots on the anterior part of the body both below and above the lateral line. I would estimate that the Bitter Creek cutthroat trout is approximately 80% *S. c. virginalis*.

Lake Fork Creek, Taos Co. T29N, R14E, S8. N=17, 85-208 (157) mm SL. This creek is also a tributary to the Red River but the spotting pattern is strikingly different from the Bitter Creek specimens. These specimens have large "Pecos" type spots, but variable in position with some spots on ventral region of some specimens. All have basibranchial teeth, 6-14 (8.8) and other meristic characters indicate the hybrid influence is predominantly from non-native cutthroat trout rather than rainbow trout.

El Rito Creek, Rio Arriba Co. Two samples: T27N, R6E, S35 (N=24, 78-204 [131] mm SL) and T27N, R6E, S10 (N=22, 114-192 [145] mm SL). El Rito Creek is tributary to the Rio Chama. The El Rito Creek samples are typical of *virginalis* in their spotting pattern. A slight rainbow trout influence is suggested in their lower scale counts (means of 157 and 159) and slightly higher counts of most meristic elements. However, the influence of rainbow trout genes on basibranchial teeth is readily detected. Sample one has 12 of 24 specimens without teeth (mean of 1.8) and sample 2 has 10 of 22 specimens lacking teeth (mean of 1.6) (Note: on computer printout, sample one is listed as site 2 and sample two as site 1).

I have previously noted that a very small infusion of rainbow trout genes into *S. c. virginalis* populations can act strongly on basibranchial teeth with little effect on other characters. From Ricardo Creek, a headwater tributary to the Vermejo River (Canadian R. basin) in Colorado, I found a sample of cutthroat trout to be wholly typical of *S. c. virginalis* in all of its characters except that basibranchial teeth were lacking in 11 of 21 specimens.

West Fork Luna Creek, Mora Co. Two samples: T23N, R15E, S21 and S16 (N=9, 85-149 [114] mm SL) and T23N, R15E, S8 (N=4, 104-150 [123] mm SL), both samples contain brown trout. Luna Creek is tributary to the Mora River of the Canadian River basin. In my monograph on western trouts (Behnke 1979a) I summarized the evidence that leads me to conclude that *S. c. virginalis* is native to the Canadian River basin. However, this conclusion is not certain because there are no old museum collections to verify the occurrence of trout in the Canadian River system prior to the time of introductions.

Although these samples from the West Fork of Luna Creek show some evidence of slight hybridization with rainbow trout, they are quite typical of *S. c. virginalis* in their spotting pattern.

Three of 9 specimens of the first sample and 1 of 4 of the second sample lack basibranchial teeth. All other meristic characters are quite typical of *S. c. virginalis*. The significance of the Luna Creek cutthroat trout is that trout bearing a typical resemblance to *S. c. virginalis* are extremely rare in the Canadian River basin. During Propst's survey in 1976, he found only one population, in Little Blue Creek, that appeared to be pure or nearly pure *S. c. virginalis*. However, Propst also found only 8 specimens of cutthroat trout amidst an abundant brown trout population in Little Blue Creek.

The loss and reduction of basibranchial teeth is the only indication of a hybrid influence in the Luna Creek samples. I estimate that they are about 90% pure *virginalis*. Several brown trout specimens were collected with the Luna Creek samples.

East Fork Luna Creek, Mora Co. T23N, R15E, S10. Six specimens plus brown trout (119-149 [134] mm SL). Sample size is small but the characters show no real differences from the West Fork samples. One of 6 specimens lacks basibranchial teeth.

Grade C samples.

Rito del Medio, Taos Co. T30N, R13E, S34. Sample of 16 specimens 72-177 (108) mm SL. The Rito del Medio is a direct tributary to the Rio Grande north of the Red River. There is evidence of hybridization from both rainbow trout and non-native cutthroat trout. Eight of the 16 specimens lack basibranchial teeth (rainbow trout influence) but one specimen has 27 basibranchial teeth (Yellowstone-Seven Springs cutthroat influence). The spotting pattern is predominantly cutthroat (mixture of *virginalis* with Yellowstone-Seven Springs cutthroat), but a rainbow influence can be noted in the spotting pattern of several specimens. Most meristic characters denote a definite rainbow trout influence -- low scale counts (147) and higher counts of other characters. However, hybrid gene combinations may result in certain character values that are not intermediate, but exceed the ranges of the contributing forms. This evidently is the case with the pyloric caeca number in the Rito del Medio specimens. The mean value for pyloric caeca, 32.3, is the lowest of any of the 28 samples studied, and below the typical 35 to 40 expected in *virginalis* (50-60 in rainbow trout and 40-50 in Yellowstone-Seven Springs cutthroat trout).

Rito Primero, Taos Co. T29N, R13E, S3. Sample of 17 specimens 75-178 (113) mm SL. The Rito Primero was not located on a map but the transect data indicates that it is tributary to Cabestro Creek of the Red River drainage.

The Rito Primero specimens also indicate a hybrid influence from rainbow trout and non-native cutthroat trout, but the hybrid gene combinations govern character expression quite differently than in the Rito del Medio population. For example, although there is a more pronounced rainbow trout influence on the spotting pattern than in the del Medio specimens, all 17 specimens from the Primero sample have basibranchial teeth. Two small Primero specimens have the appearance of typical rainbow trout (122 and 128 scales) and would suggest, at first glance, that both rainbow trout and cutthroat trout coexist with a high degree of reproductive isolation in the Rito Primero (an event so rare that it is almost beyond credibility). Both of these rainbow trout-like specimens have a basibranchial tooth, demonstrating that they have a cutthroat hybrid influence. I would assume that infusions of hatchery rainbow trout have consistently occurred into the Rito Primero and the impact of hybridization is not homogenized or stabilized. The other meristic characters of the Rito Primero sample are quite similar to the Rito del Medio sample except for higher counts of pyloric caeca, 31-54 (41.4).

The Rito Primero is near Lake Fork Creek whose sample was rated as grade B. The Lake Fork sample, as discussed, reveals evidence of hybridization from non-native cutthroat trout but not from rainbow trout.

The stronger rainbow trout influence on the characters of the samples from the Rito del Medio and from the Rito Primero is responsible for their separation from the samples rated as A and B in the computer printout.

Grade F samples.

Latir Creek, Taos Co. T30N, R13E, S15. Sample of 16 specimens 92-197 (128) mm SL. Latir Creek was not located on my map but I assume it is part of the drainage originating on Latir Peak which eventually joins the Rito del Medio just before the del Medio joins the Rio Grande.

This sample represents a predominantly rainbow trout population with only a trace of cutthroat trout genes. One of 16 specimens has a single basibranchial tooth. Scale counts are only slightly higher than expected for hatchery rainbow trout, 120-159 (134). Counts of fin rays and of branchiostegal rays average one or two higher than in the grade A or B samples. The spotting pattern is typical of rainbow trout except that there is sufficient variability to indicate a slight cutthroat trout influence.

Sawmill Creek, Taos Co. T27N, R15E, S17. Sample of 12 specimens 57-171 (126) mm SL. Sawmill Creek was not found on my map. It is probably part of the Canadian River drainage. This sample is predominantly rainbow trout with only a slight cutthroat trout influence. Scale counts (mean of 124) are typical of hatchery rainbow trout. Other characters similar to Latir Creek sample except that 5 of 12 specimens each with a single basibranchial tooth. It is interesting to note that the overwhelming influence of rainbow trout genotypes in both the Latir and Sawmill samples is only weakly expressed in pyloric caeca numbers (means of 42 and 44). Although the pyloric caeca number characterizing various forms of rainbow trout stocked over the years in New Mexico is not known, I assume that it would be typical of hatchery rainbow trout in general -- about 50 to 60.

This present study conforms to previous studies on rainbow x cutthroat hybridization in that of all differentiating characters between rainbow and cutthroat trouts, the cutthroat influence generally predominates in determining the number of pyloric caeca.

MANAGEMENT CONSIDERATIONS

I would urge that a more action-oriented program of restoration and protection be initiated by the New Mexico Department of Game and Fish and the U.S. Forest Service. As top priority I would suggest action be taken soon to preserve the cutthroat trout in Luna Creek. Although I ranked the Luna samples as grade B, the rareness of trout that phenotypically are typical of *S. c. virginalis* in the Canadian River basin makes the Luna Creek population of special concern. Propst (1977) made an intensive survey of trout in the Canadian River basin and found only a single population, in Little Blue Creek, to be typical of *virginalis*. Propst also emphasized the precarious future faced by the cutthroat trout in Little Blue Creek amidst overwhelming numbers of brown trout. Brown trout were also found in the samples from the east and west forks of Luna Creek. It is probable that the cutthroat trout in both Little Blue Creek and Luna Creek will become extinct in a relatively few years if something is not done. The most feasible solution would be to remove as many cutthroat trout as possible and hold them while the stream is chemically treated to eliminate all brown trout downstream to a point where a natural or artificial barrier occurs. This management technique has been widely used by Lloyd Hazzard, southwestern regional fisheries biologist with the Colorado Division of Wildlife to establish several new populations of Rio Grande cutthroat trout.

It will be necessary to learn more about the interaction of cutthroat trout and brown trout in New Mexico in order to develop management strategies that can favor the cutthroat over the brown. When the two species occur together, two factors may strongly tilt the balance in favor of the brown trout -- angling and land use practices influencing a watershed. Of the common species of trout -- brook, brown, rainbow, and cutthroat -- the ranking of resistence to being caught by anglers is: brown > rainbow > brook > cutthroat. That is, the brown trout is the most difficult trout to exploit and the cutthroat the most vulnerable to exploitation by anglers. I estimate that the order of magnitude between the susceptibility between brown trout and cutthroat trout to angling exploitation is about 20 fold. Thus, if brown trout and cutthroat trout occurred in equal numbers in a stream and the stream is exposed to angling pressure, about 95% of the catch is likely to be cutthroat trout. This differential vulnerability to angling can give the brown trout a tremendous advantage over the cutthroat with all other factors equal.

In the South Platte River, near Denver, a heavily fished section of the river consists of 70% brown trout and 30% rainbow trout (despite heavy stocking of catchable rainbow trout). An immediate upstream section under catch-and-release (no kill) regulations, and no stocking, has about 70% rainbow trout and 30% brown trout (data from R. Barry Nehring, Colo. Div. Wildlife). It is apparent that under normal regulations in the South Platte R. brown trout are favored over rainbow trout because the rainbow is more vulnerable to being caught. Because of this, the ratio of the two species is not an accurate reflection of their niche potential in that section of the river. That is, it is erroneous to assume that brown trout are dominant because they are favored over the rainbow by the environmental factors of the particular section. They are favored because of differential angler catch.

In the Lewis River of Yellowstone National Park, a catch-and-release (no kill) regulation was instituted in 1974. At the time (under normal regulations) electrofishing surveys showed brown trout and brook trout to occur at a 50/50 ratio; although 90% of the angler catch was brook trout. By 1978, under the catch-and-release regulation, the brook trout became dominant over brown trout by 90% to 10% (1978 and 1979 Yellowstone Park annual fish management reports).

Thus, one solution to a situation where brown trout threaten the Rio Grande cutthroat is to institute catch-and-release regulations on the cutthroat and retain the standard regulations on other trout. However, this solution may not always be practical. To insure high survival of trout caught and released, angling must be restricted to flies and artificial lures. About a 95% survival is obtained with trout caught on artificial flies and lures (no real difference between flies and lures or single or treble hooks or barbed and barbless hooks), but only about a 60% survival can be expected from bait caught trout that are released.

Land use practices as they influence flows, temperatures and sediment load can also favor brown trout over cutthroat trout. As emphasized by Propst (1977), livestock grazing exerts a severe negative impact on most of the New Mexican streams with cutthroat trout that he examined.

An overgrazed watershed with accelerated erosion has magnified amplitudes of flood flows, higher temperatures and high sediment loads during high flows (in the spring when cutthroat spawn). Brown trout spawn in the fall during low water periods when even normally turbid streams typically run clear. Thus, the incubation of brown trout eggs in flows with low sediment loads are in an advantageous position in relation to the spring spawning cutthroat trout in watersheds with accelerated erosion. Also, the eye of the brown trout is specially adapted to perceive in dim light which gives them an advantage in turbid waters.

As a start in learning more about the biology of Rio Grande cutthroat trout, the ranking system in this report can be useful. What is it about the streams that have A and B grade populations in relation to the streams that have obvious hybrids, or streams where cutthroat are completely gone? What are the common denominators, the cause-and-effect relationships of elevation, size of stream, flow and temperature regime, gradients -- the characterization of a stream and its watershed? If such a study was to be undertaken by competent biologists, an overall picture should emerge delineating the factors acting positively and negatively on cutthroat trout and some solutions to problems should become apparent.

A habitat management plan (2620) was written for the Rio Grande cutthroat in 1971 by the Santa Fe National Forest. Among the points brought out in the plan was the significance of riparian vegetation and the need to protect it from livestock impact, and the need to maintain environmental quality of the watersheds to reduce erosion. To my knowledge, there has been no concerted efforts made to implement this plan.

One problem with implementation of well meaning habitat management plans concerns continuity of concerned biologists. The 1971 plan for the Santa Fe Forest was developed by Mr. Don Duff who soon after transferred to a Forest Service job in Montana. Later Mr. Duff transferred to a job with the BLM in Utah and only recently he has been assigned to work with the Forest Service again. Along the way, Mr. Duff has accumulated considerable experience and expertise on livestock interactions with fish and wildlife. His expertise, however, has not yet been utilized by the federal agencies to implement meaningful true multiple use habitat management plans that restore and protect trout habitat in conflict with livestock grazing.

In a recent publication (Behnke 1979b) I discussed another problem common to meaningful protection of fish and wildlife values in conflict with other uses. This concerns a knee-jerk response to initiate "research" projects to solve problems without asking the right questions to begin with. For example, if it is found that a population of Rio Grande cutthroat trout are threatened by habitat degradation induced by livestock grazing, no amount of research on water quality, coliform bacteria, insect diversity indices, age-growth, food habits, etc. can be of any value to solve the problem. The problem simply is one of range management, not fishery and wildlife biology. A grazing system must be designed that reverses the trend of accelerated erosion and restores riparian vegetation.

I hope that this report might stimulate some determined action to activate a viable multiple use management program on National Forests lands that would enhance the abundance of the Rio Grande cutthroat trout and reverse the decline of this beautiful trout that began more than 100 years ago.

LITERATURE CITED

Barker, R. E. 1968. A New Mexico native -- cutthroat -- how they're grown. New Mex. Wildlf., July-Aug. 1968:2-4.

Behnke, R. J. 1979a. Monograph of the native trouts of the genus *Salmo* of western North America. U.S. Fish and Wildlife Serv., Denver, CO:215p.

Behnke, R. J. 1979b. Values and protection of riparian ecosystems. p. 164-167 in G. A. Swanson (Tech. Coord.). The mitigation symposium. U.S. For. Serv., Rocky Mtn. For., Rng. Exp. Sta., Gen. Tech. Rep. RM-65.

Behnke, R. J. 1980. A systematic review of the genus *Salvelinus*. p. 441-480 in E. K. Balon (ed.). Charrs salmonid fishes of the genus *Salvelinus*. W. Junk, the Hague, Netherlands.

Propst, D. L. 1977. Taxonomic analysis of cutthroat trout, *Salmo clarki* spp., collected in northern New Mexico, 1976. Final Rep. 516-64-22, New Mex. Dept. Game and Fish:77p.

Stork, E. F. 1975. Distribution of the Rio Grande cutthroat trout in the Santa Fe National Forest. M.S. Thesis, Colo. St. Univ.:55p.

Wernsman, G. R. 1973. Systematics of native Colorado cutthroat trout. M.S. Thesis, Colo. St. Univ.:57p.

REPORT ON SAMPLES OF CUTTHROAT TROUT FROM THE UPPER MISSOURI RIVER BASIN, MONTANA

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October 1980

Two subspecies of cutthroat trout are native to Montana. Both subspecies have suffered enormous declines and have been almost completely replaced by non-native trouts in most waters of the state. The trout native to the upper Missouri drainage (excluding Yellowstone drainage), *Salmo clarki lewisi*, has a broad and disjunct distribution on both sides of the Continental Divide. Within this distribution, *S. c. lewisi* manifests distinct ecological specializations--lacustrine, resident small stream, and migratory from small streams to larger rivers. A management strategy for *S. c. lewisi* should include the preservation of the genetic diversity of both ecological and geographical forms. The significance of the present collection of specimens is that they represent the upper Missouri drainage, a geographical area from which previous studies have indicated the native cutthroat trout to be very rare.

STATUS OF *S. c. lewisi*

Since the completion of Roscoe's (1974) thesis on *S. c. lewisi* I have been involved in further study on this trout and new publications (Loudenslager and Thorgaard 1979; Loudenslager and Gall 1980) have contributed new information on the systematics of *S. c. lewisi*.

Cutthroat trout became fractioned into three major groups prior to the last glacial epoch. East of the Cascade Mountains, the interior cutthroat trout separated from the coastal cutthroat and then divided into two basic forms, one in the northern parts of the Columbia River basin and one in the Snake River division of the Columbia. The differences between these two interior forms are apparent in coloration and spotting pattern and in chromosome numbers. The northern Columbia form of cutthroat trout has small, irregular shaped spots, the genetic potential to develop brilliant coloration (if crustaceans are common in the diet), and 66 chromosomes. The Snake River form of cutthroat trout has large, roundish spots, lacks the genetic basis for brilliant colors, and has 64 chromosomes.

From the Snake River drainage, the ancestral cutthroat trout gave rise to several subspecies in the Great Basin, Colorado River, South Platte River, and in the Rio Grande. After the last glaciation, the large-spotted Snake River cutthroat trout crossed the Continental Divide into the Yellowstone drainage and became established downstream to the Tongue River. Also after the last glaciation (about 7,000 to 10,000 years ago), the small-spotted upper Columbia River cutthroat trout crossed the Continental Divide to become established in the South Saskatchewan and upper Missouri basins. In the Missouri, continuous distribution, in historical times, extended downstream to about Fort Benton. No trout were native to the Black Hills near the junction of the Missouri and Yellowstone. Thus, there has always been a substantial gap in distribution between the two subspecies east of the Continental Divide.

Despite the clear-cut distinctions between the two subspecies of cutthroat trout native to Montana there has been a great deal of taxonomic confusion surrounding them. A specimen of cutthroat trout collected near Great Falls was named "Salar lewisi" in 1856. Thus, the name lewisi is the correct subspecific name for the trout native to the upper Missouri drainage and for all cutthroat trout sharing their most recent common ancestry with the upper Missouri cutthroat (as interpreted from the taxonomic characters). Besides the upper Missouri drainage, S. c. lewisi is native to the upper Columbia (Kootenai, Pend Oreille-Flathead, and Spokane-St. Joe drainages) in Montana, British Columbia, and Idaho, the Salmon and Clearwater drainages of the Snake River division of the Columbia in Idaho, the John Day River drainage of the middle Columbia basin in Oregon (identified in 1980), and to the South Sakatchewan drainage of Montana and Alberta. There is considerable variability in some taxonomic characters among S. c. lewisi from widely scattered parts of its range, but its spotting pattern is consistently uniform and unique, readily distinguishing it from all other trouts.

Throughout its range, S. c. lewisi has suffered great declines in distribution and abundance but it is much more common in the Columbia River basin than in the South Saskatchewan and Missouri drainages. A management plan for S. c. lewisi in Montana should give priority to securing the preservation of representative populations in the upper Missouri and South Saskatchewan drainages.

RESULTS OF EXAMINATION

Thirteen samples consisting of 95 specimens collected in the Elkhorn Mountain area (Jefferson River drainage?) were examined and evaluated for relative purity. All samples are predominantly S. c. lewisi (about 90% or more pure). The effects of a slight introgression from rainbow trout is indicated by the spotting pattern and lack of basibranchial teeth in some samples. This may be due to a gradual infiltration of rainbow trout genes from a predominantly rainbow trout population downstream in the watershed. Unless the hybrid influence is of recent origin, I assume that the overwhelming predominance of the native genotype indicates that the present environment strongly favors the native genotype, and any disruption of this environment would likely stimulate and greatly increase the hybrid influence.

In Montana, introductions of rainbow trout and of Yellowstone cutthroat trout result in hybridization with S. c. lewisi. A hybrid influence from rainbow trout, depending on the magnitude, can be detected by a change in the spotting pattern (spots are larger, particularly anteriorly, spots occur anteriorly below the lateral line and on top of the head), loss and reduction of basibranchial teeth, increased numbers of pyloric caeca and decreased numbers of scales (rainbow trout lack basibranchial teeth, have about 50 to 60 caeca and about 25 to 30 scales above the lateral line and 120 to 140 scales in the lateral series). Yellowstone cutthroat trout have large, roundish spots, more-or-less evenly distributed over the sides of the body, have 20-21 gillrakers (with good development of posterior rakers), typically 20-25 basibranchial teeth and 40-45 caeca.

Most specimens are less than 100 mm which makes accurate assessment of spotting pattern and basibranchial teeth difficult. Typically, a hybrid spotting pattern is not apparent until a fish is about 150 mm and basibranchial teeth continue to arise until a fish is about 100 mm.

The precise manifestation of a hybrid influence can not be predicted. No two hybrid populations are the same--the unlimited potential for recombination makes for uneven expression of characters. Typically, in S. c. lewisi, spotting pattern and basibranchial teeth are the most sensitive indicators of a hybrid influence, but they may not be concordant. For example, most of the specimens from Dutchman Creek lack basibranchial teeth but the spotting pattern and all other characters indicate pure *S. c. lewisi*. On the other hand all 11 specimens from upper McClellan Creek have basibranchial teeth but some specimens have an obvious hybrid spotting pattern.

Evaluation of each sample is as follows:

Prickley Pear Creek (N=6) lowest gillraker count (17.6) and highest lateral series scale count (196), but no indication of a hybrid influence. All specimens have basibranchial teeth and spotting pattern is very typical of pure *S. c. lewisi*.

Muskrat Creek (N=1) Only one specimen. The number of gillrakers (21) and basibranchial teeth (14) would suggest a Yellowstone cutthroat influence, but the spotting pattern is typical of *S. c. lewisi*.

Silver Creek (N-5) Lateral series scale counts are low (158) and mean number of basibranchial teeth are somewhat low (3.4), but all specimens have teeth and there is no indication of a hybrid influence in the spotting pattern.

Dog Creek (N-10) Although scale counts are somewhat low (42 above lat. line and 161 in lat. series), spotting and other characters are typical of pure *S. c. lewisi*.

Stauback Creek (N=6) One specimen lacks basibranchial teeth and the other 5 have only 1 to 3 teeth. However, spotting and other characters typical of *S. c. lewisi*. I suspect this population has a very slight influence (ca .5% or less) from rainbow trout, but the rainbow trout genes are only expressed by a slight suppression of basibranchial teeth.

Main Fork Beaver Creek (N=6) Four specimens lack basibranchial teeth and some specimens have spots below lateral line anteriorly and have unusual parr marking. This population may have about 10% rainbow trout hybrid influence.

Dutchman Creek (N-10) Seven of 10 specimens lack basibranchial teeth but all other characters typical of pure *lewisi*. All four specimens less than 100 mm lack basibranchial teeth and three of six specimens more than 100 mm lack teeth. I assume that some hereditary influence from rainbow trout suppresses the development of basibranchial teeth in this population, but does not affect other characters.

East Fork McClellan Creek (N=10) Four of 10 specimens lack basibranchial teeth (all more than 100 mm), some specimens with hybrid spotting pattern (larger spots, anterior spots below lateral line and on top of head). Probably at least 10% rainbow trout influence in this population.

Upper McClellan Creek (N=11) The larger specimens in this collection have a hybrid spotting similar to the sample from the East Fork of McClellan Creek, but all 11 specimens from upper McClellan Creek have basibranchial teeth. The number of teeth is low (1-5 [2.2]), suggesting a slight suppression effect from rainbow trout genes.

Crystal Creek (N=8) Slight hybrid spotting pattern. Largest specimen with spots on top of head. Second largest specimen with hybrid type of body spots. Other characters typical of *S. c. lewisi*.

Teepee Creek (N=8) Largest specimen with large spots on body and on top of head; aberrant parr marks. Two of three specimens more than 100 mm with basibranchial teeth; four of five specimens less than 100 mm lacking basibranchial teeth. Perhaps 10% hybrid influence from rainbow trout.

Willard Creek (N=8) No indication of hybrid influence in spotting pattern but five of eight specimens lack basibranchial teeth (3 of 6 specimens more than 100 mm lack teeth).

South Fork Warm Springs (N=6) Two largest specimens with hybrid spotting pattern. All specimen with basibranchial teeth and other characters typical of *S. c. lewisi*.

FINAL COMMENTS

Most of the samples have some indication of a hybrid influence from rainbow trout and because of the small size of the samples and the small size of the specimens I would not certify any sample as pure *S. c. lewisi*. However, the hybrid influence is small, probably not exceeding 10% of the hereditary background in any of the populations that these samples were drawn from. For identification purposes these populations should be recognized as *S. c. lewisi* because they overwhelmingly retain the native genotype.

Native cutthroat trout are rare in the upper Missouri basin and the Elkhorn Mountain region appears to be a stronghold for populations that are predominantly *S. c. lewisi* with some streams probably containing pure populations. From past experience, I have found that land-use practices such as clear-cutting, grazing, mining, road building, etc. that increase sediment loads and temperature will act to stimulate and increase a hybrid influence and/or replace the native trout with non-native trout if they have access to the habitat. These considerations should be taken into account for any multiple use activity in these watersheds that may modify the present environmental regime that currently favors the maintenance of the native cutthroat trout.

LITERATURE CITED

Loudenslager, E. J. and G. H. Thorgaard. 1979. Karyotype and evolutionary relationships of the Yellowstone (*Salmo clarki bouvieri*) and west-slope (*S. c. lewisi*) cutthroat trout. J. Fish. Res. Bd. Canada 36:630-635.

Loudenslager, E. J. and G. A. E. Gall. 1980. Geographic patterns of protein variation and subspeciation in cutthroat trout, *Salmo clarki*. Systematic Zoology 29:27-42.

Table 1. Selected meristic characters.

Locality	Gillrakers	Scales above l.l. and lateral series	Pyloric caeca	Basibranchial teeth	Remarks
Prickley Pear Crk. N=6	16-19 (17.5)	40-47 (42) 192-199 (196)	28-39 (33)	2-9 (5)	Spotting typical of <u>Lewisi</u>
Muskrat Crk. N=1	21	41 185	36	14	Typical <u>lewisi</u> spotting
Silver Crk. N=5	17-19 (18.0)	37-42 (40) 153-166 (158)	29-34 (31)	2-5 (3.4)	Typical <u>lewisi</u> spotting
Dog Crk. N=10	16-21 (18.6)	36-41 (35) 148-174 (161)	27-43 (33)	1-16 (6.2)	Typical <u>lewisi</u> spotting
Stauback Crk. N=6	18-21 (19.6)	42-45 (43) 189-195 (192)	26-29 (27)	1 no teeth 5 w/1-3 (2)	Typical <u>lewisi</u> spotting
Main Fk. Beaver Crk. N=6	17-21 (18.8)	38-44 (41) 172-204 (188)	27-36 (33)	4 no teeth 2 w/1-2	Some hybrid spotting
Dutchman Crk. (Above forks) N-10	17-19 (18.0)	36-43 (40) 179-199 (191)	29-35 (32)	7 no teeth 3 w/3 each	Typical <u>lewisi</u> spotting
E. Fk. McClellan Crk. N=10	18-20 (19.2)	39-47 (43) 174-203 (190)	29-39 (33)	4 no teeth 6 w/1-6 (3)	Some hybrid spotting
Upper McClellan Crk. N=11	17-19 (18.3)	40-47 (44) 185-209 (194)	28-34 (31)	1-5 (2.2)	Some hybrid spotting
Crystal Crk. N=8	18-20 (18.8)	32-44 (39) 163-191 (179)	26-36 (31)	1-8 (3)	Slight hybrid spotting
Teepee Crk. N=8	18-22 (19.6)	43-46 (44) 178-195 (187)	26-35 (29)	5 no teeth 3 w/1-2	Some hybrid spotting

Table 1. (continued)

Locality	Gillrakers	Scales above l.l. and lateral series	Pyloric caeca	Basibranchial teeth	Remarks
Willard Crk N=8	17-19 (18.0)	35-40 (38) 178-195 (187)	24-33 (28)	5 no teeth 3 w/2-11(6)	Typical *lewisi* spotting
So. Fk. Warm Springs Crk. N=6	17-20 (18.5)	39-46 (42) 182-203 (192)	31-38 (36)	2-7 (3.2)	Slight hybrid spotting