REPORT ON COLLECTIONS OF CUTTHROAT TROUT FROM GLACIER NATIONAL PARK

Evaluation of purity of specimens collected in 1978.

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INTRODUCTION

A single species and subspecies of trout (genus Salmo) is native to all drainage basins of Glacier National Park (Columbia River system, South Saskatchewan River system, and upper Missouri River system). This fact has not been clearly understood nor delineated in past fisheries activities in the Park and has resulted in considerable confusion.

Park waters have a long history of introductions of nonnative trout. The cutthroat trout of Yellowstone Lake, a subspecies distinctly different from the native trout, was the most widely and abundantly introduced trout, but other species such as rainbow, brook and brown trout, lake trout, kokanee salmon and lake whitefish were also introduced.

The replacement of the native trout by the introduced species is a major problem confronting the Park Service's goal of preserving and restoring native fauna. Basic to this goal is the documentation of the occurrence of the native trout, a correct taxonomic diagnosis of the native subspecies, and the identification of hybrid populations.

No previous study on this subject has been undertaken in the Park because the problem was believed to be insoluble. This mistaken notion essentially can be traced to the studies of Schultz (1941) and to the general belief that the cutthroat trout species is so variable that the validity of subspecies determination could never be verified. Schultz believed that the coastal cutthroat trout, S. clarki clarki, is the native trout in the Columbia (Flathead) River basin in the Park and that the Missouri basin lakes and streams held S. c. lewisi. He also assumed that the Yellowstone Lake trout is S. c. lewisi,but mentioned that trout resembling the greenback cutthroat trout, S. c. stomias, inhabited Park waters (these are actually introduced Yellowstone Lake cutthroat trout).

A reading of Schultz' 1941 publication conveys an attitude of hopelessness that the taxonomy of the native trout would ever be satisfactorily worked out. Because of the massive introductions of nonnative species and subsequent hybridization, it appeared that the correct identification of native trout would be an impossible task.

The basic problem, however, was that no one had ever accumulated sufficient data on the cutthroat trout species from throughout its range to make accurate diagnoses of all of the subspecies. During more than 20 years of study on cutthroat trout taxonomy I believe I now have the necessary data on which to correctly define the many subspecies. In recent years, my taxonomic arrangement also has been supported by other evidence such as chromosome numbers and gene loci data (electrophoresis).

Several years ago it became apparent to me that the trout native to the upper Missouri basin (S. c. lewisi) also is the native trout of the South Saskatchewan River drainage and the upper Columbia River basin. The Yellowstone Lake trout is derived from a distinctly differentiated ancestor crossing the Continental Divide from the Snake River drainage into the Yellowstone River drainage. The subspecific designation of the

Yellowstone trous is Salmo clarki bouvieri. S. c. lewisi and S. c. bouvieri never came into contact in the Missouri River basin (although they occur within a few miles of each other in headwater tributaries in their respective drainages in Yellowstone National Park) and thus have remained distinct. The spotting pattern and (potential) coloration between the two subspecies is entirely different and field separation to one subspecies or the other can be readily made (but a slight hybrid influence cannot be determined from external examination). The Yellowstone cutthroat trout has large, roundish spots more or less evenly distributed on the body. S. c. lewisi has a profusion of small, irregularly shaped spots concentrated posteriorly with few or no spots occurring in an area of an arc from the anal fin to the pectoral fin. S. c. lewisi has the genetic potential to develop brilliant red, yellow, or orange coloration, but the pigments must be derived from the diet and are also dependent for expression on age and sex. S. c. bouvieri lacks the genetic basis for brilliant coloration. They typically exhibit brownish-yellow base colors with some tints of pink or orange occasionally appearing on old specimens (particularly males).

The details of the taxonomy and distribution of S. c. lewisi and S. c. bouvieri was the subject of a graduate thesis by Roscoe (1974).

In the specimens examined in the present study I found several characters correlated with the spotting differences between the two subspecies. There is a clear-cut distinction between the two subspecies in the number of gillrakers on the posterior side of the first gill arch. There are significant differences in the number of anterior gillrakers and in the number of basibranchial teeth. A total of 12 characters were recorded from all specimens and the data were run in two multi variate analysis computer programs, one for principal component analysis and one for discriminant function analysis. The computer printout assisted in the evaluation of possible hybrid influence in the S. c. lewisi samples.

This present study is unique in that the specimens used in the morphological analysis were also used for electrophoretic analysis to detect gene loci differences between the two subspecies and evaluate hybridization. This is the first attempt to correlate electrophoretic data with morphological data on the same samples of fish. The report on the results of the electrophoretic analysis is being prepared at the University of Montana.

This present study is based on samples from five lakes in the North Fork of the Flathead River drainage, totalling 142 specimens.

DISCUSSION OF RESULTS

Evangeline Lake

The trout in Evangeline Lake are judged to represent a pure population of the introduced Yellowstone cutthroat trout. Evangeline Lake is at the headwaters of Camas Creek. A high barrier falls occurs between Evangeline Lake and Arrow Lake, further downstream. Evidently, Evangeline Lake was barren of fish before it was stocked with 90,000 eggs and fry of Yellowstone Lake trout in 1925 and 1935.

The 30 specimens from Evangeline Lake are identical to Yellowstone Lake trout, with large, pronounced, roundish spots. Undoubtedly, it was the introduced Yellowstone Lake trout that Schultz (1941) referred to as "S. c. stomias-like" trout in Park waters. The Evangeline Lake specimens differ from the native trout samples in their more numerous gillrakers, 19-22 (20.7) and basibranchial teeth (8-44). There is a clear-cut (non-overlap) difference in the number of gillrakers on the posterior side of the first gill arch: 3-16 in Evangeline Lake specimens; 0, 1, or 2 in native trout.

Arrow Lake

Examination of 30 specimens from Arrow Lake revealed 28 specimens identified as the native trout, S. c. lewisi, and two specimens of the nonnative S. c. bouvieri, based on spotting pattern. The two specimens, numbers 16 and 17 are 180 mm and 185 mm total length and evidently moved downstream from Evangeline (or Camas) Lake over the barrier falls. The number of gillrakers and basibranchial teeth also identify these specimens as Yellowstone trout. If specimens 16 and 17 resulted from hybridization, a gradual transition in characters in the sample would be expected. This did not occur, these two specimens are sharply differentiated from the other 28 specimens and the computer identified them with the Evangeline Lake sample.

Almost certainly some hybridization between S. c. bouvieri moving down from above the barrier falls and S. c. lewisi in Arrow Lake must have occurred over the last 50 years. There is some evidence for this assumption in the data analysis. Two specimens with high numbers of basibranchial teeth are specimens 4 and 19 from Arrow Lake with 15 and 13 teeth, respectively. I found no basibranchial teeth in specimens 3, 8, 13, 22, and 29. The lack of basibranchial teeth indicates hybridization with rainbow trout.

Although the Arrow Lake sample may be considered the "most hybridized" of any of the samples, the hybrid influence is small. The Arrow Lake population is overwhelmingly S. c. lewisi genotype and is identified as S. c. lewisi (but not pure). A hybrid influence is not apparent from external appearances. Obviously, the Arrow Lake population has been exposed to hybridization (not only from migration from above but also from the introduction of 122,000 eggs and fingerlings of Yellowstone Lake trout into Arrow Lake in the 1920's and 30's), and has resisted genetic swamping. Natural selection must strongly favor the native genotype and negative selection must occur against S. c. bouvieri and hybrids. This would be expected in any population living and adapting to the same environment for perhaps several thousand years. They should have a definite selective advantage over nonnative groups of the same species as long as the environment does not change. In this regard, a cestode parasite may play a role in favoring the native subspecies. I found the most severe infestation of parasites in Arrow Lake specimens, but they showed no indication of ill effects -- they are fine, robust fish. The evolution of the native population with a parasite should promote adaptations to lessen negative impacts of parasite infection. The Yellowstone Lake cutthroat trout evolved with different parasite species and may lack the particular physiological adaptations of the native trout for tolerating the parasite burden.

Quartz Lake and Cerulean Lake

Quartz Lake is in the Quartz Creek drainage. It contains a population of native trout but was stocked with 8,500 cutthroat trout fry (probably of Yellowstone Lake origin) in 1940. Quartz Lake specimens are very similar to specimens from Cerulean Lake which lies above it in the drainage. The only significant difference noted in any character is the mean value of pyloric caeca (Table 1). The most sensitive indicator of a hybrid influence from Yellowstone Lake trout is the number of posterior gillrakers. Typically, S. c. lewisi has 0, 1, or 2 posterior gillrakers. Cerulean Lake sample averages 0.6 posterior rakers, the Quartz Lake sample 0.9, Logging Lake 1.1, and Arrow Lake 1.2; in the order from "purest" to "most hybridized". The Evangeline Lake sample averages 11.0 posterior gillrakers, typical of Yellowstone Lake trout.

Fish from Quartz Lake can migrate into Cerulean Lake and free mixing is theoretically possible. However, resident lake populations generally exhibit little movement out of lakes except for spawning. I would assume that the dominant movement would be of young fish (surplus reproduction) from Cerulean Lake into Quartz Lake.

The computer analyses (Figures 1 and 2) of the data treating all characters in various combinations places the Cerulean and Quartz Lake specimens most distant from Yellowstone trout as represented by Evangeline Lake specimens. Analyses of data and the remoteness of Cerulean Lake (no stocking records) indicates that this population is the purest of the groups examined. The Quartz Lake population is ranked a close second.

Logging Lake

Logging Lake is formed on Logging Creek and is the largest body of water sampled in the 1978 collections (about 6 miles long by .5 miles across). Phenotypically, the specimens appear to be wholly typical of

S. c. lewisi. The lake was stocked with 202,000 fingerling Yellowstone trout from 1934 to 1944. There is also possible movement of fish down from Grace Lake (believed to hold hybrids) and perhaps up from the North Fork of the Flathead River. The computer analyses of all characters did place some Logging Lake specimens toward Evangeline Lake specimens. The surprising aspect is that the Logging Lake population appears as pure as it is despite exposure to massive hybridization. As with Arrow Lake, the native genotype possesses superior adaptive and survival qualities in its undisturbed native environment and has resisted the influence of hybridization.

Discussion and Recommendations

The most significant result of this study of the taxonomy of samples from five populations is that native cutthroat trout can be identified from introduced cutthroat trout with certainty. None of the populations are obviously hybridized. Considering all of the information, the ranking from "most pure" to least pure" is in the order, Cerulean, Quartz, Logging, and Arrow. In this case I would consider the "least pure" to still be on the order of 90-95% pure *S. c. lewisi*. Thus, for classification purposes, and all practical purposes (except for reintroductions) all the samples, except Evangeline Lake (*S. c. bouvieri*), should be classified as *S. c. lewisi*. The massive numbers of Yellowstone cutthroat trout stocked into these drainages have not significantly altered the native genotypes. The Yellowstone trout is established only in the originally barren Evangeline Lake. The presence of two Evangeline Lake fish among the sample of 30 specimens from Arrow Lake (and no obviously intermediate specimens) suggests that Yellowstone Lake trout from above are continually mixing into the Arrow Lake population, but are not contributing, to any extent, to reproduction. Obviously, they are at a severe competitive disadvantage with the native fish. As mentioned, the heavy level of parasite infestation in Arrow Lake may be one of the selective factors favoring the native trout.

The cestode parasite was most commonly found in the pyloric caecae. Specific identification of the parasite was not made but the scolex is without hooks as in Proteocephalus. I assume that the parasite has a completely aquatic life cycle, entering the fish via infected crustaceans in the diet. Thus this cestode should be absent from lakes barren of fish (none were observed in Evangeline Lake specimens). Antipa (1974) and Becker and Brunson (1968) discussed tapeworms identified (possibly incorrectly) as Proteocephalus amboplites, infecting trout in the Northwest.

Although, there was no observable ill effects of the parasite on the specimens examined (the largest, most robust specimens were often the most heavily infected), it would be adviseable not to spread the parasite. Thus, for introductions of native trout into barren waters, eggs or newly hatched fry could be used. If a lake is treated to eliminate non-native fish. A period of time (perhaps one year) without fish should eliminate the parasite.

It is not known if the relatively clear-cut results of this study will extend to other Park waters. Where the native trout were exposed to hybridization with rainbow trout, S. gairdneri, may be quite different situations in regards to hybrid resistance. There is a suggestion of a rainbow trout hybrid influence in Arrow Lake with 5 of 28 specimens (18%) lacking basibranchial teeth. However, no other character suggests a rainbow influence. Typically, I expect pure populations of cutthroat trout to have basibranchial teeth in 90% or more of the population.

It is now clear that the native trout of Glacier National Park can be positively identified and this is not such a complex problem as formerly believed. Field identification as S. c. lewisi can be based on observation of the consistency of the diagnostic spotting pattern. Populations of suspected hybrids or populations considered as a source for introductions will require a more detailed study of specimens.

Literature Cited

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TABLE 1. Character Variation

Sample	Gillrakers	Scales	Basibranchial	Pyloric caeca
Evangeline N=30 (+2 from Arrow L.)	19-23 (20.7) ant. 3-16 (11.0) post.	35- 49 (43.6) 158-206 (177.8)	8-44 (18.0)	31-49 (38.5)
Arrow N=28	16-20 (18.4) 0- 2 (1.2)	37- 46 (40.9) 163-211(182.8)	0-15 (4.4) 5 w/o teeth (18%)	30-43 (35.0)
Logging N=35	17-21 (19.0) 0- 2 (1.1)	33- 45 (38.6) 141-186(166.5)	0-16 (7.2) 1 w/o teeth (3%)	29-45 (36.1)
Quartz N=30	16-20 (18.2) 0- 1 (0.9)	34- 42 (37.8) 156-195(170.7)	0-12 (6.2) 1 w/o teeth (3%)	33-57 (42.4)
Cerulean N=17)	16-21 (18.6) 0- 2 (0.6)	34- 42 (37.8) 157-185(169.1)	0-13 (5.1) 1 w/o teeth (6%)	26-41 (34.2)

FIGURES

Figures one and two are graphic representation of the specimens arranged according to the morphological data. Figure 1 is the results of a principal component analysis and figure two represents a discriminant function analysis. The major difference between these two types of multivariate analyses is that with principal components, the data from the specimens are not identified with any group, whereas in discriminant function the specimens are assigned to known groups (Arrow Lake, Cerulean Lake, etc.). Principal component analysis stresses variance between groups and discriminant function emphasizes the variance between individuals. Principal components is an identification statistic (identification of unknown specimens) and discriminant function is more of a classification statistic (testing the "goodness of fit" between groups of predetermined classification).

Both techniques clearly show the separation of the native S. c. lewisi specimens from the nonnative Yellowstone Lake cutthroat trout and also classified the two specimens of Yellowstone trout found in Arrow Lake with the Evangeline Lake specimens. The "centroids" depicted on Figure 2 are the "mean of means" for a particular sample. Note the horizontal distance between the four centroids representing S. c. lewisi and the Evangeline Lake centroid. Some specimens from Logging Lake and Arrow Lake are oriented toward Evangeline Lake specimens, but the tightness of the clusters and lack of transitional specimens indicates any hybrid influence is slight.

Figure 3 illustrates the spotting pattern of *S. c. bouvieri* and Figure 4 the spotting of *S. c. lewisi*. *S. c. bouvieri* may be highly variable in spotting pattern in different geographical areas. Spots may vary from sparse to abundant and may be generally distributed on the body or concentrated posteriorly. *S. c. lewisi* (pure populations) are less variable in spotting pattern, but the two subspecies are always distinct in the size and shape of the spots. The spots are large, rounded and more-or-less smooth in outline in *S. c. bouvieri*. In *S. c. lewisi* the spots are small, irregularly shaped and concentrated on the caudal peduncle area.

Figure 5 depicts the known distribution of *S. c. lewisi*. This subspecies is the only trout of the genus *Salmo* indigenous to Glacier National Park.

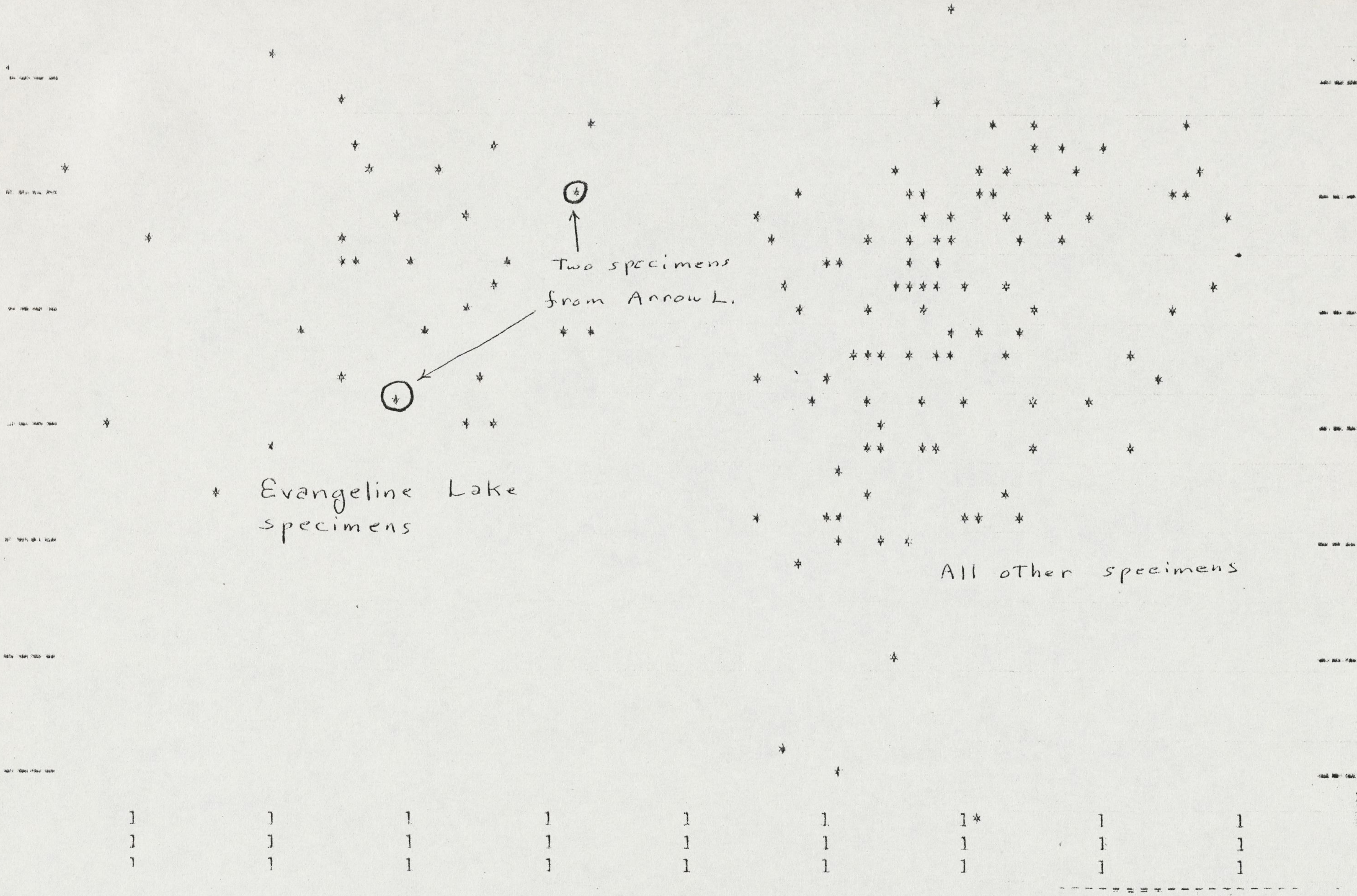

FIGURE 1. Principal component analysis.

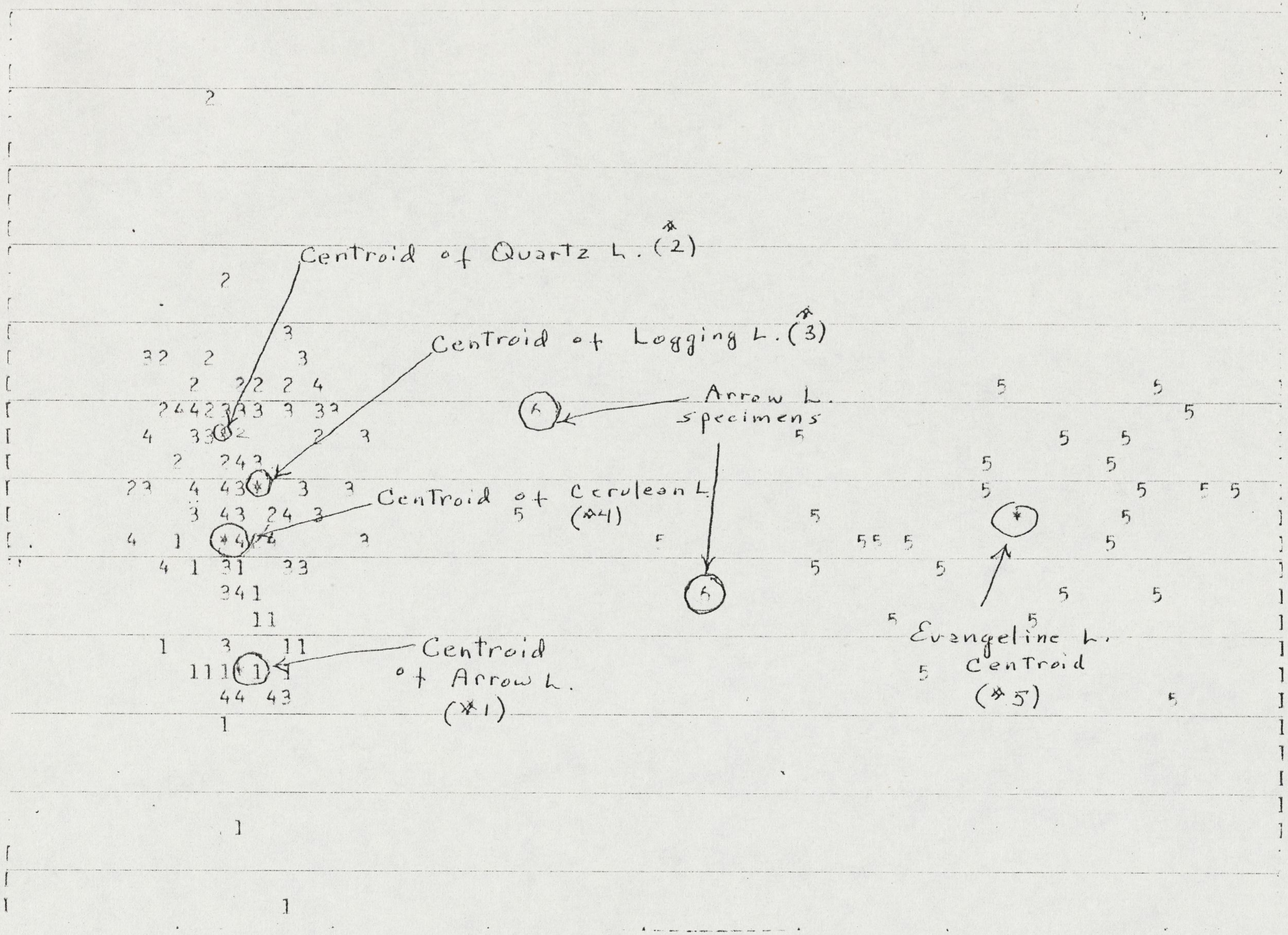

FIGURE 2. Discriminant function analysis.

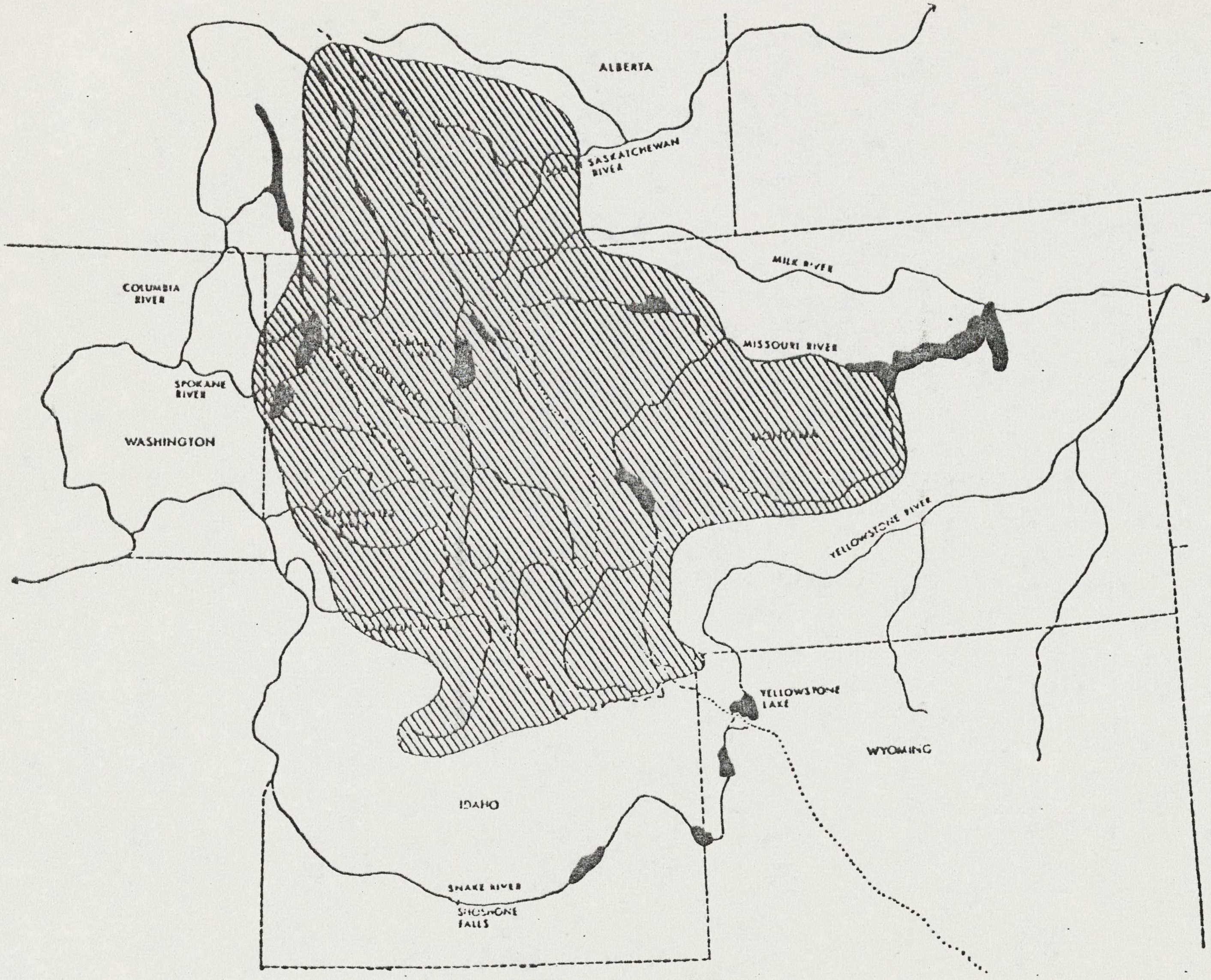

FIGURE 5. Distribution of Salmo clarki lewisi.