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A PRELIMINARY STUDY OF THE GENUS *PROSOPIUM*, WITH SPECIAL REFERENCE TO *PROSOPIUM WILLIAMSONI* (GIRARD)

by

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A preliminary study of the genus *Prosopium*, with special reference to *Prosopium williamsoni* (Girard)

INTRODUCTION

The suborder Salmonoidea, or the family Salmonidae in its broader sense, is a group of fishes characterized by the presence of an adipose fin. This character is also found in several other groups, but these have little likelihood of being confused with the salmon and their allies, since their affinity to this family is at the best very remote. The Salmonidae are found only in the north temperate zone and in the Arctic regions, but within this range are abundant wherever conditions are suitable to their existence. Most of the species are fresh water forms, living either in lakes or in rivers, or at times moving from one environment to the other as the occasion warrants. Some are anadromous, spending a part of their life in fresh water and a part in the sea, the migrations taking place at quite definite periods. The stream dwellers may enter the sea or lakes occasionally, but not as a general habit, while the lake forms generally spend the greater part of their life in the deeper waters, approaching the shore or running up streams at the spawning season.

As originally described, the family Salmonidae was made up of two subfamilies, the Coregoninae and the Salmoninae. However, it has been suggested that the differences are great enough to justify the formation of separate families, the basis of separation being the relation between the parietal and supraoccipital bones of the head. Thus the family Coregonidae includes those forms in which the parietals are united, and the family Salmonidae embraces those in which the parietals are separated by the supraoccipital (Koelz 1927). This follows current American usage.

In their recognition of the various species of the family Coregonidae the Europeans and Americans also differ. In the European sense of the word, Coregonus includes all the known species of whitefish and lake herrings. The Americans have divided these forms into various groups, giving them generic or subgeneric designations in various ways, but in the present paper the classification of Koelz will be followed. Koelz (1927) regards Leucichthys, Coregonus, and Prosopium as distinct genera and does not recognize the subgenera of Jordan and Evermann (1911).

DISTRIBUTION

The European genus Coregonus, which is approximately the same as the American family Coregonidae, is distributed almost completely around the world in the northern latitudes. Nowhere in America does its southern limit exceed the fortieth parallel, while in Europe this southern limit approximates the fiftieth degree of latitude. This distribution may also be applied with a fair degree of accuracy to the genus Prosopium, since it is represented by one or another of its species in practically all waters where Coregonus is found.

VARIABILITY

It has been demonstrated by Koelz (1929 and 1931) that the Coregonids are an extremely variable group. At the same time, many of the species are separated by comparatively small differences, so that the range of variation within a species may be greater than the difference between two apparently distinct forms. This last statement applies particularly to the genus Leucichthys, but it may be referred to Prosopium with almost equal emphasis.

The original concept of a species was much more definitely limited than is our present day view. It is now recognized that a species may be composed of a heterogeneous group, the extreme variants at either end of which may be very different in appearance. Although a group may have a wide distribution, the individuals of the group and their progeny are generally restricted to a comparatively limited locality. Thus environment is given the opportunity to work its effect, and variants having characteristics which fit them best for survival in any particular region will eventually become the dominant forms there. In a large lake, therefore, several varieties of a single species may be found. Since in such a case the range of the species in the lake is probably more or less continuous, intergrading forms will be found to exist, and this is ideally the criterion of a subspecies. On the other hand, it is likely to happen that a species may be found scattered in more or less isolated lakes or streams, or separated by natural barriers so that no intermingling is possible. In such a case, where the effects of latitude are at a minimum, it is quite possible to find two bodies of water which are closely situated geographically, differing greatly in physical characteristics such as depth, chemical composition of the water, temperature, and the like. In the same way, widely separated lakes or rivers may be almost exactly similar in physical characters. Since in a species the same mutation tends to recur with a fairly definite frequency, it will eventually supersede its parent if conditions are such that it is more adaptable to its surroundings. Thus, it is more likely to find varieties of a fish species distributed according to habitat than according to geographical location.

A definite tendency is evident in the work which has been done on the systematics of the Prosopium group to give names to types which have originated as a direct consequence of environment. It is quite evident to anyone who has any acquaintance with systematic work that a limit must be drawn somewhere in giving names to animals of any kind. In many cases this dividing line between species must be arbitrary if the species are not to be needlessly multiplied, otherwise in the extreme case we would have each individual a separate species.

The influence of environment on body form in fish has been demonstrated by several workers. Dymond and Hart (1927) refer to the work of Hubbs on the influence of temperature in determining the number of vertebrae, fin rays, and scales. It is found that these characters have a higher average count in fish which have developed at lower temperatures. Other factors, such as muscular development, may materially affect various body proportions, producing an apparently distinct race.

I believe also that confusion may have arisen in some cases as a result of the practice followed by some investigators of picking a single individual as the type specimen, and of drawing their description of the species from this one fish. An example of this procedure may be found in the work of Jordan and Snyder (1909) in their description of Coregonus oregonius. The description is given from the type specimen, which is described as the largest specimen known. The authors also include a table showing proportional measurements of five other individuals, and it is seen that the head and also the snout are relatively much shorter in the smaller fish. It is a characteristic of Prosopium williamsoni that in the breeding season the snout, and consequently the head, becomes much elongated in many cases, and it is quite likely that such is the case with Jordan and Snyder's species. This will be discussed further under the descriptions of the various species.

If it is necessary that a type specimen be selected for deposition in a museum, then it seems more reasonable that a considerable series should be examined, and an individual chosen which approximates most closely the average values of each of the characters studied.

SYSTEMATIC DISCUSSION

The recognition of Prosopium as a distinct genus is attributed to Koelz (1927) by Hubbs (Letter), but this first appeared in print in Hubbs' check list of the fishes of the Great lakes (1926). The chief difference between Prosopium and the other two species of Coregonidae is the presence of a single flap between the nostrils, as opposed to two flaps in Leucichthys and Coregonus. Another important feature which was not emphasized by Koelz, but which is stressed by Dr. Hubbs is the presence in the young of Prosopium of parr markings such as are developed in the young of the Pacific salmon. These are never present in the other two genera. Other distinguishing features of Prosopium are the small mouth, the absence of teeth, and the presence of a comparatively small number of short, thick gill rakers.

The oldest species name given to this group is Salmo cylindraceus Pallas, 1784. In a recent paper, Berg (1936) refers this species to the genus Prosopium, and, finding the American species Prosopium quadrilaterale to be only slightly different from the European species, regards it as a subspecies of the latter. Although considerable work has yet to be done before the relationships between the various species of this group are clear, it seems reasonable at present to divide them into three main groups. These groups are characterized by their general resemblance to the three definite species of Prosopium, namely cylindraceus, williamsoni, and coulteri. The three groups, with the synonymy of their included species, and the reasons for so grouping them, are as follows below.

FIRST GROUP

Prosopium cylindraceus (Pallas)

Salmo cylindraceus Pallas, in Pennant, Arctic Zoology, 1, 1784: CIII (in part: Lena, Indigirka, Kolyma).
Salmo microstomus Pallas, Zoographia Rosso-asiatica, 3, 1811: 405 (in part: Lena, Indigirka, Kolyma).
Coregonus mongolicus Varpakhovskii, Ann.Mus.Acad.Imp.St.-Petersb., 5, 1900: 424, pl.13, fig.2 (basin of upper Yenisei river).
Coregonus cylindraceus Berg, Poissons des eaux douces de l'URSS, 1, 1932: 219 (Kolyma, Lena, Khatanga, Taimyr, Piassina, right tributaries of Yenisei), figs. 166a-c on p. 208 (Kolyma r.); ibid., 2, 1933: 846. Awerinzew, Intern.Rev.ges.Hydrob.und Hydrogr., 32, 1935: 60 and 73 (lower course of Lena r.).
Coregonus lavaretus pidschian natio *mongolicus* Berg, ibid., 1, 1933: 257, fig. 204.

Scales 8-11, 89-106, 7-9, average in lateral line 97. Gill rakers usually 18 to 20. From the right tributaries of the Yenisei to Kolyma. Synonymy and description from Berg (1936).

Prosopium cylindraceus quadrilateralis (Richardson)

Salmo cylindraceus Pallas, in Pennant, Arctic Zoology, 1, 1784: CXXVII (in part: "Kamchatka").
Salmo microstomus Pallas, Zoographia Rosso-asiatica, 3, 1811: 405 (in part: Anadyr, Okhota, Kukhtui, "Kamchatka").
Coregonus quadrilateralis Richardson, in Franklin, Narrative of a journey to the polar sea, 1823: 714, pl.25, fig.2 (small rivers about Fort Enterprise and in the Arctic sea).
Coregonus novae-angliae Prescott, Amer.Journ.Sci.Arts, XI, 1851, 342 (lake Winnipiseogee, N.H.).
Prosopium quadrilaterale Koelz, Bull.U.S.Bur.Fish., 43 (2), 1927 (1929): 544 (Great lakes except Erie; lake Nipigon), fig.30 (lake Huron).
Coregonus cylindraceus Kaganowsky, Fishes of the Anadyr river, in press (Anadyr and southward to the Vivenskaya river at 60 N.Lat., near Korf bay; Penshina river at Penshino). Berg, Poissons des eaux douces de l'URSS, 1, 1932: 219 (in part: drainage of the Pacific in Asia).

Basing his statements on Koelz (1927), Berg finds that this species differs slightly from cylindraceus in having fewer lateral line scales and fewer gill rakers. In numerous specimens from the Great lakes and lake Nipigon the lateral line scales were (74) 84-95 (100), and the number of gill rakers usually 16 to 18. Synonymy from Berg (1936) and Evermann and Smith (1894).

Prosopium cylindraceus stanleyi (Kendall)

Coregonus stanleyi Kendall, Bull.U.S.Fish Comm., XXII, 1902 (1904), 366 (thoroughfare between Mud and Cross lakes, Maine).
Prosopium quadrilaterale minor Koelz, Pap.Mich.Acad.Sci.Arts and Letters, XIII, 1930, 382 (in part: Cross lake thoroughfare, Me.).

Kendall states that his species has the general appearance of *Coregonus quadrilateralis*, but differs in the less slender body, shape of head, less curved profile, less compressed snout, and larger mouth. It has also possibly somewhat fewer lateral line scales, the number in eight specimens ranging from 82 to 90 with an average of 85. These differences seem hardly sufficient for specific rank and this is confirmed by a letter from Dr. Hubbs (1937) in which he states that Berg's arrangement would throw the form *stanleyi* as a subspecies of *cylindraceus*. Koelz refers the Cross lake thoroughfare whitefish to his subspecies *minor* of *quadrilaterale*, and it is presumed that he means the form *stanleyi*, although he does not definitely mention this species. If these two are to be included under the same subspecific heading, the name *stanleyi* should stand, and *minor* should be included in the synonymy.

Prosopium cylindraceus minor (Koelz)

Prosopium quadrilaterale minor Koelz, Pap.Mich.Acad.Sci.Arts and Letters, XIII, 1930 (1931), 382 (lake Chazy, New York).

This species is described by Koelz as differing from quadrilaterale in having fewer lateral line scales, fewer gillrakers on the first branchial arch, and a relatively larger head and paired fins. The lateral line scales vary from 79 to 90 in twenty specimens, with an average of 83. The gill rakers on the first arch range from 14 to 18 with an average of 16. Koelz states that probably none of the inland lake forms of Prosopium will be found to be exactly like those which occur in the Great lakes. He finds that the Cross thoroughfare and the Chazy lake specimens differ in somewhat the same way from the typical quadrilaterale of lake Michigan, although there are also slight differences between these varieties. If the two are considered as identical, then stanleyi has the priority, and the form minor should not be recognized.

SECOND GROUP

Prosopium williamsoni (Girard)

Coregonus williamsoni Girard, Proc.Acad.Nat.Sci.Phila., 1856, 136 (Des Chutes river, Oregon).
Coregonus couesii Milner, Rep.U.S.Fish.Comm.for 1872-73 (1874), 88 (Chief mountain lake, Montana).

This species has a wide distribution. According to Jordan and Evermann (1909) it inhabits the rivers of the Sierra Nevada and the west slope of the Rockies, from the Fraser and the Columbia to the Truckee and other streams of the Lahontan basin of Nevada, being especially abundant in the lakes of northern Idaho, western Montana, and Washington. Evermann (1891) also reports it from Wyoming, and Bajkov (1927) from the Athabasca river. Jordan (1905) mentions Vancouver island as the western limit of the species, but as far as is known, there is no record in the literature of its capture in this locality. According to Dr. Hubbs it is a very real problem whether the type _williamsoni_ is not of the _oregonius_ sort. Judging from the type locality, this may well be so. If such is the case, the name _williamsoni_ should replace _oregonius_, and a new name should be resurrected from the synonymy for the form which we now know as _williamsoni_.

Prosopium williamsoni cismontanus (Jordan)

Coregonus williamsoni cismontanus Jordan, Bull.U.S.Fish.Comm., IX, 1889, 49, pl.9, figs.8,9 (Horsethief Springs creek, a tributary of the Madison river, Montana).

It is doubtful as to the real existence of this variety, in view of the great variability of the whole group. It differs from _williamsoni_ proper by the more slender body and shorter fins. Body depth is a poor character on which to base specific differences, and fin lengths are hardly more suitable unless very significantly different from the type. Evermann and Smith (1894) and Eigenmann (1894) say that the differences from _williamsoni_ are very slight. Dr. Schultz tells me it is at best only a subspecies or race.

Prosopium williamsoni couesi (Milner)

Coregonus couesii Milner, Rep.U.S.Fish.Comm. for 1872-73 (1874), 88 (Chief Mountain lake, Montana).

This species or variety is included by Evermann and Smith (1894) in the synonymy of *Prosopium williamsoni*. There seems to be considerable difference among the various authors as to the status of this form, however. Jordan and Snyder (1909) say it is doubtless the same as *cismontanus*, and that the two represent at the most a subspecies of *williamsoni*. On the other hand, Jordan and Evermann (1909) refer to *couesi* as "a strongly marked species, allied to *oregonius*, and improperly confounded with *Coregonus williamsoni*". Dr. Schultz (Letter 1937) says it is probably a subspecies or race of *williamsoni*, while Dr. Dymond (Letter 1937) states that he examined the type in Washington, and that if it is a typical representative of the population, it is distinct from *williamsoni*. It is found in the headwaters of the Saskatchewan river.

Prosopium oregonium (Jordan and Snyder)

Coregonus williamsoni Girard, in Jordan and Evermann, Fishes of north and middle America (in part). Smithson.Inst., U.S.Nat.Mus., Bull. 47, 1896.
Coregonus oregonius Jordan and Snyder, Proc.U.S.Nat.Mus., XXXVI, 1909, 425 (Mackenzie river, Oregon).
Irillion oregonius Jordan, Proc.Acad.Nat.Sci.Phila., 1918 (1919), 342.

In the original description the authors refer to *oregonius* as a well marked species agreeing with *C. couesi* in the long snout, and further distinguished by a high adipose. Jordan (1918) erected a new genus *Irillion* for this species, but there seems to be no justification for this action. Myers (1932) says the species is closely related to *williamsoni*, and that according to Hubbs it should be known as *Prosopium oregonium*. Later, in a letter (1937) Myers states that Schultz thinks *oregonium* is a synonym of *williamsoni*. This statement is probably hardly correct, because Dr. Schultz (Letter 1937) apparently still believes there is some distinction between the two, although he says that he and his assistants had great difficulty in distinguishing one from the other. Dr. Dymond (Letter) says he examined the type in Washington, and that if a typical example of the race, it is definitely distinct from williamsoni. It has a very large head, with long snout and maxillary, and long fins, particularly the adipose, which is nearly twice as large as the typical williamsoni. He admits the possibility, however, that the specimen is abnormal. In connection with this it is necessary to refer back to page of the introduction, and the statement that the type specimen selected in this case hardly seems to be representative of the group described. The long snout and maxillary can be attributed to the characteristic lengthening of these features which takes place in the older fish, especially at the breeding season. It is true that the adipose in these specimens of oregonium is larger than in williamsoni, but in view of Schultz' preliminary work on the two species in the Columbia river, it is possible that a study of a considerable series of specimens from this river would show that intergrading forms exist. Dr. Hubbs (Letter 1937) thinks that the one is only a subspecies of the other, with the further reservation that it may be necessary to interchange the names, as discussed under williamsoni. Crawford (1925) gives the distribution of this form as the Columbia watershed, although he says it may occur rarely in other places. According to Schultz (Letter 1937) it occus only in the Columbia, being found in the main stream and the larger tributaries, while williamsoni occurs in the smaller tributaries and in the lakes.

THIRD GROUP

Prosopium coulteri (Eigenmann and Eigenmann)

Coregonus coulterii Eigenmann and Eigenmann, Amer.Nat., Nov. 1892, 961 (Kicking Horse river, Field, B.C.)

There is not much doubt that *coulteri* is a distinct species. According to Evermann and Smith (1894) it is most closely related to *williamsoni*, but the differences are numerous. In its smaller size and generally more slender appearance it is distinct, and added to these differences in appearance are differences in discrete characters such as scale number and gill rakers. The scales in the lateral line vary from 60 to 64 in seven specimens with an average of 61, and the gill rakers are also less in number. The authors also mention the lack of parr marks in the specimens examined by them, saying that in specimens of *williamsoni* the same size these markings are distinct. However, the examples of *coulteri* are older than those of *williamsoni* of equal size, and it is po possible that they have lost their juvenile characters. This species was described from the Kicking Horse river at Field, British Columbia, and has since been reported from Diamond lake, Washington, and from southwestern Alaska, Chignik river and lake Aleknagik. Dr. Schultz (Letter 1937) is convinced that this is a good species. He has taken it in lake McDonald, in Glacier National Park, Montana. Dr. Dymond (Letter 1937) examined the type in the British Museum, and found it distinct from *williamsoni*, *quadrilaterale*, or *oregonium*.

Prosopium snyderi Myers

Prosopium snyderi Myers, Copeia, 1932, 2, 62 (Crescent lake, Washington). The chief fault with this species is that it is based on a single specimen. This differs from coulteri in having a longer head, higher dorsal and anal fins, longer pectorals and pelvics, large adipose, more compressed body, and lower scale count. Dr. Schultz (Letter 1937) conveys the impression that there is some doubt as to the validity of the species. The distinguishing characters, such as the longer head, larger eye, longer fins, and so on, may possibly be the features of a younger fish, and since Myers makes no mention of age in his description, this possibility must be entertained.

As well as the species which fit in these three groups, two other species of western whitefishes exist which will require further study before their relationships are clear. These were described by Snyder (1917) from Bear lake, in Idaho and Utah, a part of the drainage system of Great Salt lake. Although both of these fish were described as species of Coregonus, the locality in which they were taken and their general appearance as illustrated, suggest that they belong to the genus Prosopium.

Prosopium spilonotus (Snyder)

Coregonus spilonotus Snyder, Bull.U.S.Bur.Fish., XXXVI, 1917-18 (1921), 3, (Bear lake, Idaho and Utah).

Differing from williamsoni in having smaller and more numerous pigment spots, larger scales, longer heads, and deeper and heavier bodies. The lateral line scales range from 74 to 81 and average 78 for twenty-two specimens.

Prosopium abyssicola (Snyder)

Coregonus abyssicola Snyder, Bull.U.S.Bur.Fish., XXXVI, 1917-18 (1921), 3 (Bear lake, Idaho and Utah).

The smaller specimens differ from the young of the previous species in having no pigment spots. The older specimens of spilonotus lose the characteristic markings but develop a longer maxillary and snout and deeper body, so that at this stage the structure of the head serves to distinguish the two. The males of abyssicola develop pearl organs on the scales in the breeding season. These occur on the females occasionally, but are never so prominent or numerous.

Another species which has been sometimes referred to Prosopium is Coregonus kennicotti Milner. Dr. Dymond has also examined the type of this species, and concludes (Letter 1937) that it properly belongs to to the genus Coregonus. Dr. Hubbs (Letter 1937) also agrees with this view.

ECONOMIC IMPORTANCE

None of the species of the genus Prosopium is of any particular value as a commercial food fish. This is probably due in the main to their small size, and to the fact that they never occur in particularly large numbers in lakes, where their capture by means of gill nets would be possible. In various parts of Alberta and British Columbia williamsoni is caught in considerable numbers by angling in lakes, mouths of streams, and up the streams. In British Columbia at least this occurs in the cold weather, evidently on the spawning migration. In the vicinity of Michel the residents fish for this species through the ice, using hooks baited with hellgrammites, a larval form of the Dobson fly, of the Neuropteran family Cordalinae. In the Vedder river, in the vicinity of the Cultus lake outlet, the hook is baited with a single salmon egg. Considerable numbers are caught in this way, and are often peddled from door to door at this time of year.

In quality of flesh this fish has been compared favourably to the commercial Coregonids of the Great lakes. The flesh is fairly rich in oil, and for this reason is suitable for frying. Opinion is not unanimous in this respect, however, and some consider the flesh to be coarse.

Prosopium may be of some value as an article in the diet of other fishes. Dr. Rawson found two specimens in the stomach of a six pound lake trout from Waterton lake in 1937. Such a species might prove to be of great importance as a food for trout and other game fishes.

According to the present view, however, the chief economic importance of the genus is a negative one, and concerns the predatory habits of these fish with respect to the Pacific salmon. Snyder (1918) reports that *williamsoni* seems to be particularly fond of the eggs of spawning fishes, even to the extent of devouring the eggs of its own kind. Foerster (1925) finds that the species destroys the eggs of spawning sockeye salmon. He says: "Rocky mountain whitefish (*C. williamsoni*) are shown to have subsisted during spawning time on sockeye eggs, and in a river system where they are abundant, their activities might prove very disastrous to the continuance of a satisfactory sockeye yield." He ranks the whitefish together with the trout and suckers as being probably the most serious marauders at the spawning beds of the sockeye salmon (*Oncorhynchus nerka*). That this whitefish extends its destructive habits to a later phase in the life history of the sockeye is shown further on in the present paper by the presence of seversl newly emerged sockeye fry in the stomach of an individual from Cultus lake.

MATERIAL EXAMINED

The specimens actually examined in the course of this work form a fairly general collection from various localities in western Canada and the northwestern United States. The first lot were collected by Dr. Rawson in the summer of 1936 from certain lakes of the Bow river drainage system in western Alberta. These were examined for stomach contents and rate of growth, and were measured in detail for body proportions and meristic characters such as scales, fin rays, and so on. In 1937 Dr. Rawson made collections in Waterton lakes park in southwestern Alberta, and this material was treated in the same way. The Cultus lake whitefish were collected over a period of several years incidental to the study of the life history of the sockeye salmon being made by the Biological Board of Canada. These were examined for food, growth, and body proportions. The Elk river specimens were collected near Michel, B. C. in 1938. This sample was examined for systematic characters and rate of growth. The remainder of the material was obtained from the collections of the United States National Museum. This was subjected to detailed measurements and counts, and the rate of growth was determined for each lake.

VARIATION IN PROSOPIUM WILLIAMSONI

Introduction

To illustrate the amount of variation between the various races of a single species of Prosopium, and also to show the range of variation within a race or population, detailed measurements and counts were made of all characters which might be expected to show significant differences. A total of 230 individuals from 13 localities were examined in this way. Measurements of the various body proportions were made to the nearest millimetre, and were then calculated as percentages of the standard length. The results are tabulated in detail as percentages in tables I to XI.

Approximately 30 different characters were recorded for each fish examined. Of these, some showed a considerable degree of variation within the population, and exhibited significant differences between populations, while others varied within a smaller range, and were not of value in distinguishing racial characters. Those which proved useful for the recognition of populations included the dimensions of the head, the proportions of the various fins, the number of scales in the lateral line, and particularly the rate of growth. In most cases, in fact, differences in body proportions from the typical williamsoni can be correlated to a considerable degree with the growth rate.

A problem which caused some difficulty in the comparison of the various populations examined is the lack of data descriptive of the typical *williamsoni*. Since specimens from the type locality are not available, it is necessary to accept the next best alternative, and therefore for purposes of comparison the Waterton lake specimens are selected as representative of the normal form.

Rate of growth

Scales were examined from 419 specimens and the standard lengths at the end of each year of life were calculated by a method similar to that used by Van Oosten (1923). The results of these calculations are given in tables XII to XX.

Although the growth rate varies somewhat from lake to lake, the material can be divided into four main groups. The first, which contains those populations having a rate of growth similar to that of the typical *williamsoni*, includes the samples from lake Minnewanka and Third lake in Banff park, Waterton and Maskinonge lakes in the Waterton lakes park, Bowman lake, Logging lake and lake McDonald in Glacier National park, Montana, and possibly the Nooksack and Tolt rivers in Washington. The second division is represented by the Cultus lake fish, which have a considerably faster growth in their first three or four years, although they do not appear to attain a greater size at maturity. The third group is distinguished by a very slow growth, the rate being only about half as great as in the Waterton lake fish. Fourthly, the Elk river fish must be placed by themselves because of their very small growth in the first year.

The Cascade river population may also fall in this group. Table XXI presents the average calculated standard length at the end of each year of life for each of the populations studied.

GROUP 1

Waterton lake

As shown in the table, these fish attain a greater age than those from any of the other localities. It will be noticed, however, that they do not exceed the others in size to any great extent. It is a recognized fact that in a population of fish a limit exists in regard to the maximum size attainable, and therefore the more rapidly growing individuals mature earlier and die younger. Thus, if other factors do not influence the result, the slower growing races should reach a greater age, as is well illustrated in this case.

Bowman lake, Logging lake, and lake McDonald

In this case, conditions in the three lakes are evidently very similar, if the growth rate is to be considered as an indication. This might be expected from the fact that all three are closely situated and drain into the same river system. The slight differences in rate of growth, if significant, can probably be explained by the effect of altitude.

Lake Minnewanka

Although this lake is at a higher altitude than any other in the group, the growth rate is relatively rapid, and the maximum age attained is probably not much greater than ten years. The growth in the early years is much the same as for the Waterton lake fish, and for this reason the whitefish population is placed in the same group.

Third lake

The growth of these fish very closely parallels that of the previous lot, and there is little doubt that both belong in the same category.

Maskinonge lake

Two individuals in their second year made up the sample from this lake. The average size at the end of the first year cannot therefore be considered significant. However the close connection between Waterton and Maskinonge lakes leaves little doubt as to the relation between the two samples.

Tolt and Nooksack rivers

Here again the small size of the samples causes the figures to be of little significance. In view of the locality, it seems more likely that these races should be similar to the Cultus lake fish. The figures obtained agree more closely with the average values for the first group, however, and for this reason the two samples are included provisionally with the Waterton lake type.

GROUP 2

Cultus lake

At first sight, the reason for separating the Cultus lake race may appear obscure. In size attained and maximum age the similarity to the Minnewanka and third lake fish is marked. It will be observed, however, that the growth rate in the first three years is considerably greater than in any other case. This might be explained in part by the low altitude of the lake. As will be seen in a later section, the separation of the Cultus lake fish is further justified by differences in body proportions.

GROUP 3

Bow lake

The greater altitude and rather unusual physical characteristics of Bow lake are reflected to a marked degree in the rate of growth of the whitefish population. This is particularly noticeable in the first three or four years, when the rate is only about half as great as in the Waterton lake group, and only one-third as much as in Cultus lake. The greatest age attainable seems to be closely comparable to the other groups, but the maximum size is considerably less. This is caused probably to a great extent by the combined action of lower temperatures and the presence of silt in the water, which must have a great effect on the available food supply and the penetration of light.

Lake Louise

The growth rate appears to be somewhat greater in the early years, although the maximum size and age are probably much the same. Conditions in Bow lake and lake Louise are similar, and the effects of the physical characteristics produce parallel variations in the whitefish populations.

GROUP 4

Elk river

The type here shows a combination of the characters of groups three and one. In the first year the growth is poor, being comparable to the first year's growth in lake Louise. After the first winter, however, the rate of growth becomes as rapid as in the Waterton lake group. The small growth of the first year may be an effect of a later spawning, producing fry which do not develop scales until relatively late in the summer.

Cascade river

The sample consists of a single specimen in its second summer. Unless the specimen is abnormal, the effect produced here is greatly similar to that occurring in the Elk river. The first year's growth is small, but the growth in the second summer is considerable, even though the second summer's development is not complete. Tentatively, this specimen is placed with the Elk river fish.

BODY PROPORTIONS

In considering the proportions of the various body characters, it must be kept in mind that while some vary directly as the length, others do not.. In other words, all parts of the fish do not grow at the same rate. The head for instance as a general rule grows less rapidly than the body, so that in the younger fish the heads are proportionately longer. The snout and maxillary correspond very closely in growth rate with the head. The body itself grows relatively deeper and wider as the fish increases in age.

It is necessary, therefore, that the data be divided into groups which will be comparable with each other. This may be done either according to the size or the age of the fish. In view of the great variation in rate of growth of the different races of fish, it can be seen that a grouping according to size is unsatisfactory, and the selection of age in years as a unit on which to base the separation seems more reasonable.

Taking the growth of the head as an example, it will be observed that the rate changes in relation to the growth of the body as the fish grows older, and past a certain point the two increase in size proportionately. This point at which the two rates approximately coincide comes somewhere towards the end of the second year, and it therefore seems reasonable to conclude that in fish two years of age or older this character is comparable. This conclusion is fairly well supported by the data presented in this paper.

In the other characters studied, there is less evidence of a difference between younger and older fish, but in order to ensure that the effect of any difference will not be allowed to influence the results, the yearling fish and the fry are not included in drawing averages for a population.

<u>Length of head</u>

The percentage head lengths of the various races are presented in table

XXII. To render more intelligible the meaning of the average values, the individual head lengths are listed in the form of frequency distributions. This helps to give a pictorial idea of the deviation from the average value, and the significance of any average differences which may occur.

An examination of the first section of table XXII will show that in spite of the elimination of the younger fish from the calculations, there is still a definite correlation between size and proportional head length. Thus the differences in average values for this character in fish from different localities can be explained with reference to environmental factors. For this reason it must be emphasized that relative head length should not be allowed much weight as a systematic character in this genus.

Cultus lake

This race has the shortest head of any population examined. In *Leucichthys*, short-headedness is in general a southern trait (Koelz 1931) and must therefore be associated with higher temperatures or other factors characteristic of southern locations. It is likely that the same may be true of *Prosopium*. In this case we are dealing with differences in elevation, rather than latitude, but if temperature or some related factor which is a direct consequence of low altitude is the governing one, the Cultus lake fish should certainly have shorter heads than any of the others here studied.

Lake Minnewanka

That these fish should have heads as short as the Cultus lake population is rather difficult to explain in terms of altitude. Conditions of temperature in lake Minnewanka are quite moderate, however, and the physical characters of the two lakes are evidently not as diverse as the great spread in altitude would lead one to believe.

Tolt river

The locality of capture of this single specimen would suggest that it should resemble the Cultus lake fish. Insofar as head length is concerned, it is likely that there is a close relation between the two forms, although the data can hardly be considered significant.

Waterton lake

In head length the Waterton lake specimens vary over a comparatively wide range, but the average value approximates closely that of the typical williamsoni. An interesting feature which appears here in a more marked degree than in any of the other samples is the increase in growth rate of the head with increasing age. This is undoubtedly due to the lengthening of the snout or rostrum which so often occurs in this species with approaching maturity.

Third lake

As might be expected from its proximity and similarity to Waterton lake, the Third lake population appears to be very similar as regards average head length. This is true even though the fish in the sample average considerably greater in standard length.

Logging lake

This race also agrees closely in head length with the fish from Waterton lake.

Bow lake

The Bow lake population shows a significant increase in average length of head over the preceding samples. That the cause is largely due to the effects of environment is not to be doubted, although the effect seems to be somewhat out of proportion to the average length of the fish when compared to the Logging lake sample for instance. The yearling fish also have heads which are exceptionally large for their age.

Elk river

The long heads of the Elk river fish cannot be explained so well on the basis of the average length of the sample. It would be expected that the proportion of head to body would be less, if the rate of growth is the chief factor controlling head length. This seems therefore to strengthen the theory that the Elk river fish belong to a distinct race.

Bowman lake

The sample in this case consisted wholly of young fish, and this has almost certainly exaggerated the relative size of the head. For the purpose of determining the relationships of the Bowman lake population, the head lengths of the yearling fish are undoubtedly more comparable, as reference to the second section of table XIII will show.

Nooksack river

Nooksack river

Here also the data, although of small significance, supports the idea that locality should determine the relations of the population. The head lengths of the yearling fish in the Nooksack are closely allied with those of the Cultus lake race.

SNOUT LENGTH

As a general rule, snout length and head length are closely correlated, although there is considerably less variation in the former character. This correlation can be judged from table XXIII, in which the long-headed races appear to have somewhat longer snouts. This lengthening of the snout is usually accompanied by the peculiar modification of this feature which reaches its greatest development in oregonium, and alters the appearance of the head considerably. The Cultus lake fish show little evidence of this phenomenon, except in the mature fish. On the other hand, the Waterton lake specimens are nearly all modified in this way to some extent. The Elk river race is distinct in having the longest snout of any, and yet there is no external evidence of the bulging rostrum characteristic of the Waterton fish.

MAXILLARY

The relation of snout to maxillary varies considerably in the different races. In most cases the maxillary is exceeded in length by the snout, but this is not the rule in Bow lake or in Bowman lake, where the maxillary slightly exceeds the snout. A comparison of the data for the yearling fish in tables XXIII and XXIV will provide a reasonable explanation. In the younger fish, snout and maxillary compare very closely in size, as shown by the tables, but with increasing size the snout grows more rapidly, so that in the largest fish the difference between these two characters is greatest. The Bow and Bowman lake fish are slow growing races, and it is reasonable to suppose that the older fish in these cases will be more likely to retain the characteristics of younger fish.

No great correlation exists between snout and maxillary in any of the populations examined, with the exception of the Elk river series. Here the maxillary agrees with the snout in being relatively longer than in any other race.

EYE

An examination of tables I to XI will show that the eye grows less rapidly than the individual, and continues to do so throughout the life of the fish. The rate of decrease in relative eye diameter is correlated more closely with size than with age, but in fish of equal size there is little variation in the average size of this organ. For this reason, eye diameter is of little value as a systematic character in this group.

Table XXV gives the distribution of relative eye diameters for several localities. It will be noticed that the races having the largest eye, for example the Bowman and Bow lake populations, are those with the slowest growth rate. This is in accord with the previous observations.

DEPTH OF HEAD

As might be expected, the long-headed forms also have the deepest heads, and vice versa. In comparing tables XXII and XXVI it will be noticed that this correlation is not absolute, but this is probably due to unavoidable errors in sampling rather than to any departure from the general rule. Any differences noted with regard to this point are not significant. The figures contained in table XXVI again show that up to a certain point the head grows less rapidly than the body.

DISTANCE FROM SNOUT TIP TO OCCIPUT

Here the same correlation with the other head dimensions is demonstrated. Table XXVII gives the distribution and average values of this character for the various lakes and rivers. The conclusions to be drawn from these data are similar to those discussed in the previous section.

LENGTH OF DORSAL FIN BASE

The differences between the average values for this character are not marked, as shown by table XXVIII. Differences which do appear are probably not highly significant, but it is interesting to note that the long headed forms are at the two extremes with regard to dorsal fin base. The Bow lake fish, and the other long-headed races with the exception of the Elk river population, have the shortest bases on this fin. The latter group (Elk river), however, have a relatively long base to the dorsal, and agree closely with the Cultus lake type in this respect. This relation does not show so well in comparing the yearling fish, but the discrepancy can be traced to insufficient samples.

LENGTH OF ANAL FIN BASE

The results for this character as presented in table XXIX confirm the conclusions drawn for the base of the dorsal fin. Minor differences will be noted if the two tables are compared, but these are not significant, and do not detract from the value of the general statements made.

HEIGHT OF DORSAL FIN

The dorsal fin varies in height over a fairly wide range, as will be observed from table XXX. In general, the slower growing races seem to have higher dorsal fins, as illustrated by the data from Bow and Bowman lakes. The Elk river fish are characterized by a relatively high dorsal and are equalled in this respect only by the Bowman lake population.

HEIGHT OF ANAL FIN

The relations between the various lakes with respect to this character are almost exactly the same as for the dorsal height. The Elk river population is an exception for the reason that the anal is relatively much higher than in any of the others. This is due to the peculiar structural modification of this fin in which the anterior portion is produced ventrally into a distinct lobe. In the older fish this is accompanied by a similar enlargement of the ventral lobe of the caudal fin. Table XXXI gives the data concerning this character.

LENGTH PECTORAL FIN

In the older fish, this character seems to be correlated inversely with size, and thus inversely with the growth rate. It is doubtful whether this is a result of the effect of juvenile characters produced by the low rate of growth, since an examination of the second part of table XXXII will show that no significant differences exist between the pectoral fin lengths of the yearling fish. The Cultus lake fish and the other fast growing forms have the shortest pectorals, while the Bow lake specimens have distinctly the longest. The Elk river race is intermediate with respect to this feature.

LENGTH PELVIC FIN

Table XXXIII shows that the slow growing fish from Bow lake and the Elk river posses the longest pelvic fins. The Cultus and Waterton lake forms agree in being intermediate with respect to this character, while the remainder of the races examined are relatively short-finned. The pelvics in the yearling fish do not differ significantly.

ADIPOSE FIN

Koelz (1927) in his study of Great lakes Coregonidae, found that the adipose was extremely variable and had little value as a systematic character. In Prosopium, however, the size of this fin has been used to separate one of the western forms from the rest of the species found in the same general locality. Pratt (1923) in his manual of the Vertebrates of the United States separates the western species as follows:

Adipose fin with a much shorter base than the anal

C. coulteri

C. williamsoni

Adipose fin with as long a base as the anal

C. oregonus

In this study of a number of races of *P. williamsoni*, however, it has been found that the adipose, as stated by Koelz, is highly variable, and no such definite relation as the one on which the above key is based seems to exist.

Length adipose

In table XXXIV the values for this character are listed. The range of variation within each race is relatively great, so that no significant differences between populations are shown, except in the case of the Cultus lake fish, and undoubtedly also in those from the Nooksack and Tolt rivers in the state of Washington. This incidentally constitutes further evidence for the placing of the Nooksack and Tolt fish in a group with the Cultus lake population.

Base adipose

The same holds true in a general way for this character. Distinctive features of table XXXV are the relatively short base for the adipose of the Elk river fish, and the long base on this fin in the Cultus lake race.

Height adipose

This character varies to some extent, but in no case could the adipose be described as "banner-like", which is the description applied to the adipose of oregonium.

Ratio of adipose base to anal base

This ratio was calculated for comparison with Pratt's key. The differences between races are of doubtful significance, but the important feature of table XXXVI is the fact that the adipose not only equals the anal, but even exceeds it in some cases. It must be admitted, of course, that the average value for any population shows the anal base to exceed the adipose. The Elk river population has the shortest adipose base, and the Cultus lake fish have the longest in relation to the base of the anal. The relation of the adipose length to the anal base was also calculated for each group, but no new conclusions can be drawn fron this ratio.

PECTORAL FIN RAYS

Table XXXVII gives the variation in number of rays in the pectoral fin. This variation is so great in comparison to any differences observed, that this feature is of little use systematically. The difference in the Cultus lake fish is worthy of note, however.

SCALES IN THE LATERAL LINE

Again no significant differences are to be observed. It may prove, however, that the Cultus lake and Elk river fish have slightly more scales in the lateral line than the other races. The averages and dispersions are illustrated in table XXXVIII.

Table I - Systematic characters of Prosopium from lake Minnewanka. Body proportions in percentages of standard length.

Age	7+	6+	6+	5+	5+	4+	3+	3+	2+	2+	2+
Standard length	335	315	310	285	260	230	225	210	185	175	155
Length head	20.3	19.9	20.4	20.4	19.1	19.7	19.7	20.7	21.3	21.5	22.0
Depth head	13.5	13.7	14.1	13.2	12.7	12.4	12.7	13.6	13.0	13.5	13.2
Greatest depth body	21.3	24.2	20.2	21.8	19.2	20.0	19.6	20.5	19.7	20.5	18.4
Width body	13.6	15.5	12.3	13.2	12.7	12.6	12.6	11.6	12.5	12.5	12.1
Least depth caudal peduncle	6.6	6.9	6.4	6.4	6.2	6.0	6.2	6.4	6.3	6.3	6.3
Snout	5.5	5.8	6.4	5.7	4.8	5.5	5.4	5.8	5.7	5.6	6.0
Maxillary	4.5	4.6	5.0	5.0	4.5	5.4	4.8	5.3	5.2	5.3	5.6
Diameter eye	3.9	4.4	4.2	3.9	3.9	4.6	4.0	5.1	4.7	4.8	5.5
Interorbital width	6.2	6.5	6.3	6.6	6.3	6.1	6.2	6.6	6.7	6.5	6.2
Snout tip to occiput	15.2	15.4	15.6	14.7	14.7	15.7	14.7	16.4	16.2	16.4	17.0
Snout tip to dorsal	44.5	44.5	44.5	45.0	43.1	42.6	40.6	42.6	42.7	42.8	44.3
Snout tip to pelvic	50.5	51.2	52.3	52.0	50.0	50.0	49.6	50.3	51.0	53.1	52.8
Length dorsal fin base	11.6	13.0	12.0	11.6	11.4	11.9	11.9	12.2	12.0	12.2	11.9
Length anal fin base	9.4	8.4	8.4	8.6	7.9	8.3	8.9	8.7	8.1	8.7	8.8
Height dorsal fin	12.4	12.4	13.2	13.1	13.0	14.5	13.9	14.1	14.3	14.7	14.5
Height anal fin	11.9	10.4			11.3	11.1	11.3	10.8		11.5	11.0
Length pectoral	15.0	15.7	15.9	16.2	15.8	16.9	16.3	17.0	15.7	17.4	17.8
Length pelvic	12.7	12.3	13.2	13.2	13.3	13.8	13.7	12.7	13.7	14.0	14.4
Height adipose	2.3	2.5	2.7	2.2	2.5	2.6	2.3	3.5	3.1	3.0	2.3
Base adipose	6.9	7.2	7.1	6.3	6.8	6.6	6.8	6.7	7.4	7.3	7.2
Length adipose	8.3	9.1	7.7	7.5	7.8	8.3	7.9	8.6	9.6	8.9	8.2
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.88	1.08	0.92	0.87	0.99	1.0	0.89	0.99	1.18	1.02	0.93
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.73	0.86	0.85	0.73	0.86	0.80	0.76	0.77	0.91	0.84	0.82
Dorsal rays	12	12	12	12	12	12	13	13	12	12	12
Anal rays	11	11	11	10	10	11	11	11	11	11	10
Pectoral rays	18	17	17	17	16	16	16	17	17	17	18
Pelvic rays	11	11	11	11	11	11	10	11	11	11	11
Scales in lateral	82	84	81	82	87	79	80	83	88	80	84
Lateral to dorsal	9	9	10	9	10	9	9	9	9	9	9
Lateral to pelvic	8	9	8	8	8	8	8	8	8	8	8
Gill rakers - short arm	9	9	8	9	8	9	9	9	9	9	9
Gill rakers - long arm	13	14	12	13	12	12	14	14	13	13	12
Branchiostegals	9	8	8	8	8	8	8	9	8	8	8

Table II - Systematic characters of <u>Prosopium</u> from Bow lake.

Age	9+	8+	8+	7+	7+	7+	6+	6+	6+	5+	3+
Standard length	220	215	177	207	190	189	161	158	154	144	133
Length head	21.6	21.7	21.6	22.5	22.6	21.4	23.1	23.0	22.1	22.7	22.8
Depth head	15.5	14.3	15.2	14.9	14.9	14.9	15.3	15.5	14.5	14.9	15.0
Greatest depth body	19.4	19.9	20.9	22.0	21.0	19.6	21.5	23.2	20.6	20.2	21.1
Width body	13.0	12.4	12.9	12.9	11.9	12.2	13.4	13.5	12.4	11.2	11.2
Least depth caudal peduncle	6.2	6.4	6.1	6.4	6.5	6.1	6.7	6.7	6.3	6.2	6.2
Snout	5.6	5.6	6.2	6.0	5.8	5.6	5.5	5.6	6.2	5.6	5.9
Maxillary	5.5	5.9	5.8	6.1	5.6	5.5	6.0	5.6	5.8	6.0	
Diameter eye	5.5	5.5	5.1	5.4	5.7	5.3	6.3	6.4	5.9	6.0	5.6
Interorbital width	6.8	6.2	6.1	6.5	6.2	6.2	6.7	6.8	5.9	6.4	6.2
Snout tip to occiput	16.3	17.3	16.3	16.9	16.8	16.4		17.9	17.8	17.6	16.4
Snout tip to dorsal	42.1	40.6	43.2	44.0	43.4	41.5		44.0	42.8	43.0	42.6
Snout tip to pelvic	52.3	51.1	51.7	54.2	52.9	51.1		52.2	52.5	50.6	50.9
Length dorsal fin base	11.3	11.8	10.9	11.2	11.6	11.5	12.2	11.8	11.0	12.6	11.6
Length anal fin base	8.7	9.8	10.3	8.8	8.4	8.5	10.2	9.1	8.8	8.7	9.9
Height dorsal fin	16.8	14.9	14.4	14.6	16.4	14.7	16.1	16.1	14.9	15.6	14.0
Height anal fin	13.3	13.2	13.3	11.6	13.6	11.3	12.3	12.2	11.9	11.7	11.7
Length pectoral	20.3	18.6	17.9	18.2	20.3	17.8	19.9	20.0	19.2	17.9	17.1
Length pelvic	15.8	15.2	15.1	14.5	15.3	13.6	14.6	16.0	14.4	14.6	13.8
Height adipose	3.4	2.8	3.0	2.9	3.0	2.7	3.4	3.5	2.5	2.6	2.8
Base adipose	6.4	7.5	6.6	6.8	6.8	7.7		7.0	7.5	6.5	7.4
Length adipose	9.6	9.0	8.2	8.5	8.1	9.3		8.9	8.8	8.3	9.0
Ratio $\frac{\text{adipose}}{\text{anal base}}$	1.1	0.92	0.80	0.97	0.96	1.09		0.98	1.0	0.95	0.91
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.74	0.77	0.64	0.77	0.81	0.91		0.77	0.85	0.75	0.75
Dorsal rays	12	12	12	12	13	13	13	13	11	12	12
Anal rays	11	11	12	11	11	11	12	11	11	11	11
Pectoral rays	17	17	16	16	17	16	17	17	16	17	17
Pelvic rays	11	11	11	11	11	11	12	11	11	11	11
Scales in lateral	78	84	85	80	78	80	83	78	79	81	78
Lateral to dorsal	9	9	9	9	8	8	9	9	9	9	9
Lateral to pelvic	8	8	8	8	8	8	8	8	8	8	8
Gill rakers - short arm	8	8	9	9	8	9	9	9	9	8	9
- long arm	12	12	12	12	11	12	13	13	13	11	12
Branchiostegals	8	8	8	9	9	7	7	8	8	8	8

Table II - Bow lake (Concluded)

Table III - Systematic characters of Prosopium from lake Louise.

	Table II			Table III						
Age	2+	1+	1+	1+	1+	1+	1+	1+	1+	1+
Standard length	98	75	71	71	68	67	67	66	66	62
Length head	23.7	24.0	25.3	24.9	25.5	26.9	25.4	25.5	25.9	26.5
Depth head	14.6									14.7
Snout	5.1									
Maxillary	5.8									
Diameter eye	6.2									
Snout tip to occiput	18.4	18.7	20.4	19.6	19.3	20.8	20.3	20.6	20.5	18.9
Snout tip to dorsal	44.0	42.4	45.0	46.0	45.2	45.7	44.7	46.3	44.7	44.9
Snout tip to pelvic	55.2	52.8	52.8	52.1	51.9	52.3	51.9	51.8	51.8	52.3
Length dorsal fin base	11.4									13.5
Length anal fin base	8.2									9.6
Height dorsal fin	16.6									
Height anal fin	12.2									
Length pectoral	17.6									
Length pelvic	14.1									
Base adipose	7.9									
Length adipose	9.2									9.6
Ratio adipose / anal base	1.12									1.0
Ratio adipose base / anal base	0.96									
Scales in lateral	79									87

Table IV - Systematic characters of <u>Prosopium</u> from Waterton lake.

Age	14+	12+	9+	7+	5+	4+	3+	2+	2+	1+	1+
Standard length	378	325	355	290	255	235	230	175	165	140	135
Length head	23.1	23.7	22.0	20.5	21.4	20.7	20.4	19.1	20.2	22.1	22.4
Depth head	15.2	15.9	13.8	13.3	14.1	14.3	13.0	12.7	13.2	14.7	14.6
Greatest depth body	20.9	23.2	21.3	21.0	22.1	20.6	21.5	19.4	19.5	20.1	20.3
Width body	12.0	12.6	11.8	13.2	12.1	11.9	12.3	11.9	13.3	11.7	13.9
Least depth caudal peduncle	7.0	7.0	6.7	6.6	7.1	6.6	6.7	6.5	6.2	6.6	6.6
Snout	7.1	7.6	6.7	6.1	6.0	5.7	5.7	5.4	5.6	6.1	6.2
Maxillary	6.5	6.9	6.1	5.8	5.3	5.4	5.4	4.8	5.1	5.7	5.9
Diameter eye	4.3	4.6	4.2	4.0	4.4	4.4	4.4	4.7	5.0	5.3	5.3
Interorbital width	6.7	7.2	6.4	5.9	6.6	6.0	6.0	5.5	5.8	6.1	5.7
Snout tip to occiput	16.7	18.4	15.6	15.5	16.5	16.3	15.9	15.5	15.4	16.8	17.4
Snout tip to dorsal	46.8	46.8	44.5	44.5	46.3	42.9	41.6	41.5	42.4	43.3	44.3
Snout tip to pelvic	54.8	53.3	52.4	52.1	52.2	50.9	50.8	49.2	49.3	52.1	51.1
Length dorsal fin base	12.6	13.0	13.1	11.5	12.9	12.5	12.3	11.4	11.4	13.1	12.0
Length anal fin base	9.8	10.3	9.6	8.5	10.2	9.4	9.6	10.0	9.4	10.2	9.4
Height dorsal fin	13.1	15.5	14.4	13.4	15.1	15.2	13.8	14.6	13.1	14.5	15.6
Height anal fin	11.2	13.4	12.1	10.7		12.3	12.7	12.1	10.5	12.6	11.9
Length pectoral	16.6	18.5	16.3	16.3	17.7	17.0	17.3	15.5	14.3	15.6	15.7
Length pelvic	13.7	16.0	14.9	13.9	15.1	14.5	14.2	13.8	13.0	13.9	14.6
Height adipose	2.9	3.3	2.6	2.6	2.7	2.8	2.7	2.5	2.1	2.6	
Base adipose	7.3	7.5	7.1	7.5	8.2	7.7	7.0	6.9	6.9	8.2	7.6
Length adipose	8.7	10.2	9.0	9.7	9.7	8.4	8.5	8.3	7.7	9.8	9.3
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.89	0.99	0.94	1.14	0.95	0.89	0.88	0.83	0.82	0.96	0.99
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.74	0.73	0.74	0.88	0.80	0.82	0.73	0.69	0.73	0.80	0.81
Dorsal rays	13	11	12	11	12	12	12	11	12	11	13
Anal rays	11	11	11	11	9	11	11	11	11	11	11
Pectoral rays	17	17	17	17	18	18	16	16	16	17	17
Pelvic rays	11	11	11	11	11	12	11	11	11	11	11
Scales in lateral	80	81	81	83	75	81	81	83	86	82	82
Lateral to dorsal	9	9	9	9	9	9	9	9	9	9	9
Lateral to pelvic	8	8	8	8	8	8	8	8	8	8	8
Gill rakers											
- short arm	9	10	9	10	9	10	10	9	11	10	10
- long arm	13	13	13	13	12	14	13	13	13	13	12
Branchiostegals	9	9	8	8	9	9	8	8	9	9	8

Table IV - Waterton lake (Concluded) Table V - Third lake.

	Table IV - Waterton lake (Concluded)						Table V - Third lake.		
Age	3+	3+	3+	2+	2+	1+	8+	7+	4+
Standard length	218	198	215	188	162	123	355	340	245
Length head	21.1	20.7	20.6	21.4	21.6	22.6	21.0	20.5	21.5
Depth head	13.4	13.5	13.1	13.5	13.7	14.1	14.3	14.7	14.3
Greatest depth body							23.0	22.0	19.8
Width body							14.3	14.2	11.8
Least depth caudal peduncle	6.9	6.6	6.6	6.9	6.2	6.5	6.8	6.6	6.0
Snout	6.1	5.7	5.5	6.1	6.2	5.5	6.6	5.9	6.0
Maxillary	5.8	5.4	5.2	5.5	5.9	5.4	5.7	4.5	5.2
Diameter eye	4.4	4.3	4.4	4.8	5.2	5.4	3.7	4.1	4.9
Interorbital width	6.4	6.3	6.1	6.4	5.9	5.9	6.8	6.5	6.7
Snout tip to occiput	16.2	16.0	15.4	16.6	17.1	17.1	15.8	15.1	16.5
Snout tip to dorsal	46.3	43.6	43.5	45.0	44.6	45.1	45.1	43.5	44.1
Snout tip to pelvic		49.6	50.3	48.9	49.6	47.6	53.0	53.3	52.3
Length dorsal fin base	13.5	12.8	12.5	13.7	12.7	12.7	11.0	12.5	11.1
Length anal fin base	9.6	9.8	10.0	9.3	9.6	10.5	8.5	9.0	9.0
Height dorsal fin	15.5	15.6	16.0	16.3	15.4	15.0	13.2	13.9	14.2
Height anal fin	13.1	12.7	13.0	12.3	12.1	12.8	10.8	11.6	11.4
Length pectoral	16.9	17.3	17.8	17.8	16.8	15.9	15.3	15.5	17.6
Length pelvic	14.3	14.8	14.4	14.9	13.8	14.3	13.4	13.1	13.8
Height adipose	3.0	3.2	2.9	3.2	2.3		2.6	2.8	2.2
Base adipose	7.3	6.6	7.3	7.3	6.5		7.1	7.1	7.3
Length adipose	9.2	8.1	8.5	9.2	7.3		9.5	9.4	8.7
Ratio adipose / anal base	0.96	0.83	0.85	0.99	0.76		1.12	1.04	0.97
Ratio adipose base / anal base	0.76	0.67	0.73	0.79	0.68		0.84	0.79	0.81
Dorsal rays	13	12	12	12	13	12	13	13	12
Anal rays	11	12	12	11	11	11	11	11	11
Pectoral rays	17	17	16	18	18	16	17	18	16
Pelvic rays	11	11	11	11	11	11	11	11	10
Scales in lateral	83	83	82	85	92	80	84	81	77
Lateral to dorsal	9	10	10	10	9	10	9	9	9
Lateral to pelvic	8	9	9	8	8	8	8	8	8
Gill rakers - short arm	9	9	9	9	9	10	7	8	8
Gill rakers - long arm	13	14	13	12	12	13	13	13	13
Branchiostegals	9	9	8	8	9	8	8	8	7

Table VI - Systematic characters of <u>Prosopium</u> from Cultus lake.

Age	5+	4+	3+	3+	2+	2+	2+	2+	2+	2+
Standard length	298	259	283	252	248	241	231	230	228	210
Length head	19.5	20.2	21.2	20.1	20.4	20.5	19.7	19.0	20.6	19.3
Depth head	13.4	13.4	12.6	13.9	12.3	14.8	13.5	13.4	13.8	13.6
Greatest depth body	21.4	20.6	19.1	22.7	19.6	21.1	21.2	19.4	21.4	
Width body		12.6	12.5	14.9	13.1	14.7	14.9	12.0	14.3	
Least depth caudal peduncle	6.0	6.4	6.2	6.6	6.5	6.8	6.4	6.1	6.4	6.2
Snout	5.5	6.0	6.4	6.2	5.9	5.4	5.8	5.2	6.0	5.2
Maxillary	5.5	5.8	6.3	5.8	5.7	5.6	5.7	5.1	5.6	5.1
Diameter eye	3.8	4.1	4.0	3.9	4.1	4.2	4.1	4.4	4.6	4.1
Interorbital width	5.6	5.6	5.8	5.9	5.5	6.2	5.6	5.1	5.7	5.7
Snout tip to occiput	14.6	15.4	15.1	15.3	15.3	15.6	14.8	16.0	15.9	15.0
Snout tip to dorsal	42.3	41.5	42.8	44.0	40.8	42.3	41.1	42.4	42.8	42.3
Snout tip to pelvic	52.0	51.0	53.7	52.2	51.2	51.0	51.8	50.9	50.0	52.4
Length dorsal fin base	11.5	13.3	12.5	12.9	12.5	13.2	13.3	11.2	12.7	12.9
Length anal fin base	9.3	10.9	10.1	10.3	10.0	10.9	10.7	9.7	10.0	10.5
Height dorsal fin	13.5	14.4	14.5	13.7	15.0	14.4	14.2	12.8	14.5	15.5
Height anal fin	11.6	12.3	13.0	13.1	12.5	12.9	12.3	12.3	11.7	13.2
Length pectoral	15.0	16.1	15.9	16.6	16.3	16.6	16.6	14.0	15.5	15.5
Length pelvic	13.8	14.7	14.3	14.9	14.2	14.4	14.0	13.5	14.1	12.9
Height adipose	3.7	4.2	3.6	4.0	2.9	3.2	3.4	3.6	3.2	3.2
Base adipose	7.0	9.7	7.4	9.5	8.5	8.6	8.2	9.1	8.8	8.4
Length adipose	10.0	11.2	9.9	12.0	10.1	10.8	10.3	10.6	11.0	10.0
Ratio $\frac{\text{adipose}}{\text{anal base}}$	1.08	1.03	0.98	1.16	1.01	0.99	0.96	1.09	1.1	0.95
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.75	0.89	0.73	0.92	0.85	0.79	0.77	0.94	0.88	0.80
Dorsal rays	13	13	13	13	13	13	14	14	13	14
Anal rays	12	12	13	12	11	12	12	12	11	12
Pectoral rays	17	17	15	17	16	16	16	18	15	15
Pelvic rays	11	11	11	11	11	11	11	11	11	11
Scales in lateral	85	82	85	88	83	81	84	87	85	82
Lateral to dorsal	10	9	9	10	9	10	9	9	10	9
Lateral to pelvic	8	8	8	8	8	8	8	7	8	8
Gill rakers										
- short arm	9	8	9	9	8	8	8	8	9	9
- long arm	13	13	13	14	13	11	11	14	11	13
Branchiostegals	9	8	8	8	7	8	8	9	8	8
Sex	♀	♀	♀	♀	♂	♂	♀	♀	♀	♀

Table VI - Cultus lake (Continued)

Age	2+	2+	2+	2+	2+	1+	1+	1+	1+	1+
Standard length	205	202	200	193	187	135	134	132	128	124
Length head	21.1	19.9	20.7	21.1	20.5	19.9	21.5	22.0	21.5	21.6
Depth head	14.3	13.7	13.9	14.4	13.3	12.9	14.5	12.9	13.7	13.9
Greatest depth body				19.6	18.2					
Width body				15.2	14.2					
Least depth caudal peduncle	6.7	6.3	6.5	6.6	6.4		6.3	6.1	6.4	6.3
Snout	6.0	5.6	5.8	5.0	5.0	5.3	6.0	6.1	5.6	6.4
Maxillary	5.5	5.3	5.0	4.7	4.9	5.3	5.2	6.1	5.9	6.0
Diameter eye	4.4	4.2	4.3	4.6	4.5	4.8	5.1	5.3	5.4	5.9
Interorbital width	5.9	5.5	5.9	6.4	5.9		6.5	6.8	6.6	7.1
Snout tip to occiput	16.2	15.2	15.6	15.9	15.4	15.8	16.6	17.1	16.8	17.1
Snout tip to dorsal	43.8	42.7	44.2	41.2	42.9	41.8	41.4	43.2	43.0	43.1
Snout tip to pelvic	52.3	50.3	52.0	49.2	50.8	51.0	51.5	51.1	50.8	50.8
Length dorsal fin base	12.2	12.8	13.1	12.4	12.6	13.3	12.7	12.0	12.5	12.7
Length anal fin base	9.8	10.9	10.0	10.6	10.5	9.9	10.8	9.7	10.6	10.5
Height dorsal fin	16.2	14.8	15.6	15.3	13.6	14.8	14.9	15.1	16.4	14.5
Height anal fin	13.5	13.2	12.6	12.5	12.3	12.4	12.3	12.1	13.9	11.7
Length pectoral	17.3	15.6	16.2	17.2	15.8	15.5	15.2	14.5	15.8	15.7
Length pelvic	14.5	13.3	13.8	14.5		12.9	12.3	12.5	12.1	12.5
Height adipose	3.1	3.1	3.1	3.2	3.4					
Base adipose	7.8	7.5	8.3	9.4	9.6	8.9	9.0	7.6	8.2	9.3
Length adipose	9.8	9.5	10.1	11.4	11.2	10.4	10.4	10.2	10.5	10.5
Ratio adipose / anal base	1.0	0.87	1.01	1.07	1.07	1.05	0.96	1.05	1.0	1.0
Ratio adipose base / anal base	0.80	0.69	0.83	0.89	0.91	0.90	0.83	0.78	0.78	0.89
Dorsal rays	13	14	13	14	14					
Anal rays	11	12	12	12	12					
Pectoral rays	16	16	15	16	15					
Pelvic rays	11	11	11	11						
Scales in lateral	85	87	81	81	84	84	85	88	78	83
Lateral to dorsal	9	10	10	10	9					
Lateral to pelvic	8	8	8	8	8					
Gill rakers - short arm	9	9	9	10	10					
Gill rakers - long arm	12	12	13	13	13					
Branchiostegals	8	8	8	8	8					
Sex	♀	♀	♂	♂	♀	♀	♂	♀	♂	♂

Table VI - Cultus lake (Continued)

Age	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+
Standard length	120	119	119	118	118	117	116	114	114	113
Length head	22.5	20.6	21.8	22.4	21.2	21.8	21.7	22.8	22.3	20.8
Depth head	13.3	12.8	13.4	13.1	14.8	13.7	14.0	14.0	14.5	12.4
Greatest depth body										
Width body										
Least depth caudal peduncle	5.8	6.7	5.9	6.1		6.7	6.3	6.1		6.0
Snout	6.2	5.2	5.5	5.7	5.8	6.0	5.5	6.0	6.0	5.3
Maxillary	6.0	5.7	5.7	5.7	5.6	6.0	5.5	6.1	5.9	5.3
Diameter eye	5.6	5.2	5.5	5.9	5.2	5.3	5.6	5.7	5.7	5.3
Interorbital width	6.7	6.5	6.7	6.4		6.8		6.4		5.8
Snout tip to occiput	17.5	16.0	17.2	17.4	16.9	16.9	16.8	17.5	17.9	15.9
Snout tip to dorsal	43.3	43.0	42.8	43.2	42.3	43.6	43.2	43.1	43.8	41.5
Snout tip to pelvic	50.0	48.8	51.2	50.0	51.7	49.6	50.8	49.5	51.6	49.5
Length dorsal fin base	12.5	12.2	12.8	12.3	12.9	12.4	12.9	13.6	13.1	12.4
Length anal fin base	10.0	9.2	8.4	10.3	9.5	10.3	10.1	9.7	10.3	10.2
Height dorsal fin	15.8	15.1	15.3	16.1	15.5	15.8	15.9	15.8	15.5	14.2
Height anal fin	12.5	11.8	12.6	12.7	13.5	13.5	12.9	12.7	12.5	12.2
Length pectoral	15.0	15.5	15.1	16.1	15.6	16.2	15.6	15.3	15.7	14.6
Length pelvic	12.5	12.6	12.2	13.6	12.3	13.8	12.7	13.2	13.0	11.9
Base adipose	8.5	7.1	8.8	8.5	8.6	8.6	8.4	8.3	8.4	8.9
Length adipose	9.9	9.0	10.1	10.6	10.7	10.7	9.7	9.2	12.4	10.2
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.99	0.98	1.2	1.03	1.13	1.04	0.96	0.95	1.2	1.0
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.85	0.77	1.05	0.83	0.91	0.84	0.83	0.86	0.81	0.87
Scales in lateral	83	85	86	85	89	85	88	88	89	87
Sex	♂	♀	♂	♀	♀	♂	♂	♂	♂	♀

Table VI - Cultus lake (Continued)

Age	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+
Standard length	113	113	111	111	111	110	108	106	105	105
Length head	22.1	21.4	22.1	22.5	21.2	21.6	21.0	23.1	21.9	22.4
Depth head	13.4	13.4	13.5	13.5	12.6	13.2	13.4	14.1	13.4	13.8
Least depth caudal peduncle	6.2	6.4	6.1	6.3	6.3	5.9	6.5	6.4	6.2	6.5
Snout	5.7	6.0	5.9	5.9	5.4	5.0	5.8	5.7	5.7	6.2
Maxillary	5.7	5.7	6.1	5.9	5.6	5.5	5.7	5.7	6.2	6.2
Diameter eye	5.5	5.3	5.6	5.6	5.4	5.7	5.6	5.7	5.7	5.9
Interorbital width	6.6	6.9	6.7	7.2	6.3	6.5	6.5	6.6	6.7	6.7
Snout tip to occiput	17.7	16.6	17.7	17.1	17.6	16.8	17.1	17.0	17.6	17.1
Snout tip to dorsal	42.9	42.8	43.2	44.1	42.3	42.5	42.6	42.4	42.8	43.6
Snout tip to pelvic	49.1	49.5	49.1	51.4	47.3	50.0	49.1	50.0	50.3	49.3
Length dorsal fin base	12.4	12.4	12.6	13.5	12.2	11.8	12.0	12.3	12.4	12.4
Length anal fin base	10.3	10.2	10.4	9.9	9.9	9.5	9.7	9.4	9.5	9.5
Height dorsal fin	15.5	15.7	14.4	15.8	14.9	15.0	14.8	16.0	16.2	15.7
Height anal fin	13.1	13.1	12.6	13.1	12.6	12.3	12.8	13.2	12.4	12.4
Length pectoral	16.3	15.5	15.3	16.2	15.5	15.6	15.7	16.0	15.9	17.1
Length pelvic	13.3	12.4	12.2	13.2	12.6	12.5	12.2	13.7	12.4	12.6
Base adipose	9.3	8.7	9.7	8.3	8.8	8.2	7.9	8.5	9.3	8.6
Ratio adipose / anal base	1.08	0.95	1.09	0.91	1.05	1.12	1.0	1.05	1.2	1.0
Ratio adipose base / anal base	0.90	0.85	0.93	0.84	0.89	0.86	0.81	0.90	0.98	0.91
Scales in lateral	82	86	83	79	83	85	82	77	81	88
Sex	♂	♀	♂	♀	♂	♀	♂	♀	♀	♂
Length adipose	11.1	9.7	11.3	9.0	10.4	10.6	9.7	9.9	11.4	9.5

Table VI.- Cultus lake (Concluded)

Age	1+	1+	1+	1+	1+	1+	1+
Standard length	104	103	103	102	99	96	95
Length head	22.1	21.9	22.3	22.1	21.7	21.9	21.9
Depth head	14.9	14.7	13.4	13.7	13.6	13.6	13.5
Least depth caudal peduncle			6.3	5.9	6.1	6.2	6.3
Snout	6.2	5.8	6.3	5.4	5.1	5.2	5.3
Maxillary	6.0	5.8	6.1	5.9	5.6	5.4	5.5
Diameter eye	5.9	5.8	5.8	5.9	5.6	5.4	5.8
Interorbital width			6.8	6.4	6.6	7.1	6.5
Snout tip to occiput	17.8	17.1	17.3	17.4	17.7	17.5	17.7
Snout tip to dorsal	41.4	41.3	42.5	42.2	42.4	43.8	43.2
Snout tip to pelvic	51.1	51.3	50.0	49.2	47.0	51.0	48.5
Length dorsal fin base	12.9	11.6	12.6	14.2	13.6	12.0	11.6
Length anal fin base	10.1	9.9	10.2	11.0	9.6	9.6	10.5
Height dorsal fin	15.1	16.6	15.5	16.7	16.4	14.6	15.8
Height anal fin	13.5	13.1	12.1	13.5	12.6	12.0	12.6
Length pectoral	16.1	17.0	16.0	16.7	15.9	15.1	15.8
Length pelvic	12.5	13.2	12.6	13.2	13.1	12.0	11.8
Base adipose	7.9	7.5	9.2	8.3	7.9	7.8	8.2
Length adipose	9.7	9.8	10.4	9.8	9.6	9.9	10.3
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.96	0.99	1.02	0.89	1.0	1.03	0.98
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.78	0.76	0.90	0.75	0.82	0.81	0.78
Scales in lateral	88	83	83	79	85	82	89
Sex	♀	♂	♂	♀	♀	♂	♀

Table VII - Systematic characters of <u>Prosopium</u> from Logging lake.

Age	3+	3+	3+	3+	3+	2+	2+	2+	2+	2+
Standard length	190	184	178	178	174	177	173	172	170	169
Length head	21.0	20.4	20.8	21.0	21.2	21.4	21.4	20.9	20.6	22.5
Depth head	13.7	13.6	14.3	14.0	14.4	13.8	15.0	14.5	14.7	15.4
Greatest depth body										
Width body										
Least depth caudal peduncle	6.3	6.5	6.7	6.7	6.6	6.8	6.9	6.4	6.5	7.1
Snout	5.3	5.4	5.6	5.6	5.5	5.1	5.5	5.8	5.9	5.9
Maxillary	5.3	5.2	5.3	5.6	5.2	5.1	5.2	5.5	5.6	5.9
Diameter eye	4.7	4.9	4.5	5.1	4.6	5.1	5.2	4.6	5.3	5.0
Interorbital width	6.8	6.5	6.2	6.2	6.6	7.4	6.7	6.4	5.9	6.8
Snout tip to occiput	15.2	15.2	16.3	15.2	14.9	15.2	16.2	16.3	15.9	17.1
Snout tip to dorsal	41.6	42.6	43.2	42.1	44.2	43.5	42.8	43.0	42.3	43.5
Snout tip to pelvic	50.0	50.5	52.5	51.1	49.7	50.3	51.4	51.2	52.3	48.8
Length dorsal fin base	11.6	12.2	11.5	11.2	11.2	11.9	11.3	11.6	11.8	11.5
Length anal fin base	10.0	9.8	9.3	9.3	7.8	9.9	9.8	8.7	9.1	10.1
Height dorsal fin	13.7	15.2	14.0	14.0	14.1	14.7	13.9	14.2	14.1	16.0
Height anal fin	10.8	12.0	11.2	10.7	11.3	10.6	11.8	11.0	11.2	12.4
Length pectoral	16.3	15.5	15.4	15.7	15.2	16.4	15.9	16.3	15.9	17.1
Length pelvic	13.4	13.0	12.9	12.4	12.9	13.6	13.3	12.8	13.2	13.9
Height adipose	2.6	2.7	2.8	2.5	2.6	2.5	2.6	2.6	2.9	3.0
Base adipose	7.6	8.2	7.3	7.9	8.0	7.9	7.5		7.6	7.1
Length adipose	9.2	9.5	9.3	9.3	9.2	9.3	8.7	8.7	8.5	8.9
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.92	0.97	1.0	1.0	1.18	0.94	0.89	1.0	0.93	0.88
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.76	0.84	0.79	0.85	1.02	0.80	0.77		0.84	0.70
Dorsal rays	13	12	13	12	12	12	12	12	12	12
Anal rays	12	11	11	11	11	11	11	11	11	12
Pectoral rays	17	18	18	17	17	19	17	17	16	17
Pelvic rays	11	11	11	11	11	12	11	11	11	11
Scales in lateral	78	83	79	85	77	82	78	80	87	77
Lateral to dorsal	9	10	9	9	9	9	9	9	9	9
Lateral to pelvic	8	8	8	8	8	8	8	8	8	8
Gill rakers										
- short arm	8	9	9	9	10	9	10	10	9	9
- long arm	14	13	13	13	14	15	13	14	13	15
Branchiostegals	9	9	9	9	8	8	8	9	8	8
Sex										

Table VII - Logging lake (Continued)

Age	2+	2+	2+	2+	2+	2+	2+	2+	2+	2+
Standard length	163	162	162	161	158	158	157	157	157	156
Length head	21.5	21.3	21.6	20.6	21.5	20.9	21.0	21.3	20.7	20.5
Depth head	14.7	13.9	13.6	14.9	14.5	13.3	13.4	14.6	14.0	14.7
Greatest depth body										
Width body										
Least depth caudal peduncle	6.7	6.5	6.5	6.2	7.0	6.3	6.4	6.7	6.7	6.7
Snout	5.2	5.6	6.0	5.3	5.4	5.1	5.4	5.4	5.1	4.8
Maxillary	4.6	5.2	5.6	5.0	5.4	5.1	5.4	5.1	5.1	4.8
Diameter eye	4.9	4.6	4.8	4.8	5.1	5.1	4.8	4.9	4.8	4.5
Interorbital width	6.7	7.1	5.9	6.2	7.0	6.2	6.7	6.4	7.0	6.7
Snout tip to occiput	16.6	15.7	16.7	14.9	15.8	15.8	15.3	15.6	15.0	15.1
Snout tip to dorsal	44.4	41.9	43.2	42.8	43.0	41.4	44.3	42.3	42.7	43.6
Snout tip to pelvic	50.6	49.3	51.2	50.9	50.6	49.6	49.0	48.4	52.2	50.6
Length dorsal fin base	11.0	12.0	11.1	10.6	12.0	11.7	11.1	12.7	10.8	11.2
Length anal fin base	8.9	9.6	8.6	9.9	10.8	10.1	8.3	9.6	9.6	9.0
Height dorsal fin	14.7	13.9	14.5	13.0	13.3	14.5	12.7	14.6	13.7	14.1
Height anal fin	11.6	10.5	12.0	10.6	12.0	11.4	10.8	12.1	11.5	10.6
Length pectoral	16.6	15.4	15.7	15.5	15.8	14.9	13.7	15.9	15.3	16.0
Length pelvic	12.9	13.0	13.5	12.4	13.0	12.0	13.0	13.7	13.4	12.8
Height adipose	2.6	3.1	2.8	2.2	2.5	2.5	2.9			2.6
Base adipose	7.4	8.0	8.0	7.5	7.9	7.7	6.7	7.6	6.7	7.1
Length adipose	8.6	9.3	9.3	8.7	9.5	8.9	8.3	9.9	8.6	8.3
Ratio adipose / anal base	0.97	0.97	1.08	0.88	0.88	0.88	1.0	1.03	0.90	0.92
Ratio adipose base / anal base	0.83	0.83	0.93	0.76	0.73	0.76	0.81	0.79	0.70	0.79
Dorsal rays		12		12	12	12	11	12		12
Anal rays		11		11	11	11	11	11		11
Pectoral rays		18		18	17	18	17	17		18
Pelvic rays		11		11	11	12	11	11		11
Scales in lateral	83	78	82	87	79	85	84	77	81	82
Lateral to dorsal		9		9	9	9	9	9		9
Lateral to pelvic		8		8	8	8	8	8		8
Gill rakers										
- short arm		9		9	9	8	9	9		10
- long arm		13		13	14	13	14	13		13
Branchiostegals		8		9	9	8	9	8		8
Sex										

Table VII - Logging lake (Continued)

Age	2+	2+	2+	2+	2+	2+	2+	2+	2+	2+
Standard length	155	150	149	148	145	145	144	144	141	137
Length head	19.7	20.7	20.8	22.6	22.1	22.1	21.5	22.2	22.0	21.5
Depth head	13.5	14.3	14.1	14.9	14.8	14.1	13.7	14.6	14.2	14.6
Least depth caudal peduncle	7.1	6.7	6.7	6.8	6.8	6.5	6.2	6.7	6.4	6.6
Snout	4.8	4.3	5.0	6.1	5.2	5.9	5.2	6.2	5.8	5.1
Maxillary	4.8	4.3	5.0	5.7	5.5	5.9	5.2	5.6	5.7	5.1
Diameter eye	4.5	4.7	5.0	5.4	5.2	5.5	5.0	5.6	5.5	5.1
Interorbital width	6.4	6.7	6.4	6.4	7.2	6.7	6.6	6.6	7.1	6.6
Snout tip to occiput	15.5	15.7	16.8	17.9	16.2	17.2	16.7	17.0	17.7	16.8
Snout tip to dorsal	43.8	42.0	43.6	43.5	43.4	45.5	43.0	43.8	43.9	44.8
Snout tip to pelvic	47.7	50.6	50.0	50.0	51.0	49.7	49.3	50.0	49.6	51.1
Length dorsal fin base	11.6	12.0	11.7	12.2	12.4	12.4	11.4	13.2	11.3	11.3
Length anal fin base	9.4	10.0	9.7	10.1	10.0	9.5	9.7	9.4	8.9	9.5
Height dorsal fin	14.2	13.0	15.4	14.2	15.2	15.6	14.6	15.9	14.2	13.9
Height anal fin	11.0	10.0	11.7	12.5	11.7	12.7	12.2	12.8	11.7	10.2
Length pectoral	16.8	15.3	16.4	16.9	15.8	16.5	16.0	17.3	15.7	15.3
Length pelvic	13.5	12.3	12.7	13.5	12.4	13.4	12.5	13.9	13.1	12.4
Height adipose	2.9	2.7	2.3	3.4	2.4			2.6		2.6
Base adipose	7.7	8.0	8.1	8.0	7.9	8.1	8.2	7.4		6.2
Length adipose	9.0	10.0	9.4	9.1	9.7	9.5	9.4	9.0	8.5	7.3
Ratio adipose / anal base	0.96	1.0	0.97	0.90	0.97	1.0	0.97	0.96	0.96	0.77
Ratio adipose base / anal base	0.82	0.80	0.84	0.79	0.79	0.85	0.85	0.79		0.65
Dorsal rays	12	12	13	12	12		12			12
Anal rays	12	12	12	11	12		11			11
Pectoral rays	18	16	19	18	17		17			17
Pelvic rays	12	11	11	12	11		11			11
Scales in lateral	76	79	80	80	84	85	75	74	80	77
Lateral to dorsal	9	9	9	9	9					9
Lateral to pelvic	8	8	8	8	8					8
Gill rakers										
- short arm	10	9	9	8	8		8			8
- long arm	13	13	15	14	12		13			13
Branchiostegals	8	8	8	8	8		8			8

Table VII - Logging lake (Continued)

Age	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+
Standard length	130	127	124	124	123	121	120	119	118	117	115
Length head	23.1	22.4	22.2	23.0	21.5	23.1	22.1	21.4	21.2	21.4	22.6
Depth head	14.4	14.2	13.5	14.5	14.2	14.9	14.2	13.4	13.5	13.5	13.0
Least depth caudal peduncle	6.0	6.9	6.0	6.9	6.1	6.4	6.7	6.3	6.4	5.1	6.1
Snout	5.2	5.7	5.6	6.4	5.3	5.1	5.6	5.3	5.3	5.6	5.4
Maxillary	5.4	5.9	5.6	6.0	5.3	5.4	5.9	5.5	5.6	5.6	5.6
Diameter eye	5.4	5.5	5.2	5.6	5.3	5.8	5.8	5.5	5.3	5.6	5.6
Interorbital width	7.1	6.8	6.4	6.4	6.5	6.6	6.2	6.3	7.2	6.4	6.1
Snout tip to occiput	16.5	17.3	16.5	18.1	16.7	17.8	17.5	16.4	16.9	16.7	16.5
Snout tip to dorsal	44.6	44.8	43.9	44.3	44.3	45.3	44.2	42.8	44.0	44.8	44.3
Snout tip to pelvic	50.3	50.3	50.0	49.6	50.3	49.6	49.2	50.3	50.0	50.0	52.2
Length dorsal fin base	11.5	13.0	10.9	11.7	11.4	11.4	11.2	12.2	11.4	11.4	10.2
Length anal fin base	9.2	10.4	10.1	10.1	8.9	9.3	9.2	8.8	8.5	8.5	10.4
Height dorsal fin	14.6	16.5	15.3	15.7	13.8	15.3	14.2	14.3	13.1		13.7
Height anal fin	12.3	13.4	13.3	13.7	11.4	13.2	10.8	10.9	10.6	10.7	11.7
Length pectoral	15.4	17.3	16.1	17.7	15.0	16.5	16.7	14.3	15.0	15.4	14.8
Length pelvic	12.7	13.4	13.3	14.1	11.8	13.2	14.6	12.6	12.3	12.0	12.2
Height adipose		3.1					2.2	2.3			
Base adipose	7.7	8.3	7.3	7.3	7.1	9.1	7.5	8.4	6.1	7.3	8.3
Length adipose	9.2	9.4	8.1	8.1	8.9	9.9	9.2	9.2	7.6	7.7	9.1
Ratio $\frac{\text{adipose}}{\text{anal base}}$	1.0	0.90	0.80	0.80	1.0	1.06	1.0	1.04	0.89	0.91	0.87
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.84	0.79	0.72	0.72	0.80	0.98	0.82	0.95	0.72	0.86	0.80
Dorsal rays		12					12	12			
Anal rays		12					11				
Pectoral rays		17					17				
Pelvic rays		11					11				
Scales in lateral	81	78	82	86	83	76	83	79	82	84	79
Lateral to dorsal		9					9				
Lateral to pelvic		8					8				
Gill rakers											
- short arm		9					9				
- long arm		14					13				
Branchiostegals		8									

Table VII - Logging lake (Concluded)

Age	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+
Standard length	114	114	113	113	113	113	108	108	105	103	99
Length head	22.8	22.4	22.5	22.5	22.2	22.5	23.7	23.7	21.9	23.3	24.3
Depth head	14.7	14.9	14.1	14.0	13.7	13.7	13.9	13.9	14.3	14.6	17.2
Least depth caudal peduncle	6.6	6.1	6.2	6.2	6.2	6.2	6.5	6.5	6.5	6.6	7.1
Snout	5.7	5.7	5.3	5.3	5.7	5.3	6.0	5.6	5.5	5.8	6.6
Maxillary	6.1	5.3	5.3	5.3	5.5	5.3	5.6	6.0	5.7	5.8	6.1
Diameter eye	5.7	5.7	6.2	5.5	5.5	5.3	5.7	5.6	5.7	5.8	6.6
Interorbital width	6.1	6.8	6.6	5.9	7.1	6.2	6.5	6.3	6.5	7.3	7.9
Snout tip to occiput	17.5	18.4	16.8	17.2	17.7	17.7	17.6	16.8	17.1	18.9	21.2
Snout tip to dorsal	43.8	44.7	43.3	43.3	43.3	44.2	43.0	44.8	43.3	46.6	46.0
Snout tip to pelvic	49.1	48.7	49.1	50.4	51.3	48.6	48.6	50.9	50.5	51.5	51.5
Length dorsal fin base	11.8	11.8	11.1	10.6	11.5	12.4	11.6	11.1	11.0	10.2	11.8
Length anal fin base	8.8	9.6	8.2	9.0	9.3	9.7	9.3	9.3	8.6	9.5	9.3
Height dorsal fin	14.9	17.1	15.0	13.7	14.1	15.0	14.8	14.3	14.5	15.7	16.2
Height anal fin	12.3	13.1	11.1	11.0	11.5	11.5	11.1	13.0	11.4	14.1	13.2
Length pectoral	16.2	17.5	15.0	15.9	15.9	15.9	15.7	14.8	16.7	17.5	18.2
Length pelvic	12.7	14.0	12.4	12.5	12.8	12.8	12.5	13.0	12.4	15.5	14.7
Height adipose	2.5										
Base adipose	7.0	7.0	7.5	7.1	8.4	8.0	7.1	8.3	8.6	7.3	8.6
Length adipose	8.3	8.3	8.8	8.8	9.3	9.7	8.8	10.2	9.5	8.7	9.6
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.94	0.86	1.07	0.98	1.0	1.0	0.95	1.10	1.10	0.92	1.03
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.80	0.73	0.92	0.79	0.90	0.82	0.76	0.89	1.0	0.77	0.93
Scales in lateral	79	83	81	82	83	87	78	70	84	82	75

Table VIII - Systematic characters of <u>Prosopium</u> from lake McDonald.

Age	1+	1+	1+	1+	1+	1+	1+
Standard length	124	123	114	112	111	109	97
Length head	22.6	22.3	22.1	22.8	22.2	23.6	24.2
Depth head	14.3	14.4	14.6	15.2	14.0	14.9	15.2
Least depth caudal peduncle	6.1				6.6	6.7	6.5
Snout	5.8	5.2	5.4	5.5	5.8	6.2	6.2
Maxillary	5.3	5.2	5.4	5.5	5.7	6.1	6.3
Diameter eye	5.0	5.2	5.4	5.5	5.8	5.5	6.1
Snout tip to occiput	16.8	17.1	17.3	17.8	16.8	18.4	19.6
Snout tip to dorsal	42.7	44.6	43.4	45.0	42.9	44.5	45.9
Snout tip to pelvic	48.9	49.6	50.7	51.5	51.3	50.4	51.6
Length dorsal fin base	11.8	12.4	11.3	12.1	12.3	13.6	12.0
Length anal fin base	9.0	8.9	7.7	9.1	9.5	9.9	9.6
Height dorsal fin	14.5	14.9	14.6	14.3	13.9	17.0	16.9
Height anal fin	11.9	11.2	10.5	12.5	11.2	13.9	13.7
Length pectoral	16.2	15.4	14.3	15.9	14.9	17.4	18.3
Length pelvic	12.6	12.4	11.7	13.1	11.5	13.9	14.4
Base adipose	7.1	7.2	8.8	7.1	7.7	8.9	7.2
Length adipose	8.9	8.2	9.8	8.9	9.0	9.7	9.3
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.99	0.92	1.27	0.98	0.95	0.98	0.97
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.79	0.81	1.14	0.78	0.81	0.90	0.75
Scales in lateral line	81	85	81	86	83	79	86

Table VIII - Lake McDonald (Concluded)

Age	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+
Standard length	68.5	62.0	61.0	60.5	59.0	58.5	57.0	54.0	53.5	52.5	52.0
Length head	23.8	25.4	25.2	25.0	26.6	26.4	25.3	25.3	26.8	26.0	25.1
Snout tip to occiput	17.7	20.2	19.3	18.7	20.3	19.3	20.5	19.9	20.8	19.0	20.4
Snout tip to dorsal	44.8	45.5	44.5	45.4	45.3	45.7	44.7	46.8	46.9	43.3	44.3
Snout tip to pelvic	51.7	52.4	50.8	50.7	52.9	52.8	52.8	53.7	53.4	53.3	52.4

Age	0+	0+	0+	0+	0+	0+	0+	0+	0+	0+
Standard length	52.0	51.0	51.0	50.0	49.5	49.0	45.0	38.0	36.0	33.5
Length head	25.1	25.9	27.3	25.8	25.4	25.7	28.0	27.8	27.9	28.8
Snout tip to occiput	20.1	20.8	21.4	20.2	19.7	20.4	22.9			
Snout tip to dorsal	45.8	45.1	46.1	46.2	46.1	46.5	46.6			
Snout tip to pelvic	52.2	53.3	53.6	52.4	54.8	55.2	53.5			

Table IX - Systematic characters of <u>Prosopium</u> from Bowman lake.

Age	2+	2+	2+	2+	2+	2+	2+	2+	2+	2+
Standard length	133	123	123	111	110	106	101	100	96	94
Length head	21.3	22.7	21.9	22.7	23.1	23.5	23.8	22.1	22.9	24.5
Depth head	13.4	14.2	13.6	14.2	14.2	14.0	13.9	14.3	14.6	14.9
Least depth caudal peduncle	6.5	6.7	6.3	6.5	6.3	6.4	6.2	6.7		
Snout	5.8	5.8	5.7	5.4	5.6	5.8	5.8	5.7		5.9
Maxillary	5.7	5.8	5.7	5.9	5.9	5.8	6.0	5.8		6.1
Diameter eye	4.7	5.5	5.5	5.7	5.6	5.8	5.9	5.9		6.4
Interorbital width										
Snout tip to occiput	16.5	17.1	16.7	17.8	17.7	18.9	18.3	17.8	18.4	19.4
Snout tip to dorsal	43.0	44.7	44.6	43.8	44.3	44.5	44.0	44.0	45.2	44.8
Snout tip to pelvic	48.8	50.7	49.0	49.7	49.9	50.4	51.3	49.6	50.5	51.2
Length dorsal fin base	11.4	11.5	11.4	12.6	10.7	12.1	11.6	11.7	12.2	12.3
Length anal fin base	9.4	9.7	9.5	8.4	9.1	9.6	9.7	9.2	9.1	9.6
Height dorsal fin	15.6	15.8	16.1	17.4	15.7	16.6	16.0	17.2	17.5	17.2
Height anal fin	11.8	12.4	12.8	12.3	12.4	13.0	12.9	12.7	12.7	13.0
Length pectoral	16.5	16.6	17.3	17.7	16.4	17.6	17.8	17.9	17.5	17.8
Length pelvic	12.9	13.0	13.5	12.7	13.3	12.6	13.9	13.2	13.1	13.1
Height adipose										
Base adipose	8.3	7.3	6.8	7.2	7.5	7.8	7.9	7.4	7.7	7.2
Length adipose	9.6	9.0	8.8	8.7	9.5	9.5	9.6	9.0	9.2	8.7
Ratio $\frac{\text{adipose}}{\text{anal base}}$	1.02	0.93	0.77	0.69	0.89	0.99	0.99	0.98	1.01	0.91
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.88	0.75	0.72	0.86	0.82	0.81	0.81	0.80	0.85	0.75
Scales in lateral	83	75	86	82	79	81	84	82	81	81
Sex	♂	♀	♂	♂	♂	♂	♀	♀	♂	♂

Table IX - Bowman lake (Concluded)

Age	1+	1+	1+	1+	1+	1+	1+	1+	1+
Standard length	104	89	86	86	83	81	80	80	80
Length head	21.4	23.5	23.3	23.0	23.9	24.6	24.6	23.8	24.6
Depth head	13.2	14.2	14.0	14.3	14.1	14.0	13.4	14.5	14.1
Least depth caudal peduncle	6.6	6.4			6.3				
Snout	5.9	5.6			5.7		6.3		
Maxillary	6.0	6.1			6.4		6.5		
Diameter eye	5.2	6.3			6.0		6.4		
Snout tip to occiput	16.9	18.1	18.1	18.8	19.0	19.0	19.0	19.4	17.4
Snout tip to dorsal	44.2	45.0	44.6	44.3	43.6	44.7	44.5	44.1	45.1
Snout tip to pelvic	51.9	50.7	50.0	50.2	51.0	50.8	51.5	50.8	50.0
Length dorsal fin base	9.4	10.9	11.9	11.4	12.2	12.0	12.1	12.5	11.2
Length anal fin base	8.6	9.2	9.3	9.6	9.4	10.8	9.6	9.0	9.1
Height dorsal fin	15.5	15.7	16.5	16.6	16.6	16.1	16.3	16.0	15.4
Height anal fin	12.0	12.0	12.6	11.9	12.9	13.0	12.8	12.5	13.5
Length pectoral	16.0	15.5	17.1	16.0	16.5	16.4	16.6	16.3	17.0
Length pelvic	12.8	11.8	13.6	12.9	13.4	13.0	13.4	12.8	12.5
Base adipose	6.7	7.1	7.8		7.6		6.6	6.9	8.9
Length adipose	7.7	7.9	9.1		9.0		8.1	8.9	10.0
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.90	0.86	0.98		0.96		0.84	0.99	1.10
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.78	0.77	0.84		0.81		0.69	0.77	0.98
Scales in lateral	81	82	80		80		81	86	82

Table X - Systematic characters of Prosopium from Maskinonge lake, Nooksack river, and Tolt river.

	Maskinonge lake		Nooksack river		Tolt river
Age	1+	1+	1+	1+	3+
Standard length	110	104	115	114	200
Length head	23.3	24.0	20.9	22.3	20.6
Depth head	15.2	15.7	13.9	14.6	14.2
Least depth caudal peduncle			6.7	6.9	6.3
Snout	5.7	5.9	5.6	5.6	5.8
Maxillary	5.6	5.9	5.6	5.6	6.0
Diameter eye	5.9	6.4	5.8	5.9	4.8
Interorbital width			6.6	6.4	5.8
Snout tip to occiput	17.4	18.3	17.2	18.1	15.9
Snout tip to dorsal	43.8	44.1	42.3	45.2	42.2
Snout tip to pelvic	52.5	53.0	50.8	51.1	52.8
Length dorsal fin base	12.9	12.7	13.6	13.8	12.4
Length anal fin base	9.7	9.6	10.5	10.6	9.9
Height dorsal fin	15.8	15.9	17.0	16.5	15.2
Height anal fin	12.8	12.7	14.0	15.8	12.5
Length pectoral	16.2	15.7	17.7	16.7	16.6
Length pelvic	13.0	12.6	15.8	14.8	14.3
Height adipose			2.9	3.3	3.6
Base adipose	7.4	7.5			9.8
Length adipose	9.1	8.7	11.3	10.9	11.9
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.94	0.91	1.08	1.03	1.20
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.76	0.78			0.99
Dorsal rays			13	13	13
Anal rays			11	12	12
Pectoral rays			14	15	17
Pelvic rays			10	11	11
Scales in lateral	82	84	82	76	83
Lateral to dorsal			9	9	10
Lateral to pelvic			8	8	8
Gill rakers					
- short arm			9	10	9
- long arm			12	13	14
Branchiostegals			8	8	8

Table XI - Systematic characters of <u>Prosopium</u> from the Elk river.

Age		4+	3+	3+	3+	3+	2+	2+	2+
Standard length	254	231	210	206	200	195	201	184	183
Length head	22.0	22.2	22.4	22.3	22.2	22.0	22.5	23.1	22.4
Depth head	15.5	14.3	15.9	14.7	14.9	15.1	15.2	15.7	14.2
Least depth caudal peduncle	7.3	7.1	7.2	7.6	6.7	7.2	7.0	7.1	7.1
Snout	7.1	6.8	6.7	6.8	6.9	6.2	6.5	6.5	6.6
Maxillary	6.7	6.5	6.2	6.6	6.3	6.2	6.1	6.8	6.3
Diameter eye	4.4	4.3	4.5	4.2	4.5	4.6	4.2	4.8	4.5
Interorbital width	6.5	6.2	6.7	6.0	6.4	6.4	6.2	6.4	6.3
Snout tip to occiput	17.4	17.0	16.6	17.0	17.3	17.2	17.0	17.4	16.9
Snout tip to dorsal	44.3	44.3	43.8	43.7	43.8	43.0	43.8	42.3	43.1
Snout tip to pelvic	54.8	52.4	52.6	52.0	50.0	52.6	52.1	53.3	52.1
Length dorsal fin base	12.9	12.1	12.6	12.4	12.5	13.9	11.9	13.1	13.7
Length anal fin base	9.8	9.6	10.0	10.6	10.0	10.3	10.3	9.8	9.3
Height dorsal fin	15.4	17.3	15.7	16.4	15.8	17.4	16.9	16.3	16.0
Height anal fin	14.8	15.6	13.8	14.6	14.0	15.9	14.4	14.1	13.8
Length pectoral	17.2	18.5	17.1	17.9	17.6	18.5	16.9	16.7	17.7
Length pelvic	15.5	16.2	15.0	15.1	15.0	15.9	14.5	14.7	15.3
Height adipose	3.5	3.5	3.9	3.7	3.2	3.1	3.6	3.4	3.6
Base adipose	6.5	6.9	7.1	6.7	7.5	7.2	7.3	6.3	7.5
Length adipose	8.5	8.7	9.0	9.1	9.5	9.1	9.5	8.7	9.6
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.87	0.91	0.90	0.86	0.95	0.88	0.92	0.89	1.03
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.66	0.72	0.71	0.63	0.75	0.70	0.71	0.64	0.81
Dorsal rays	12	11	12	12	12	12	13	12	13
Anal rays	11	11	11	11	11	11	11	11	11
Pectoral rays	17	17	16	16	15	17	16	17	16
Pelvic rays	11	11	11	11	11	11	10	11	11
Scales in lateral	87	84	87	79	82	78	89	84	81
Lateral to dorsal	9	9	9	9	9	9	9	9	9
Lateral to pelvic	7	8	8	7	8	8	8	8	8
Gill rakers - short arm	10	10	11	9	9	10	10	10	9
- long arm	14	13	15	13	14	13	15	15	13
Branchiostegals	9	8	8	9	8	8	9	9	9
Sex	♀	♀	♀	♂	♂	♂	♀	♀	♂

Table XI - Elk river (Continued)

Age	2+	2+	2+	2+	2+	2+	2+	2+	2+
Standard length	182	182	181	180	180	178	178	178	178
Length head	22.8	22.0	22.5	22.3	24.3	23.0	22.6	22.2	21.9
Depth head	13.8	14.0	14.5	14.0	15.6	15.0	14.3	15.4	14.2
Least depth caudal peduncle	6.7	6.6	7.2	6.9	6.9	7.3	7.0	6.8	7.3
Snout	6.5	6.1	6.4	6.7	6.9	7.0	6.5	5.9	5.9
Maxillary	6.2	6.0	6.1	6.1	6.9	6.4	6.5	6.2	5.9
Diameter eye	4.9	4.6	4.7	4.7	5.3	4.9	4.8	4.6	4.6
Interorbital width	6.0	6.3	6.1	6.1	6.1	7.1	6.2	6.5	6.2
Snout tip to occiput	17.3	16.8	17.4	17.2	17.8	17.7	17.1	16.7	16.0
Snout tip to dorsal	43.4	44.5	43.9	43.8	43.7	45.0	44.0	44.0	43.2
Snout tip to pelvic	51.1	50.6	52.5	51.6	51.6	50.0	52.7	51.2	52.8
Length dorsal fin base	14.2	12.0	13.3	12.9	11.2	12.8	12.9	13.0	13.1
Length anal fin base	9.9	9.3	9.5	9.7	9.4	9.8	10.1	9.8	9.6
Height dorsal fin	14.9	15.6	17.1	16.1	17.2	17.4	17.4	16.9	16.3
Height anal fin	13.5	13.2	14.1	13.8	14.4	14.9	15.3	14.4	14.3
Length pectoral	17.0	17.0	18.2	17.6	18.3	17.7	17.5	17.7	18.0
Length pelvic	14.8	15.3	15.5	14.5	16.1	15.3	15.3	15.2	15.2
Height adipose	3.8	3.1	3.3	3.4	3.4	3.5	2.9	3.5	3.5
Base adipose	7.3	6.2	6.0	6.8	7.1	6.7	6.3	6.8	6.4
Length adipose	9.6	8.7	8.8	8.9	9.2	9.0	7.9	9.3	8.4
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.97	0.94	0.93	0.92	0.98	0.92	0.78	0.95	0.88
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.74	0.67	0.63	0.70	0.76	0.68	0.62	0.69	0.67
Dorsal rays	13	12	12	12	12	12	13	12	12
Anal rays	11	11	11	11	11	11	11	11	11
Pectoral rays	17	16	18	17	16	17	16	16	15
Pelvic rays	11	10	11	11	11	11	11	11	10
Scales in lateral	87	86	79	88	84	81	87	80	90
Lateral to dorsal	9	9	9	9	9	9	9	9	9
Lateral to pelvic	7	8	8	8	8	7	8	7	8
Gill rakers									
- short arm	10	9	10	9	10	10	9	9	10
- long arm	14	14	13	14	13	13	14	13	14
Branchiostegals	9	8	8	8	8	9		8	9
Sex	♂	♀	♀	♂	♂	♂	♂	♂	♂

Table XI - Elk river (Concluded)

Age	2+	2+	2+	2+	2+	2+	1+	1+
Standard length	178	177	175	172	170	167	127	126
Length head	23.0	22.9	23.7	22.4	23.2	23.4	22.8	22.5
Depth head	15.3	14.9	15.1	14.1	15.4	15.6	14.3	14.0
Least depth caudal peduncle	6.7	6.8	7.1	6.9	6.9	6.7	7.1	6.3
Snout	7.0	6.2	6.7	6.5	6.5	6.6	6.3	6.1
Maxillary	6.5	6.2	6.9	6.4	6.7	6.5	6.1	6.2
Diameter eye	4.6	5.1	4.6	4.6	5.2	5.0	5.5	5.4
Interorbital width	6.2	6.2	6.3	5.6	6.1	6.5	6.5	6.3
Snout tip to occiput	17.2	17.1	17.7	17.4	17.1	17.7	17.6	17.5
Snout tip to dorsal	44.5	43.5	44.5	43.6	44.0	44.3	43.3	43.6
Snout tip to pelvic	52.5	51.1	50.8	52.0	53.3	54.1	50.8	50.3
Length dorsal fin base	13.5	12.2	12.5	12.7	12.1	12.2	11.8	11.1
Length anal fin base	10.0	9.9	8.6	9.8	9.7	9.6	9.4	8.9
Height dorsal fin	16.3	16.7	16.6	15.1	16.0	17.2	15.7	14.9
Height anal fin	13.4	14.1	15.4	13.7	12.6	13.9	13.3	13.6
Length pectoral	17.3	17.5	18.7	17.6	16.6	18.0	16.9	16.7
Length pelvic	15.3	14.7	15.4	14.4	14.7	15.6	14.4	14.3
Height adipose	2.9	3.5	3.8	3.0	3.3	3.0		
Base adipose	6.7	7.5	7.3	6.5	7.1	6.5	6.6	6.9
Length adipose	9.0	9.7	9.3	8.7	9.3	8.7	8.7	8.4
Ratio $\frac{\text{adipose}}{\text{anal base}}$	0.90	0.98	1.08	0.89	0.96	0.91	0.92	0.94
Ratio $\frac{\text{adipose base}}{\text{anal base}}$	0.67	0.76	0.85	0.66	0.73	0.68	0.70	0.77
Dorsal rays	13	12	11	12	11	12	12	11
Anal rays	11	12	10	10	11	10	11	11
Pectoral rays	18	17	17	17	16	16	17	16
Pelvic rays	11	12	11	11	10	11	11	11
Scales in lateral	82	83	84	94	87	84	89	87
Lateral to dorsal	9	9	9	9	9	9	9	9
Lateral to pelvic	7	8	8	8	7	8	8	7
Gill rakers - short arm	10	9	9	10	9	10	8	10
- long arm	15	13	13	14	12	14	12	14
Branchiostegals	8	8	8	9	9	8	8	8
Sex	♂	♀	♀	♀	♂	♂	♀	♂

Table XII - Standard length attained by the Bowman lake whitefish at the end of each year of life.

No.	Standard length at end of year: 1	2	3	4	Scale rings: 1	2	3	4
2	28							
1	30							
3	32							
5	41	63			9	4		
4	47	63			10	3		
7	46	66			12	4		
6	51	71			11	3		
12	52	72			13	3		
11	53	72			13	3		
9	54	74			14	3		
8	58	76			11	3		
14	50	77			11	5		
13	58	78			16	5		
10	59	78			15	3		
16	61	80			14	3		
24	64	80			17	3		
32	68	80			17	2		
31	59	81			16	4		
33	61	80			18	4		
15	62	82			15	4		
18	64	82			15	3		
19	64	83			16	4		
25	65	84			18	5		
21	65	84			15	4		
22	69	84			12	3		
20	62	85			17	5		
17	60	86			15	5		
34	72	86			15	3		
30	63	87			14	4		
28	67	89			17	4		
23	69	92			16	4		
27	60	104			16	9		
26	44	82	95		14	16	4	
37	42	81	97		12	12	5	
36	44	94	100		12	16	1	
35	41	91	101		12	13	2	
29	41	91	106		12	16	3	
38	42	88	111		15	16	4	
39	43	89	112		14	14	5	
40	60	95	123		17	15	2	
41	45	100	124		19	18	4	
42	53	115	134		18	23	4	

Table XIII - Standard length attained by the Lake McDonald whitefish at the end of each year of life.

No.	Standard length at end of year: 1	2	3	Scale rings: 1	2	3
328	34					
327	36					
326	38					
325	46					
309	50					
311	50					
324	50					
313	51					
320	51					
312	52					
322	52					
321	53					
316	55					
323	55					
319	58					
315	60					
317	60					
318	61					
310	62					
314	63					
308	69			11		
306	64	98		14	7	
307	41	109		13	16	
305	44	112		12	16	
303	57	112		14	10	
304	57	115		13	13	
301	73	124		17	11	
302	74	124		21	13	

Table XIV - Standard length attained by the Waterton lake whitefish at the end of each year of life.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Calculated standard length in millimetres attained at end of year:														
U.S. 414	63														
U.S. 409	74														
U.S. 411	74														
U.S. 412	77														
U.S. 408	79														
U.S. 413	79														
U.S. 410	82														
U.S. 407	50	115													
U.S. 406	53	125													
W. 141	82	138													
W. 142	88	145													
U.S. 405	53	123	161												
W. 143	51	111	165												
W. 144	60	124	175												
U.S. 404	53	133	185												
U.S. 403	61	111	156	201											
U.S. 401	61	123	179	215											
U.S. 402	64	148	187	222											
W. 117	48	116	199	230											
W. 18	48	109	191	221	225										
W. 148	66	139	196	233	248	260									
W. 153	68	116	154	194	229	260	279	290							
W. 154	59	121	184	228	267	295	321	336	348	355					
W. 151	54	122	172	215	230	249	271	284	298	308	317	326	330		
W. 155	68	132	187	228	260	286	309	327	343	353	359	369	377	385	390

Table XV - Standard length attained by the Logging lake whitefish at the end of each year of life.

Individuals in their first year

Standard length	Frequency	Standard length	Frequency
27	1	54	5
30	1	55	7
36	1	56	4
38	1	57	5
41	2	58	4
43	1	59	3
44	3	60	3
45	7	61	3
46	8	62	2
47	2	63	2
48	2	64	1
49	10	65	1
50	13	68	2
51	8	69	2
52	7	70	1
53	8	75	1

No.	Standard length at end of year: 1	2	3	4	5	Scale rings: 1	2	3	4	5
145	59	88				13	7			
144	64	98				19	9			
143	63	99				15	10			
141	58	100				10	11			
142	59	102				18	13			
114	52	103				17	16			
140	55	103				15	15			
138	53	106				15	17			
137	65	108				16	10			
128	47	109				17	19			
136	57	112				15	14			
139	62	112				16	14			
134	75	113				16	8			
126	54	114				15	16			
113	56	114				14	11			
131	64	115				18	12			
132	69	115				18	10			
133	73	117				18	11			
127	54	118				17	17			
112	69	118				24	17			
135	56	120				20	18			
278	79	120				18	11			

Table XV - (Concluded) - Logging lake whitefish.

No.	Standard length at end of year: 1	2	3	4	5	Scale rings: 1	2	3	4	5
124	74	123				20	14			
125	63	124				17	14			
130	65	125				18	15			
111	58	128				17	21			
129	55	111	131			12	18	7		
277	41	98	137			16	24	15		
120	76	122	141			19	16	5		
123	55	95	142			19	15	13		
122	48	93	144			18	16	14		
110	72	116	145			22	12	6		
121	69	120	146			19	15	8		
107	49	101	148			14	14	12		
109	57	112	150			19	20	14		
276	45	99	151			13	17	18		
106	68	116	154			26	22	15		
274	69	117	157			20	15	12		
275	72	132	157			22	20	11		
119	71	118	158			18	12	9		
108	59	118	159			24	24	13		
116	63	117	159			24	22	13		
117	65	112	159			23	18	11		
118	57	109	162			20	18	15		
273	58	114	162			21	21	13		
105	69	127	162			24	22	12		
115	47	116	163			19	28	20		
103	63	130	169			21	24	12		
101	62	130	173			24	25	16		
267	65	121	174			24	20	18		
269	61	134	177			19	24	13		
272	80	119	154	171		25	15	12	6	
104	35	101	153	175		16	28	18	10	
271	67	111	155	176		25	17	18	9	
270	58	105	158	178		16	17	19	7	
102	58	127	167	185		19	20	11	6	

Table XVI - Standard length attained by Prosopium williamsoni at the end of each year of life.

Lake Minnewanka

Calculated standard length attained at end of year:

No.	1	2	3	4	5	6	7	8	9
14	81	124	155						
15	78	125	165						
16	66	129	179						
17	71	133	185						
18	54	124	182	210					
19	54	141	196	225					
6	60	153	220	275					
20	60	112	156	202	230				
22	53	118	167	209	240				
23	48	136	199	243	275				
8	75	156	208	251	280				
3	49	99	156	207	232	240			
4	50	109	152	189	233	255			
5	68	138	193	233	261	275			
7	53	116	187	231	262	275			
9	61	113	179	228	264	280			
10	62	129	185	235	267	285			
24	54	138	220	254	286	305			
11	55	115	182	222	258	279	295		
12	69	136	201	241	272	298	315		
21	68	125	187	222	269	298	310		
25	58	136	197	240	274	298	310		
1	69	141	188	239	265	296	322	335	
13	65	150	201	236	279	306	328	345	
2	69	154	228	283	308	338	356	368	375

Third lake

No.	1	2	3	4	5	6	7	8	9
27	82	133	181	207					
28	90	184	220	237					
29	64	122	166	222	245				
30	57	136	203	241	273	296	316	325	
31	72	153	205	262	288	312	328	340	
32	73	143	203	237	263	290	321	340	355

Cascade river

No.	1	2
55	43	106

Table XVII - Standard length attained by Prosopium williamsoni at the end of each year of life.

No.	Standard length at end of year: 1	2	3	4	Scale rings: 1	2	3	4
Maskinonge lake								
D	86	110						
E	82	103						
Nooksack river								
451	76	116			21	9		
452	80	116			21	9		
Tolt river								
461	74	129	181	200	20	14	13	5

Table XVIII - Standard length attained by the Cultus lake whitefish at the end of each year of life.

No.	Length at end of year: 1	2	3	Scale rings: 1	2	3
59	76	94		14	3	
67	84	96		16	2	
60	91	98		17	0	
90	88	99		17	1	
89	92	100		15	1	
87	92	101		18	1	
88	91	101		17	1	
55	102	102		22	0	
96	98	102		19	0	
58	87	103		17	2	
85	69	103		17	6	
95	104	104		20	0	
56	97	105		23	2	
57	97	105		19	1	
79	98	105		20	1	
51	92	106		18	2	
81	87	106		22	3	
86	88	106		20	2	
54	94	107		20	2	
84	78	107		18	8	
68	81	108		21	7	
75	108	108		25	0	
83	80	108		18	5	
53	96	110		21	2	
78	86	110		18	3	
80	100	110		16	1	
46	89	111		24	4	
49	104	111		16	1	
52	91	111		20	3	
48	83	112		17	6	
82	98	112		22	3	
50	95	113		24	3	
76	104	113		23	1	
77	84	113		18	6	
66	86	114		18	6	
94	106	114		18	1	
44	85	115		19	6	
72	87	115		18	6	
74	101	115		24	2	
65	87	116		17	6	
42	97	118		20	3	
45	76	118		19	8	
47	101	118		22	5	
71	91	118		20	5	

Table XVIII - (Concluded) - Cultus lake whitefish.

No.	Length at end of year: 1	2	3	4	5	6	7	8	9	Scale rings: 1	2	3	4	5	6	7	8	9
92	87	118								17	5							
93	119	119								24	0							
43	103	120								21	2							
69	95	124								20	4							
73	104	124								21	2							
64	86	125								18	6							
70	97	127								18	5							
63	107	129								27	3							
61	115	134								23	2							
91	87	135								18	10							
62	122	136								29	2							
37	110	217								29	31							
41	71	180	187							14	26	1						
40	74	160	193							19	27	9						
108	82	186	201							21	26	3						
110	80	179	202							19	23	5						
107	69	193	205															
109	100	201	212							27	22	2						
39	70	205	223							17	29	3						
98	85	174	228							18	25	15						
105	91	179	230							19	21	14						
99	95	175	231							25	22	18						
103	84	185	241							25	32	19						
102	110	199	248							28	26	16						
35	74	155	216	249						13	16	12	8					
100	93	167	228	252						24	20	17	8					
101	81	152	243	283						20	20	29	10					
23	95	159	206	237	249					22	16	13	8	3				
106	88	166	212	241	259					20	22	11	8	7				
104	113	192	233	271	287	298				25	23	15	11	7	5			
32	101	162	206	246	279	300				24	19	11	14	11	6			
38	98	164	220	254	283	305				24	17	15	11	9	7			
17	85	187	230	269	304	315				21	21	11	11	8	3			
9	63	138	208	256	283	320	334			15	18	20	13	10	11	5		
14	79	212	260	299	321	337	347			22	36	13	12					
13	80	158	212	249	279	306	334	343		20	24	18	12	11	8	12	3	
12	95	159	232	274	302	329	354	360		22	12	21	12	10	10	8	3	
20	105	160	214	261	294	328	346	366		20	14	16	13	12	11	7	6	
15	74	141	184	212	256	277	298	325	347	19	18	12	11	15	10	8	8	6
10	79	148	217	263	292	322	352	365	376	22	19	21	11	10				
11	98	206	241	274	299	331	350	368	376	24	28	8	10	6	7	8	5	3

Table XIX - Standard length attained by Prosopium williamsoni at the end of each year of life.

Bow lake

No.	1	2	3	4	5	6	7	8	9	10
	Calculated standard length attained at end of year:									
54	28									
53	28									
52	36									
51	35									
50	35									
49	31	61								
47	41	71								
48	40	75								
46	35	65	87							
45	34	66	98							
69	33	91	121							
72	29	56	83	100						
71	35	60	88	110						
70	34	63	91	113						
68	29	65	99	124						
67	36	63	99	136						
66	25	53	85	107	131	144				
65	26	47	79	102	129	150	161			
64	23	42	70	90	113	138	154			
63	27	62	83	109	137	152	158			
61	31	51	72	96	119	146	175	190		
60	33	57	86	122	146	168	181	189		
59	32	60	89	119	141	162	187	194		
62	24	49	80	99	122	141	157	170	177	
58	26	55	80	103	127	152	179	197	203	
56	31	63	87	105	130	163	186	204	215	
57	22	45	63	95	124	151	178	199	214	220
Lake Louise										
44	32									
43	32									
42	36									
41	37									
40	42	67								
39	41	62								
37	45	67								
36	42	67								
35	42	65								
34	40	66								
33	43	66								
38	40	72								
26	47	77	113	146	165	180	190	197	200	

Table XX - Standard length attained by the Elk river whitefish at the end of each year of life.

No.	Standard length at end of year: 1	2	3	4	5	6	Scale rings: 1	2	3	4	5	6
26	54	126					14	17				
25	55	127					12	15				
24	35	102	167				10	21	18			
23	54	126	170				13	20	12			
19	59	123	172				13	18	15			
12	40	115	175				10	21	15			
18	60	126	177				14	21	15			
22	37	109	178				10	21	19			
15	42	116	178				12	21	17			
10	42	111	178				13	21	18			
9	48	116	178				14	20	19			
7	45	120	178				13	23	17			
17	46	126	180				15	24	18			
16	53	122	180				13	21	17			
14	52	115	181				13	19	17			
21	56	119	182				15	18	18			
20	59	129	182				17	23	16			
13	36	116	183				9	23	18			
11	52	132	184				12	24	16			
8	64	135	201				16	19	18			
6	40	110	175	195			10	21	20	7		
5	59	112	161	200			17	16	17	12		
3	39	107	171	206			12	19	18	9		
2	47	108	169	210			16	20	20	14		
4	42	111	169	209	231		11	22	19	14	8	

Table XXI - Average calculated standard length at the end of each year of life for the various populations of <u>Prosopium williamsoni</u>.

	Average calculated standard length in millimetres at end of year:													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Group 1														
Bowman lake	56	93												
Lake McDonald	59	113												
Waterton lake	60	123	180	220	247	273	295	316	330	330	338	348	377	385
Logging lake	61	115	157											
Lake Minnewanka	62	130	190	231	266	302	335	368						
Third lake	73	145	197	240	274	299	322	340						
Tolt river	74	129	181											
Nooksack river	78	116												
Maskinonge lake	84	106												
Group 2														
Cultus lake	92	174	221	257	290	319	339	353						
Group 3														
Bow lake	31	59	84	104	129	152	178	192	215					
Lake Louise	42	77	113	146	165	180	190	197						
Group 4														
Cascade river	43	106												
Elk river	49	118	177	204	231									

Table XXII - Frequency distribution of percentage head lengths in fish two years of age and older.

Locality	Average length	Head length in percentage of standard length: 19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5	Average
Cultus lake	231	1	3	3	5	3								20.2
Lake Minnewanka	244	1	2	1	4		2	1						20.4
Tolt river	200				1									20.5
Third lake	313				1	1	1							21.0
Waterton lake	242	1		1	5	1	3	1		1	1			21.2
Logging lake	160		1		6	8	9	4	2					21.2
Bow lake	171						4	1	3	3	1			22.5
Elk river	188							7	8	6	2		1	22.6
Bowman lake	110						1	2	2	2	1	1	1	22.8

- Frequency distribution of percentage head lengths in fish in their second year.

Locality	Average length	Head length in percentage of standard length: 20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5	25.0	25.5	26.0	26.5	27.0	Average
Nooksack river	114			1			1										21.6
Cultus lake	113	1	1	4	7	11	6	2									21.9
Waterton lake	133					1	2										22.4
Logging lake	115			1	3	4	6	4	3		1						22.5
Elk river	126						1	1									22.6
Lake McDonald	113					2	2	1	1	1							22.9
Bowman lake	85				1			1	2	2	3						23.6
Maskinonge lake	107								1	1							23.6
Bow lake	73									1			1				24.6
Lake Louise	67											1	3	1	1	1	25.8

- Frequency distribution of percentage head lengths in fish in their first year.

Locality	Average length	Head length in percentage of standard length: 24.0	24.5	25.0	25.5	26.0	26.5	27.0	27.5	28.0	28.5	29.0	Average
Lake McDonald	52	1		4	5	3	2	1	1	3		1	26.1

Table XXIII - Frequency distribution of percentage snout lengths in fish two years of age and older.

Locality	Snout length in percentage of standard length: 4.5	5.0	5.5	6.0	6.5	7.0	7.5	Average
Logging lake	1	10	11	8				5.4
Bow lake		1	6	5				5.7
Lake Minnewanka		1	6	3	1			5.7
Bowman lake			4	5				5.7
Cultus lake		4	3	7	1			5.7
Tolt river				1				5.8
Waterton lake			6	5	1	1	1	6.1
Third lake				2	1			6.2
Elk river				5	12	7		6.6

- Frequency distribution of percentage snout lengths in fish in their second year.

Locality	Snout length in percentage of standard length: 5.0	5.5	6.0	6.5	Average
Nooksack river		2			5.6
Logging lake	2	16	2	2	5.6
Lake McDonald	1	2	4		5.7
Cultus lake	4	12	14	2	5.7
Maskinonge lake		1	1		5.8
Waterton lake		1	2		5.9
Bowman lake		2	1	1	5.9
Elk river			1	1	6.2

Table XXIV - Frequency distribution of percentage maxillary lengths in fish two years of age and older.

Locality	Length of maxillary in percentage of standard length: 4.5	5.0	5.5	6.0	6.5	7.0	Average
Lake Minnewanka	3	4	4				5.0
Third lake	1	1	1				5.1
Logging lake	2	14	12	2			5.3
Cultus lake	1	4	7	2	1		5.4
Waterton lake		3	5	4	1	1	5.6
Bow lake			4	7			5.8
Bowman lake			2	7			5.9
Tolt river				1			6.0
Elk river				10	11	3	6.4

- Frequency distribution of percentage maxillary lengths in fish in their second year.

Locality	Length of maxillary in percentage of standard length: 5.0	5.5	6.0	6.5	Average
Lake McDonald	1	4	1	1	5.6
Nooksack river		2			5.6
Logging lake		15	7		5.6
Waterton lake		2	1		5.7
Cultus lake	1	16	15		5.8
Maskinonge lake		1	1		5.8
Elk river			2		6.2
Bowman lake			2	2	6.2

Table XXV - Frequency distribution of percentage eye diameters in fish two years of age and older.

Locality	Diameter of eye in percentage of standard length: 3.5	4.0	4.5	5.0	5.5	6.0	6.5	Average
Third lake	1	1		1				4.2
Cultus lake		9	6					4.2
Waterton lake		2	9	3				4.5
Lake Minnewanka		5	3	2	1			4.5
Elk river		2	14	7	1			4.7
Tolt river				1				4.8
Logging lake			8	17	5			5.0
Bowman lake			1		4	3	1	5.7
Bow lake				1	6	3	2	5.7

- Frequency distribution of percentage eye diameters in fish in their second year.

Locality	Diameter of eye in percentage of standard length. 5.0	5.5	6.0	6.5	Average
Waterton lake		3			5.3
Elk river		2			5.4
Lake McDonald	2	3	2		5.5
Cultus lake	4	20	8		5.6
Logging lake	1	16	4	1	5.6
Nooksach river			2		5.8
Bowman lake	1		1	2	6.0
Maskinonge lake			1	1	6.2

Table XXVI - Frequency distribution of percentage head depths in fish two years of age and older.

Locality	Depth of head in percentage of standard length: 12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	Average
Lake Minnewanka	3	3	4	1					13.2
Cultus lake	2		7	3	2	1			13.6
Waterton lake	1	3	5	2	1	1		1	13.8
Bowman lake			2	5	2	1			14.1
Tolt river				1					14.2
Logging lake			7	7	11	4	1		14.3
Third lake					3				14.4
Elk river				6	4	6	7	1	14.9
Bow lake					3	6	3		15.0

- Frequency distribution of percentage head depths in fish in their second year.

Locality	Depth of head in percentage of standard length: 12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	Average
Cultus lake	2	5	15	5	3	2					13.6
Bowman lake		1	1	5	2						14.0
Logging lake		1	6	7	5	2				1	14.2
Elk river				1	1						14.2
Nooksack river				1	1						14.3
Waterton lake				1	2						14.5
Lake McDonald				1	3	3					14.7
Maskinonge lake						1	1				15.4

Table XXVII - Frequency distribution of the percentage distance from snout tip to occiput in fish two years of age and older.

Locality	Snout tip to occiput in percentage of standard length: 14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	Average
Cultus lake	1	4	6	4								15.4
Lake Minnewanka	3	1	3	1	2	1						15.6
Third lake		1		1	1							15.8
Tolt river				1								15.9
Logging lake		8	5	5	5	5	1	1				16.0
Waterton lake			5	3	4	1			1			16.2
Bow lake					4	2	2	2	1			17.1
Elk river				1	2	11	9	1				17.2
Bowman lake					2	1	1	2	2	1	1	17.9

- Frequency distribution of the percentage distance from snout tip to occiput in fish in their second year.

Locality	Snout tip to occiput in percentage of standard length: 16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0	21.5	Average
Cultus lake	3	2	13	12	2								17.1
Waterton lake			2	1									17.1
Logging lake		6	5	6	2	1	1				1		17.4
Nooksack river			1		1								17.6
Elk river				2									17.6
Lake McDonald			3	1	1	1		1					17.7
Maskinonge lake				1		1							17.8
Bowman lake			1	1	2		4	1					18.4
Bow lake						1				1			19.5
Lake Louise							1	2		3	1		20.0

- Frequency distribution of the percentage distance from snout tip to occiput in fish in their first year.

Locality	Snout tip to occiput in percentage of standard length: 17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	Average
Lake McDonald	1		1	1	3	4	4	2	1			1	20.1

Table XXVIII - Frequency distribution of the length of the dorsal fin base in fish two years of age and older.

Locality	Length dorsal fin base in percentage of standard length: 10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	Average
Third lake		2			1				11.5
Bow lake		3	4	3	1				11.6
Logging lake	1	7	11	7	3	1			11.7
Bowman lake	1		5	2	2				11.8
Lake Minnewanka			5	7		1			12.0
Tolt river					1				12.4
Cultus lake		1	1	1	5	5	2		12.6
Waterton lake			3		5	4	2		12.6
Elk river		1		6	5	7	3	2	12.8

- Frequency distribution of the length of the dorsal fin base in fish in their second year.

Locality	Length dorsal fin base in percentage of standard length: 9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	Average
Logging lake		2	1	5	8	4	1	1			11.4
Elk river				1		1					11.4
Bowman lake	1			2	1	4	1				11.5
Lake McDonald					1	3	2		1		12.2
Cultus lake					2	6	14	5	4	1	12.6
Waterton lake						1	1	1			12.6
Maskinonge lake							1	1			12.8
Nooksack river									1	1	13.7

Table XXIX - Frequency distribution of the percentage length of the anal fin base in fish two years of age and older.

Locality	Length anal fin base in percentage of standard length: 8.0	8.5	9.0	9.5	10.0	10.5	11.0	Average
Lake Minnewanka	2	6	2	1				8.6
Third lake		1	2					8.8
Bow lake	1	4	3		3	1		9.1
Bowman lake		1	3	6				9.3
Logging lake	1	3	4	11	10		1	9.5
Waterton lake		1		7	5	1		9.7
Elk river		1		9	11	3		9.8
Tolt river					1			9.9
Cultus lake				2	5	5	3	10.3

\- Frequency distribution of the percentage length of the anal fin base in fish in their second year.

Locality	Length anal fin base in percentage of standard length: 7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	Average
Lake McDonald	1			3	2	1			9.1
Elk river				1	1				9.2
Logging lake		1	3	6	8	2	2		9.3
Bowman lake			1	3	4			1	9.4
Maskinonge lake					2				9.6
Cultus lake			1	1	10	10	8	2	10.0
Waterton lake					1	1	1		10.0
Nooksack river							2		10.6

Table XXX - Frequency distribution of the percentage height of the dorsal fin in fish two years of age and older.

Locality	Height dorsal fin in percentage of standard length: 12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	Average
Lake Minnewanka	2	3		2	4							13.6
Third lake		1		2								13.8
Logging lake	1	2	3	12	6	2	2	2				14.3
Cultus lake		1	3	1	4	2	3	1				14.5
Waterton lake		2	1	1	2	2	4	1	1			14.8
Tolt river						1						15.2
Bow lake				1	3	2	1	2	2	1		15.4
Elk river						2	3	4	6	5	4	16.4
Bowman lake							2	3	1	2	2	16.5

- Frequency distribution of the percentage height of the dorsal fin in fish in their second year.

Locality	Height dorsal fin in percentage of standard length: 13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	Average
Logging lake	1	2	3	4	4	4	1	1	1	14.8
Waterton lake				1	1	1				15.0
Lake McDonald			1	3	1				1	15.2
Elk river					1	1				15.3
Cultus lake			1	3	8	7	9	4		15.5
Maskinonge lake							2			15.8
Bowman lake						3	2	4		16.1
Nooksack river								1	1	16.8

Table XXXI - Frequency distribution of the percentage height of the anal fin in fish two years of age and older.

Locality	Height anal fin in percentage of standard length: 10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	Average
Lake Minnewanka		1	3	3	1									11.2
Third lake			1	2										11.3
Logging lake	2	5	6	7	6	3	1							11.4
Waterton lake		2	1		3	4	2	1						12.2
Bow lake				4	3	1	1	3						12.4
Tolt river						1								12.5
Cultus lake				2		7	5	1						12.6
Bowman lake					1	5	4							12.6
Elk river						1	1	3	8	5	2	3	1	14.2

- Frequency distribution of the percentage height of the anal fin in fish in their second year.

Locality	Height anal fin in percentage of standard length: 10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	Average
Logging lake	2	5	5		2	4	3	1					12.1
Lake McDonald	1	2		1	1		1	1					12.1
Waterton lake				1	1	1							12.4
Bowman lake				1	5	4							12.6
Cultus lake			1	5	14	7	4	1					12.7
Maskinonge lake					1	1							12.8
Elk river							2						13.4
Nooksack river								1				1	14.9

Table XXXII – Frequency distribution of the percentage length of the pectoral fin in fish two years of age and older.

Locality	Length pectoral fin in percentage of standard length: 13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	Average
Logging lake	1			2	10	7	6	3	1							15.9
Cultus lake		1		1	3	4	4	1	1							16.0
Third lake					2				1							16.1
Lake Minnewanka				1	2	3	1	2	1	1						16.3
Tolt river							1									16.6
Waterton lake			1		1		3	3	3	2	1					16.9
Bowman lake							3		4	3						17.3
Elk river							2	5	9	4	4					17.6
Bow lake								1	1	4	1	1		2	2	18.7

– Frequency distribution of the percentage length of the pectoral fin in fish in their second year.

Locality	Length pectoral fin in percentage of standard length: 14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	Average
Cultus lake	2	4	12	10	2	2				15.7
Waterton lake			1	2						15.7
Maskinonge lake			1	1						16.0
Logging lake	1	5	3	5	3		4	1		16.1
Lake McDonald	1	1	1	2			1		1	16.1
Bowman lake			1	2	4	2				16.4
Elk river					1	1				16.8
Nooksack river					1		1			17.2

Table XXXIII - Frequency distribution of the percentage length of the pelvic fin in fish two years of age and older.

Locality	Length pelvic fin in percentage of standard length: 12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	Average
Logging lake	1	7	11	9	2					13.0
Bowman lake		2	5	2	1					13.1
Lake Minnewanka		3	2	3	2	1				13.4
Third lake			1	1	1					13.4
Cultus lake			1	2	5	5	1			14.1
Tolt river						1				14.3
Waterton lake			1	1	4	3	4		1	14.4
Bow lake				1	2	4	2	1	2	14.8
Elk rimer						6	6	9	3	15.2

- Frequency distribution of the percentage length of the pelvic fin in fish in their second year:

Locality	Length pelvic fin in percentage of standard length: 11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	Average
Cultus lake		7	14	7	3	1					12.7
Lake McDonald	2		2	1		1	1				12.8
Maskinonge lake			1	1							12.8
Bowman lake		1	1	4	3						12.9
Logging lake		3	8	4	2	2	2		1		13.1
Waterton lake						1	2				14.3
Elk river							2				14.4
Nooksack river								1		1	15.3

Table XXXIV - Frequency distribution of the percentage length of the adipose fin in fish two years of age and older.

Locality	Length adipose fin in percentage of standard length: 7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	Average
Lake Minnewanka	2	3	3	2	1						8.4
Waterton lake	2	1	5	3	2						8.8
Bow lake		2	2	5	2						8.8
Elk river		1	7	8	8						9.0
Logging lake	1		9	7	11	2					9.1
Bowman lake			2	4	4						9.2
Third lake			1		2						9.2
Cultus lake					1	6	2	4	1	1	10.5
Tolt river										1	11.9

- Frequency distribution of the percentage length of the adipose fin in fish in their second year.

Locality	Length adipose fin in percentage of standard length: 7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	Average
Elk river			2									8.6
Bowman lake	1	2		3		1						8.7
Logging lake	2	2	3	8	5	2						8.9
Maskinonge lake			1	1								8.9
Lake McDonald		1		3	2	1						9.1
Waterton lake					1	1						9.6
Cultus lake				3	6	8	11	1	2		1	10.2
Nooksack river								1	1			11.1

Table XXXV - Frequency distribution of the percentage length of the adipose fin base in fish two years of age and older.

Locality	Length adipose fin base in percentage of standard length: 6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	Average
Elk river	2	9	7	6						6.8
Lake Minnewanka		3	6	2						6.9
Bow lake		3	3	4	1					7.1
Waterton lake		2	4	7	1					7.2
Third lake			2	1						7.2
Logging lake	1	2	2	10	13					7.4
Bowman lake			3	4	2	1				7.5
Cultus lake			1	2	2	4	2	4		8.5
Tolt river									1	9.8

- Frequency distribution of the percentage length of the adipose fin base in fish in their second year.

Locality	Length adipose fin base in percentage of standard length: 6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	Average
Elk river		1	1						6.8
Bowman lake		2	2	1	1		1		7.4
Maskinonge lake				2					7.4
Logging lake	1		5	7	1	7	1		7.7
Lake McDonald			4	1			2		7.7
Waterton lake				1	1				7.9
Cultus lake			1	2	7	12	6	4	8.5

Table XXXVI - Frequency distribution of the ratio $\frac{\text{adipose base}}{\text{anal base}}$ in fish two years of age and older.

Locality	Ratio adipose base / anal base: 0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	Average
Elk river	1	8	8	5	1	1				0.70
Waterton lake		1	2	7	3		1			0.75
Bow lake		1		6	1	1	1	1		0.79
Logging lake		1	2	5	10	8		1	1	0.80
Bowman lake			1	2	4	2	1			0.80
Lake Minnewanka				4	2	4	1			0.81
Third lake					2	1				0.81
Cultus lake			1	3	3	2	5	1		0.83
Tolt river									1	0.99

- Frequency distribution of the ratio $\frac{\text{adipose base}}{\text{anal base}}$ in fish in their second year.

Locality	Ratio adipose base / anal base: 0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15	Average
Elk river	1	1									0.74
Maskinonge lake		1	1								0.77
Waterton lake			2								0.80
Bowman lake	1	2	2	1			1				0.81
Logging lake	3	3	7	2	3	2	2				0.83
Cultus lake		3	8	10	8	1	1	1			0.85
Lake McDonald		1	4		1					1	0.86

Table XXXVII - Frequency distribution of the number of rays in the pectoral fin.

Locality	Rays in pectoral fin: 14	15	16	17	18	19	Average
Nooksack river	1	1					14.5
Cultus lake		5	6	3	1		16
Elk river		2	11	11	2		16.5
Bow lake			4	7			17
Waterton lake			5	8	4		17
Lake Minnewanka			3	6	2		17
Third lake			1	1	1		17
Logging lake			2	14	8	2	17
Tolt river				1			17

Table XXXVIII - Frequency distribution of the number of scales in the lateral line.

Locality	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	Average
	Scales in the lateral line:																									
Nooksack river							1						1													79
Bow lake									4	2	2	1		1	1	1										80
Logging lake	1				1	2	2	4	5	6	4	3	7	6	4	3	1	3								81
Third lake								1				1			1											81
Bowman lake						1				1	2	5	4	1	1		2									82
Waterton lake						1					2	4	3	4		1	1						1			82
Lake Minnewanka										1	2	1	2	1	2			1	1							83
Lake McDonald										1		3		1		1	2									83
Maskinonge lake													1		1											83
Tolt river														1												83
Gultus lake								1	1	2		4	5	7	3	10	2	3	6	3						84
Elk river									1	2	1	2	2	1	5		1	6	1	2	1				1	85

FOOD

Stomach contents were examined from a total of 120 specimens of *Prosopium williamsoni* and 11 of *Coregonus clupeaformis*. The results of this work are given in tables XXXIX to LVIII. In connection with these tables it must be noted that the figures represent percentages of the total stomach contents, while the symbol X is used to denote the presence of an organism in small quantities. In many of the specimens examined, the stomachs were found to be empty, and in such cases an attempt was made to analyse the contents of the intestine. Where this was done, the relative amounts of the various organisms present were not estimated, it being thought more suitable to merely indicate the food in a qualitative way.

The results of the food studies show that the larvae and pupae of aquatic insects form the principal food of *Prosopium williamsoni*. This is true particularly of the older fish. Other organisms are taken quite frequently however, and their selection is undoubtedly mainly a matter of relative availability. It will be seen that the proportional amounts of these secondary food organisms vary considerably in the different lakes. Those found to be of importance are the Gastropods and Pelecypods, Ostracoda, Amphipoda, and small fish.

Lake Minnewanka

All the individuals examined were mature fish. These were captured during the months of July and August and at that season were feeding almost entirely on insects. The only other items of importance were the Amphipod *Gammarus* and a small unidentified Gastropod. Table XXXIX presents the detailed analysis of the stomachs, and the data are summarized in table XLIV.

Bow lake

In Bow lake during August the various aquatic insects were found to form the bulk of the food. This was true of the very young fish, as well as the older individuals, as demonstrated by tables XLVII, XLIX, and L. However, it will be noted that the importance of Cladocera is considerable, and several of the stomachs contained large quantities of these organisms. The detail of the individual stomachs is given in table XL and the proportions of the various constituents in table XLVII.

Lake Louise

The fish in this sample were all immature specimens. These were taken at approximately the same time of year as the Bow lake fish, but it is interesting to note that here the chief food evidently consisted of Entomostraca, and the insect forms were only of secondary importance. The comparison can readily be made by reference to tables XLVIII and XLIX. It would be unwise to make any general statements on the strength of these data, since it is quite probable that the food taken varies according to the time of day, as well as from season to season. It is sufficient here to remark that differences do exist. Tables XLI and XLV are included for individual and average distribution of the food organisms.

Third lake

Since only three specimens were available from this lake for stomach analyses, the averages obtained are not of great significance. However, it is worthy of note that the only evidence of bottom feeding was the presence of traces of Gastropoda in the digestive tract of one individual. Plankton Cladocera had been eaten by two, and the third had devoured small fish. See tables XLII and XLVI for detailed analysis.

Cascade river

A single specimen in its second summer was feeding exclusively on mayfly nymphs at the time of capture.

Waterton lake

The specimens obtained from this locality were shipped to the writer labelled as Prosopium williamsoni. On examination, however, the sample proved to consist of two species - P. williamsoni and Coregonus clupeaformis. This in itself offered no difficulty, but led to confusion as to the identity of 32 specimens whose stomachs were removed in the field. For this reason, the analysis of the doubtful material has been kept separate from that in which the species was definitely known, and is presented in table LI. The details of the individual stomachs of Prosopium are given in table LIII, and a summary of the data appears in table LVI. For comparison, the food of Coregonus is listed in a similar way in table LVII.

In Waterton lake the food of Prosopium is shown to be chiefly insect material. The only other item of importance is the snail Physa. Coregonus also feeds extensively on insects, but the addition of plankton forms in considerable quantities is probably a differentiating feature.

Knights lake

It is not known definitely that *Prosopium* is to be found in this lake, although stomachs were received which were labelled as this species. The actual specimens received all proved to belong to the genus *Coregonus*, hence the reason for not accepting the identification of the others as reliable. The food organisms of the indeterminate species are listed in table LI, and the analysis of the *Coregonus* stomachs is given in table LVII.

Maskinonge lake

Two specimens in their second summer had been feeding principally on mayfly nymphs. For details, reference may be made to tables LIV and LVI.

Pass creek

One individual in its fifth year, captured in July, was feeding mainly on insects. The analysis of this stomach is presented in table LV.

Cultus lake

A considerable percentage of the stomachs of these fish were found to be empty of food. The older specimens were found to have subsisted to a great extent on various aquatic insects, and in three cases snails were found to have been eaten. Of great importance in this particular lake was the discovery of twelve newly-emerged sockeye fry in one stomach. The younger fish probably feed on plankton to some extent, although insufficient stomachs have been examined for an accurate report of the food of these forms. In table LVIII, specimens 42, 43, and 91 are yearling fish. The remainder are in their third year or older. In table LIX the data for these older fish are averaged.

Table XXXIX - Stomach contents of 14 whitefish (<u>Prosopium williamsoni</u>) from lake Minnewanka.

No.	1	2	3	6	8	10	11	14	16	17	18	19	20	21
<u>Eurycercus</u> sp.				5										
Ostracoda				X										
<u>Gammarus</u> sp.											40	70		
<u>Hyalella</u> sp.												X		
<u>Pontoporeia</u> sp.												X		
Unidentified Amphipoda			X						10					
Caddis larvae			99	50	40		50		50					
Caddis pupae							50			50	60		80	
Chironomid larvae	100		X	X	30	100		50	X				X	
Chironomid pupae			X	35	30			50		X			20	100
Mayfly nymphs										50				
Formicidae									25					
Gastropoda		100												
Sphaeriidae			X	5										
Plant material									15					
Unidentified		X										30		
Organic debris	X			X								X		

Table XL - Stomach contents of 27 whitefish (*Prosopium williamsoni*) from Bow lake.

No.	45	46	47	48	49	50	51	52	53	54	56	57	58	59	60	61	62
Alona rectangula			40			10											
Daphnia pulex		40															
Unidentified Amphipoda																X	
Hydrachnidae																	20
Spider																25	
Chironomid larvae	70	20	40		X		50	50	100	50		85	80	80	90	X	X
Chironomid pupae		40				90						10		10	5		
Ceratopogonid larvae			10								X					X	
Unidentified Diptera								50									X
Caddis larvae																X	
Mayfly nymphs				70	95											25	60
Stonefly nymphs	10		10				50			20	15					15	
Lygaeidae											70						
Terrestrial Coleoptera				30													
Formicidae																	20
Formicinae																30	
Unidentified Hymenoptera											15						
Psocidae										30							
Unidentified Insecta	10																
Gastropoda				X							X						
Sphaeriidae	10											5	X	10	5		
Stones and gravel											X						
Unidentified organic material													15				

Table XL - (Concluded) - Bow lake whitefish.

No.	63	64	65	66	67	68	69	70	71	72
Alona rectangula									100	
Daphnia pulex		90								
Ostracoda						X			X	
Hydrachnidae			5	5	X					
Chironomid larvae	95		30			X	20	X		30
Chironomid pupae		X			50	X	5			30
Ceratopogonid larvae			X							X
Leptidae ?										X
Unidentified Diptera			50							
Mayfly nymphs				95	50			100		30
Stonefly nymphs						70	75			
Saldidae		10								
Terrestrial Coleoptera						X				
Myrmicinae						25				
Gastropod eggs										X
Seeds	X									
Organic debris			X				X			
Stones and gravel						X				
Unidentified organic material	5		15							X

Table XLI - Stomach contents of 12 whitefish (*Prosopium williamsoni*) from lake Louise.

No.	33	34	35	36	37	38	39	40	41	42	43	44
Alona rectangula	100			30	100	100	50	25	X		20	
Scapholeberis mucronata									50	50		30
Cyclops viridis		50		70		X	30	10	X		30	20
Chironomid larvae	X		98					50	10	50	50	50
Chironomid pupae			X				20					X
Unidentified Diptera		15										
Mayfly nymphs		15										
Stonefly nymphs								15	40			
Coleoptera		15										
Gastropoda			X									

Table XLII - Stomach contents of 3 whitefish (*Prosopium williamsoni*) from Third lake.

No.	27	29	31
Daphnia longispina	100		
Daphnia sp.		100	
Gastropoda	X		
Gasterosteus sp. (Sticklebacks)			100

Table XLIII - Stomach contents of 1 whitefish (*Prosopium williamsoni*) from Cascade river.

No.	55
Mayfly nymphs	100

Table XLIV - Food organisms of whitefish (Prosopium williamsoni).

A - Number of stomachs containing the organism
B - Greatest percentage in any one stomach
C - Average percentage in all stomachs

Lake Minnewanka - 14 individuals

	A	B	C
Eurycercus sp.	1	55	X
Ostracoda	1	X	X
Gammarus sp.	2	70	8
Hyalella sp.	1	X	X
Pontoporeia sp.	1	X	X
Unidentified Amphipoda	2	10	X
Caddis larvae	5	99	21
Caddis pupae	4	80	17
Chironomid larvae	8	100	20
Chironomid pupae	7	100	17
Mayfly nymphs	1	50	4
Formicidae	1	25	2
Gastropoda	1	100	7
Sphaeriidae	2	5	X
Plant material	1	15	X
Unidentified	3	30	2
Organic debris	2	X	X

Table XLV - Food organisms of 12 whitefish (Prosopium williamsoni) from lake Louise.

Alona rectangula	8	100	35
Scapholeberis mucronata	3	50	11
Cyclops viridis	8	70	18
Chironomid larvae	7	98	26
Chironomid pupae	3	20	2
Unidentified Diptera	1	15	X
Mayfly nymphs	1	15	X
Stonefly nymphs	2	40	5
Coleoptera	1	15	X
Gastropoda	1	X	X

Table XLVI - Food organisms of 3 whitefish (Prosopium williamsoni) from Third lake.

Daphnia longispina	1	100	33
Daphnia sp.	1	100	33
Gastropoda	1	X	X
Gasterosteus sp. (Sticklebacks)	1	100	33

Table XLVII - Food organisms of 27 whitefish (*Prosopium williamsoni*) from Bow lake.

	A	B	C
Alona rectangula	3	100	6
Daphnia pulex	2	90	5
Unidentified Amphipoda	1	X	X
Unidentified Ostracoda	2	X	X
Hydrachnidae	7	20	X
Spider	1	25	X
Chironomid larvae	20	100	33
Chironomid pupae	10	90	9
Ceratopogonid larvae	5	10	X
Leptidae ?	1	X	X
Unidentified Diptera	3	50	4
Caddis larvae	1	X	X
Mayfly nymphs	8	100	20
Stonefly nymphs	8	75	10
Lygaeidae	1	70	X
Saldidae	1	10	X
Terrestrial Coleoptera	2	30	X
Formicidae	1	20	X
Formicinae	1	30	X
Myrmicinae	1	25	X
Unidentified Hymenoptera	1	15	X
Psocidae	1	30	X
Unidentified Insecta	1	10	X
Gastropoda	2	X	X
Gastropod eggs	1	X	X
Sphaeriidae	5	10	X
Seeds	1	X	X
Organic debris	2	X	X
Stones and gravel	3	X	X
Unidentified organic material	4	15	X

Table XLVIII - Food of <u>Prosopium williamsoni</u> in the first year.

	Bow lake	Lake Louise
Alona sp.	2	5
Scapholeberis sp.		32.5
Cyclops sp.		12.5
Hydrachnidae	X	
Chironomid larvae	50	40
Chironomid pupae	18	X
Unidentified Diptera	10	
Stonefly nymphs	14	10
Psocidae	6	

Table XLIX - Food of <u>Prosopium williamsoni</u> in the second year.

	Bow lake	Lake Louise
Alona sp.	13	50.5
Cyclops sp.		20
Chironomid larvae	13	18.5
Chironomid pupae		2.5
Ceratopogonid larvae	3	
Unidentified Diptera		2
Plecoptera nymphs	3	2
Mayfly nymphs	55	2
Unidentified Coleoptera	10	2
Gastropoda	X	X

Table LI - Food of Prosopium williamsoni from the third year inclusive.

	Bow lake	Lake Minnewanka	Third lake
Alona sp.	5		
Daphnia longispina			33
Daphnia pulex	7		
Daphnia sp.			33
Eurycercus sp.		X	
Gammarus sp.		8	
Hyalella sp.		X	
Pontoporeia sp. ?		X	
Unidentified Amphipoda	X	X	
Hydrachnidae	1.5		
Spider	1		
Chironomid larvae	32	20	
Chironomid pupae	8	17	
Ceratopogonid larvae	X		
Leptidae ?	X		
Unidentified Diptera	2.5		
Caddis larvae	X	21	
Caddis pupae		17	
Mayfly nymphs	19	4	
Stonefly nymphs	10		
Lygaeidae	4		
Saldidae	X		
Terrestrial Coleoptera	X		
Formicidae	1	2	
Formicinae	1.5		
Myrmicinae	1		
Unidentified Hymenoptera	X		
Unidentified Insecta	X		
Gastropoda	X	7	X
Gastropod eggs	X		
Sphaeriidae	1.5	X	
Unidentified Ostracoda	X	X	
Gasterosteus sp.			33
Seeds	X		
Unidentified plant remains		1	
Organic debris	X	X	
Stones and gravel	X		
Unidentified organic material.	2	2	

Table LI - Stomach contents of 32 whitefish (Species doubtful) from Waterton lake.

	Average percentage in all stomachs
Leeches	6
Daphnia sp.	14
Alona sp.	X
Candona sp.	X
Cyclops sp.	X
Gammarus sp.	X
Unidentified Amphipoda	X
Mysis relicta	X
Hydrachnidae	X
Chironomid larvae and pupae	33.5
Caddis larvae and pupae	20
Mayfly nymphs	X
Grasshopper	X
Cercopidae	X
Asilidae	X
Coccinellidae	X
Neuroptera	X
Formicidae	16
Unidentified Insecta	X
Sphaerium sp.	12
Unidentified Pelecypoda	X
Unidentified Gastropoda	X
Feathers	X
Bottom ooze	X
Conifer needles	X
Chickweed	X
Stones	X
Bits of wood	X
Unidentified	X

Table LII - Stomach contents of 3 whitefish (Species doubtful) from Knights lake.

Chironomid larvae and pupae	70
Sphaerium sp.	25
Unidentified Gastropoda	X
Candond sp. ?	5

Table LIII - Stomach contents of 9 whitefish (<u>Prosopium williamsoni</u>) from Waterton lake.

No.	141	142	143	144	147	148	151	153	154
<u>Gammarus</u> sp.						10			
Hydrachnidae			X	X	X				
Chironomid larvae	60	25	20	X		X			25
Chironomid pupae	X	25	50	95	75	X	5	X	
Tipulid larvae									25
Tipulid pupae								5	
Caddis larvae	X					90	20	95	25
Caddis pupae		25	20						
Dytiscidae					5				
Psocidae	25								
Formicidae					20				25
Hymenoptera remains		25							
<u>Physa</u> sp.							75		
Unidentified Gastropoda					X				
Diatoms			X						
Miscellaneous algae			10						
Bits of wood			X						

Table LIV - Stomach contents of 2 whitefish (<u>Prosopium williamsoni</u>) from Maskinonge lake.

No.	201	202
Mayfly nymphs	X	100
<u>Planorbis</u> sp.	X	

Table LV - Stomach contents of 1 whitefish (*Prosopium williamsoni*) from Pass creek.

Organism	Percentage
Caddis larvae	40
Mayfly nymphs	20
Stonefly nymphs	10
Unidentified Cladocera	10
Chironomid larvae	10
Unidentified insect remains	10
Beetle elytron	X
Caddis pupa	X

Table LVI - Food organisms of <u>Prosopium</u> from Waterton and Maskinonge lakes.

A - Number of stomachs containing the organism
B - Greatest percentage in any one stomach
C - Average percentage in all the stomachs

Waterton lake - 9 individuals

	A	B	C
Gammarus sp.	1	10	1
Hydrachnidae	3	X	X
Chironomid larvae and pupae	9	95	43
Tipulid larvae and pupae	2	25	3
Caddis larvae and pupae	7	95	31
Dytiscidae	1	5	X
Psocidae	1	25	3
Formicidae	2	25	5
Hymenoptera remains	1	25	3
Physa sp.	1	75	9
Unidentified Gastropoda	1	X	X
Diatoms	1	X	X
Miscellaneous algae	1	10	X
Bits of wood	1	X	X

Maskinonge lake - 2 individuals

	A	B	C
Mayfly nymphs	2	100	99
Planorbis sp.	1	X	X

Table LVII - Food organisms of <u>Coregonus</u> from Waterton and Knights lakes.

Waterton lake - 7 individuals	A	B	C
Daphnia sp.	4	100	38.5
Unidentified Ostracoda	1	X	X
Epischura sp.	1	25	3.5
Unidentified Copepoda	1	30	4
Pontoporeia sp.	1	X	X
Chironomid larvae and pupae	6	75	29
Ceratopogonid larvae	2	X	X
Phalacrocera sp. (pupae)	1	80	11.5
Heptagenia sp. ?	1	10	1.5
Sphaerium sp.	2	40	7
Planorbis sp.	1	10	1.5
Mougeotia or *Zygnema* sp.	1	X	X
Conifer needles	1	X	X

Knights lake - 4 individuals	A	B	C
Candona sp. ?	4	5	1
Unidentified Ostracoda	1	X	X
Cyclops sp.	1	X	X
Hydrachnidae	1	X	X
Chironomid larvae	4	95	75
Tipulid larvae	1	X	X
Caddis larvae	1	5	1
Mayfly nymphs	1	X	X
Sphaerium sp.	2	40	20

Table LVIII - Stomach contents of 16 whitefish (<u>Prosopium williamsoni</u>) from cultus lake.

No.	1	4	7	25	26	27	28	32	40	41	42	43	91	98	100	102
Protozoa													X			
Diatoms													X			
Cyclops ? immature.													X			
Water mites												X				
Chironomid larvae											5	X	10		X	
Tipula pupae													70			
Simulium larvae												X				
Simulium pupae											95					
Limnephilid larvae	100															10
Mystacides larvae			100	95												
Unidentified caddis						100	100									
Burrowing mayfly nymph																10
Unidentified insects									X	X		X		X	X	
Gyraulus sp.				5	10											
Planorbis sp.								100								
Sockeye fry		100														
Nostoc colonies					90											
Filamentous algae													X			
Miscellaneous plant material																80
Chunks of wood										X						X

Table LIX - Food organisms of *Prosopium williamsoni* from Cultus lake. (13 specimens)

A - Number of stomachs containing the organism
B - Greatest percentage in any one stomach
C - Average percentage in all the stomachs

	A	B	C
Chironomid larvae	1	X	X
Limnephilid larvae	2	100	12
Mystacides larvae	2	100	22
Unidentified Caddis larvae	2	100	22
Burrowing mayfly nymph	1	10	1
Unidentified Insecta	4		
Gyraulus sp.	2	10	2
Planorbis sp.	1	100	11
Sockeye salmon	1	100	11
Nostoc colonies	1	90	10
Miscellaneous plant material	1	80	9
Chunks of wood	2	X	X

SUMMARY

It may be said that each of the populations studied exhibits individual differences which are characteristic of the locality, or rather the particular body of water from which it comes. Some of these differences are small and can hardly be said to have any real significance, while others appear to be abrupt and cause the particular race to stand out from the others.

In general it can be shown for any one character that intermediate stages exist which seem to bridge the gap between the two extreme values. At the same time, the material examined seems to fall naturally into four broad groups. These are correlated with environment to a considerable extent, and thus they are actually ecological divisions, for it seems that similar habitats produce similar variants, as might be expected.

For each of these four groups, a single population has been selected which seems to be characteristic of that group. Representative of the first is the Waterton lake sample, which has been more or less arbitrarily chosen as being close to the typical williamsoni. These races are all lake fish and live at an altitude of somewhere between four and five thousand feet. The second group, typified by the Cultus lake fish, has a more rapid growth rate, particularly in the first few years, and is apparently more typically a river-dwelling race found at an altitude not much above sea level. Cultus lake itself has an altitude of less than five hundred feet. Group three has for its type race the Bow lake

population. This is distinct because of its slow growth rate and small size at maturity. Bow lake and lake Louise are both very cold and heavily silted, being fed by extensive glaciers which lie close to their margins. The elevations are 6500 and 5680 feet respectively. The habitat of this group, then, is quite distinct. The fourth and last group is characterized by the Elk river fish. These probably spend their whole life in the stream and never enter a lake. The chief distinction in the rate of growth in this case is the small growth of the first year.

Waterton lake

This race appears to be intermediate for every character studied, and is thus a good choice for the type of the species. No outstanding features are present to be worthy of comment. Waterton lake lies at an altitude of 4193 feet and drains by means of the Waterton river and Oldman river into the South Saskatchewan.

Bowman lake

The Bowman lake fish are intermediate in a good percentage of their characters, but in others they approach or reach one extreme. This may be due to the age composition of the sample, for they are all young fish, the average length for the specimens examined being the least of any race. The features which do appear extreme are the ones which are characteristic of smaller fish, such as head length, large eye, high dorsal fin and fairly high anal. The most important features of this population are therefore the long pectoral fins and the short pelvics. Bowman lake is situated at an elevation of approximately 4100 feet and drains through the Flathead river into the Columbia.

Lake McDonald

No older fish were available for examination, and the characteristics of the race must therefore be inferred from the data concerning the yearlings. Comparing these with the yearling fish from other lakes, it is found that in most respects this population is intermediate, thus agreeing with the Waterton lake fish. Points of difference are the fairly deep head, short pelvic fins, and the relatively small anal. Lake McDonald is similar in altitude to Bowman lake and also drains into the Flathead.

Logging lake

The Bowman lake, lake McDonald, and Logging lake fish are similar in most respects, and agree quite closely with the Waterton lake population. Minor differences do occur, however, and the Logging lake race is no exception in this particular. These fish are characterized by a somewhat shorter snout and short pectoral fins, and agree with the last race described in having short pelvics. Logging lake lies a short distance from Bowman lake and drains into the same river system.

Lake Minnewanka

These fish exhibit a number of characteristics peculiar to the population, and the race may be said to be more distinct from the type than any other in this group. Distinguishing features are the small head and relatively small fins. The small size of the head is reflected in all its dimensions, in length, depth, distance from snout tip to occiput, length of snout and maxillary, and diameter of eye. Of the fins the dorsal is short, the anal is short and has a short base, the pelvics are fairly short, and the adipose is smaller than in any other population. The elevation of lake Minnewanka is 4769 feet. It drains into the Bow river, which in turn empties into the South Saskatchewan.

Third lake

This race resembles the Minnewanka fish to some extent. The head is intermediate in length, but has a small eye. The fins are all small with the exception of the adipose, which attains a considerable size, although its base is small in comparison. A distinctive feature found only in this sample is the small size of the maxillary in relation to the snout. Third lake is not far from lake Minnewanka and empties into the Bow river. It has an elevation of 4500 feet.

Maskinonge lake

Again only yearling fish were available, and the sample was small in size. The fish examined were distinguished by a large eye and deep head, and by a large growth in the first year. By virtue of locality this race is placed in the first group. Maskinonge lake drains into the Waterton river just below Waterton lake at an elevation of approximately 4185 feet.

Cultus lake

This population is the type of group two. Besides the rapid growth, to which reference has already been made, this race possesses a relatively small head and eye, long bases on dorsal and anal fins, fairly short pectorals, and a large adipose fin. The adipose base is not only large in relation to that of the other races, but also with respect to the base of the anal, so that the ratio of adipose base to anal base is comparatively high. Added to these features are a difference of one in the average count of pectoral fin rays and possibly a slightly higher scale count. Cultus lake empties into the Vedder river, which flows into the Fraser. Its elevation is not greatly above sea level.

Tolt river

The single specimen from this locality agrees very closely with the average characters of the Cultus lake population. In particular the large adipose may be noted. The Tolt river is in the state of Washington and flows into Puget sound.

Nooksack river

A sample consisting of two yearling fish was examined. It may be of significance that the Tolt and Nooksack specimens have deeper heads than the Cultus lake fish. Added to this in the Nooksack are the large dorsal and anal fins, long pectorals and pelvics, and large adipose. All these fins are larger in these fish than in any other sample of yearlings. The Nooksack also runs into Puget sound.

Bow lake

The type of the third group was at once considered distinct because of its slow rate of growth. This has produced a large-headed race, which rather surprisingly has a relatively short snout. In contrast with the

Third lake fish the snout in this case averages slightly shorter than the maxillary. The dorsal fin has a short base but is comparatively high, and therefore the ratio of dorsal height to dorsal base is great. The pectorals are very long, the pelvics fairly so, and the adipose is relatively small. Bow lake is rather high in the mountains, being at an elevation of 6500 feet. As mentioned previously, the water is very cold and heavily silted. The lake drains by means of the Bow river into the South Saskatchewan.

<u>Lake Louise</u>

All but one of the specimens in this sample were yearling fish. The figures for rate of growth in table XXI therefore were obtained from this single sample, except for the first year's growth. This may account for the apparent difference in growth between Bow lake and lake Louise. The characters of the young fish appear to be similar to those of the Bow lake population, as would be expected if physical similarity of environment is to be accepted as a criterion. The elevation of lake Louise is 5680 feet.

<u>Elk river</u>

Environment has produced a fairly large-headed race as the type of the fourth group. Even taking the large head into consideration, the snout and maxillary are found to be extremely long, and this is not accompanied by the characteristic bulging rostrum of the Waterton lake fish. The median and paired fins are all large with the exception of the adipose, which is very small. The ratio of adipose base to anal base is the least of any population studied. The average scale count is also even slightly higher than for the Cultus lake fish. One specimen had 94 scales in the lateral line, which is high for this species. The Elk river is in southeastern British Columbia, and flows into the Kootenay river, which is a tributary of the Columbia. The town of Michel, close to which these specimens were captured, is approximately 3800 feet above sea level.

CONCLUSIONS

The material presented in the preceding pages represents the foundation of a revision of the genus Prosopium. All the preliminary "spade work" necessary to a problem of this kind has been completed. The literature on the subject has been gone over as thoroughly as possible, and to ensure that no important details have been missed, various authorities in the systematic field have been consulted.

It has been stated on various occasions that the genus Prosopium is an extremely variable group. Opinion is unanimous in this respect, but up to the present time no measure of the extent of this variation has been forthcoming. There is some disagreement among ichthyologists as to the status of the various species, but it seems that this must be due to a lack of sufficient knowledge concerning the characteristics of these species rather than to any definite convictions supported by facts. It is the view of this writer that specific names have been applied to several forms in this genus which are only of subspecific rank, and that in all likelihood only about four or five definite species exist.

Specimens of Prosopium williamsoni have been studied from a representative series of localities covering to a great extent the known range of the species. These samples came from lakes and rivers tributary to three of our great river systems, namely the Fraser, the Saskatchewan, and the Columbia. It is regrettable that it was not possible also to examine specimens from the Athabasca river, but unfortunately an attempt to secure a series from this locality was unsuccessful. The fish examined show a relatively wide range of variation in most of the thirty-odd characters which were subjected to measurement. It was found possible to correlate most of these variations quite definitely with the type of habitat, and in this way four main races were found to exist, each characterized by a special type of environment which apparently showed its effect on growth rate and body proportions. Individual differences in food were also found to occur, and these also are undoubtedly caused by a difference in the relative availability of the various organisms present in a body of water.

It is hoped that the work will not cease here, and that some day a complete revision of the whole group will be possible. At the present time this is out of the question, for it is probable that a great amount of widespread and rather difficult field work must be carried out to bridge the wide gaps in present collections.

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