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THE RELATION OF THE REDSIDE SHINER TO PRODUCTION OF TROUT IN BRITISH COLUMBIA

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INTRODUCTION

The most abundant species of fish in many waters of the British Columbia mainland is the redside shiner Richardsonius balteatus (Richardson). Many lakes containing game fish also support dense populations of shiners, and it is therefore of importance to fisheries management that the relation of shiners to sports fishes be understood. The recent spread of shiners into such waters as the Paul lake chain near Kamloops has been viewed with alarm by many sportsmen in the belief that shiners compete with or prey upon young trout. On the other hand, in some localities such as Snowshoe lake in east Kootenay, shiners have been purposely introduced in order to provide food for Kamloops trout. Little information has been available as to the actual degree of competition or predation between shiners and game fish.

Shiners are found in most parts of the Fraser, Columbia, and Skeena drainages in British Columbia. They evidently are absent from northern British Columbia (Teslin lake), from the Peace river, and from Vancouver Island. Within their range, they occur in a wide variety of habitats including large lakes, moderately swift streams, and small ponds. They sometimes attain phenomenal levels of abundance, and probably exert considerable influence on game fishes inhabiting the same waters.

If the relationship between two species of fish is to be understood, some basic knowledge of the life history of each must be available. The feeding habits, daily and seasonal movements, spawning behaviour, etc. of a fish must be known in order to assess its interaction with other types of fish. During the summers of 1948-50, various phases of the biology of the redside shiner have been under investigation by the Fisheries Research Group of the British Columbia Game Commission. Studies have included field observations, feeding experiments at Kaslo, Summerland, and Nelson hatcheries, artificial rearing of shiners at Kaslo hatchery, and examination of over 5,000 specimens from some 61 localities in British Columbia. The present report embodies some of the findings relevent to the relations between shiners and sports fish.

During the investigation information was also obtained concerning the effect of conditions prior to hatching on the structure of adult shiners. It may be possible, from this and similar investigations, to distinguish hatchery-reared from wild game fish by examination of variable characters in the adults, as an aid in assessing and planning management policy of sports fisheries. In the present study it was established that in the shiner the number of rays in the anal fin (which varies from 10 to 21) is determined largely by the water temperature prior to hatching, one additional fin ray resulting from each increase of about 3° C. (5.4°F.) These results will be reported in detail elsewhere.

SHINERS AS FOOD FOR TROUT

Various observations indicate that shiners are eaten by Kamloops trout, cut-throat trout, and speckled char ("Eastern brook trout"). At Nelson hatchery on August 20, 1949 a number of Rosebud lake shiners, from 20 to 40 millimetres long, were introduced in a circular rearing pond containing yearling Kamloops trout about 100 millimetres long. Trout were seen to eat the shiners, usually swallowing them whole. Dead trout fry were also eaten by the yearlings.

Examination of stomachs from Rosebud lake fish showed shiners to be present in 14 of 25 speckled char, 2 of 9 cut-throat trout, 3 of 14 large shiners, and a single Kamloops trout. Shiners are apparently the major food of adult Kamloops trout in Hyas lake and Pinantan lake, and have begun to appear in stomachs of Paul lake trout. Stomachs of the larger Kootenay lake Kamloops trout taken in 1949 contained mainly fish, usually kokanee, but occasionally shiners. There is evidence to indicate that in Cottonwood lake young shiners are heavily preyed upon by diminutive mountain Kamloops trout, while adult shiners, which are too large to be eaten, live in close association with the trout.

From the foregoing and other observations it seems evident that shiners are frequently used as food by game fish. Of the species discussed, speckled char are apparently the best adapted to shiner consumption, this may be due in part to the larger mouth of the char as compared with the Kamloops and cut-throat trout.

Shiners display a behaviour which probably renders the youngest fish unavailable as trout food in the summer months. Experiments at Rosebud lake on August 28, 1949 showed that the zone close to shore with depth of two feet or less contained the highest proportion of younger fish. Of recently emerged fry taken, 100% were in this inshore zone; of larger fry of the year 56% were inshore; of yearlings about 39% were inshore; while of older shiners only 11% were inshore. Shiners in this shallow water find abundant protection in aquatic vegetation, and are probably almost unobtainable by adult trout; in addition high inshore temperatures may discourage the presence of trout.

Shiners' eggs, which have been reported in the stomach of one Kamloops trout from Pinantan lake, may be a minor item in the diet of some sports fish. Shiners spawn over a period of 7 to 10 weeks, starting sometime between the end of May and the end of June. Spawning sometimes occurs in creeks, where eggs adhere to gravel in swift-flowing water. In other localities shiners broadcast eggs over submerged masses of aquatic vegetation during the night. Eggs are slightly over one millimetre in diameter. Because of their small size and scattered distribution, they are probably not consumed in a large enough quantity to contribute substantially to the nourishment of adult sports fish.

To summarize the role of shiners as food for game fish, it is evident that they are often an important item in the diet of trout. As such they convert diffuse nourishment (in the form of plankton, insects, etc.) into concentrated food (in the form of shiner flesh). However, as shiner eggs and young are in warm, shallow water and hence are not readily available to trout, only trout which are of sufficient size to eat large shiners utilize shiners as a common food item.

SHINERS AS PREDATORS UPON TROUT

Just as the size of a trout's mouth limits the size of shiner it can eat, so the size of a shiner's mouth restricts its consumption of trout. In this case only the smallest trout, in the fry stage, can be eaten, and then only by adult shiners. However, experiment and observation show that shiners can, and sometimes do, eat young trout.

In 1946 shiners were collected from Pinantan lake following plantings of Kamloops trout fry. The stomachs of eight of these preserved specimens were examined later; two contained trout fry and three others contained unidentified fish remains.

In 1948 three attempts to feed trout fry to shiners were made, at Summerland hatchery, in an enclosure on Allison lake, and at Taylor lake. In these trials shiners did not eat fry, but several sculpins did eat trout fry. (It is suggested from these and other observations that at times predation on fry by sculpins may be of serious proportions.) In the summer of 1949 shiners were kept in a trough of the Kaslo hatchery for several weeks, and Kamloops trout fry were then introduced. Dead or injured fry were eaten by the shiners, but healthy fry remained alive for two days in the trough. Shiners would approach fry swimming near the surface, but would not pursue if the fry attempted to evade them.

Although conditioning of the hatchery shiners may have biased results of the Kaslo experiments, it is suggested that shiners may be discouraged from attacking fry if the fry make a determined effort to escape. Trout fry poured from a hatchery can into shallow water were several times observed to lie inactive on the bottom for some minutes after release. This observation, coupled with feeding experiments and the presence of freshly released fry in shiners' stomachs, suggests that trout fry may be particularly susceptible to predation when they are first introduced into new surroundings. Initial loss of freshly planted trout fry to shiners may thus occur where shiners are abundant and cover is scarce. Fry hatched under natural conditions are probably less subject to shiner predation. Loss of trout eggs to shiners has not been investigated.

The shiner is probably a less serious predator on trout than are such fish as the sculpin and the squaw fish. It is capable of preying upon only the smallest trout, although even this may be serious in lakes supporting dense populations of shiners. On the whole, its role as a predator is probably less important than its role as a competitor.

SHINERS AS COMPETITORS OF TROUT

Shiners and trout eat similar types of food, and some competition between the two almost certainly occurs. In several collections of shiners and trout captured together, every type of food found in either Kamloops, mountain Kamloops, cut-throat trout, or speckled char, was also found in the shiners. This applies to trout fry and fingerlings as well as adults.

As similar food has been found in shiners and trout taken in the same place at the same time, the two are probably in competition unless there is ample food for both. A surfeit of food organisms is unlikely in those lakes which contain dense shiner populations. Some lakes support upwards of 5,000 shiners per acre, and probably contain less than the minimum food required to completely satisfy so many fish. However, it must be borne in mind that competition is generally limited to zones where the ranges of the two species overlap. Fishes having different temperature, or other ecological preferences, may inhabit the same lake but seldom come in contact with each other. During the summer, shiners usually remain in shallow water, leaving bottom fauna of the deeper water largely at the disposal of trout. Although shiners sometimes move out over deep water at night, they probably do so in search of surface insects and are not found at great depths. Trout and char, on the other hand, while they sometimes feed close inshore in competition with shiners are probably capable of moving to greater depths than shiners and can make use of food in this zone free from competition.

From the foregoing it is evident that different intensities of competition prevail under different ecological conditions; the greater the overlap of zones tolerable to each species, the greater the competition. Further, the more variety there is in available habitat types within a lake, the less severe the competition is likely to be. For example, Kootenay lake is large and varied enough that populations of shiners and trout can exist without being thrown into severe competition. Paul lake, while smaller, includes a zone of deep cool water which is relatively free from shiners, and which is probably available to trout throughout the year. Finally, in lakes such as Pinantan, which stratify during the summer, oxygen stagnation probably forces the trout up into the same zone as the shiners. Here competition is probably considerable, although it may be partially offset by increased availability of shiners to the larger trout.

Shiner competition is apparently felt most severely by fingerling trout, as shiners deplete the food supply while not being available themselves as food to small trout. In the extreme, starvation of young trout might, in addition to reducing the growth rate, result in lowered resistance to disease and also in inability to evade predators. The presence of large predators in a lake may therefore render competition by shiners particularly injurious to trout production. Allison lake near Princeton may be an example of such a condition.

OTHER SHINER-TROUT RELATIONS

In lakes containing species in addition to trout and shiners, complex interrelationships may exist. These cannot be adequately described until more information is obtained on the habits and life histories of those species involved. However, it is known that predator-prey relations may sometimes be considerably altered by the presence of "buffer" species. Buffers may serve as alternative food for the predator, or may themselves feed on the prey, or they may in some other way affect the food-chain involving the two original species. For example, a thousand young trout in a lake containing adult squaw fish will probably stand a better chance of survival if there are in addition a hundred thousand shiners to absorb predation by the squawfish. The presence of the shiners may, on the other hand, allow the squaw fish to multiply to a point where they are more of a menace to the trout than they would have been in the absence of the shiners. In either event the shiners are acting as a buffer which alters the trout-squaw fish relation.

Probably wherever shiners, trout, and other species are present, the shiners affect trout production by this type of buffering as well as by direct action. The end result is therefore difficult to predict. However, it should be borne in mind in formulating management policy that shiners and trout may react very differently toward one another, depending upon the presence or absence of other species of fish.

Shiners in many localities are subject to so-called "black-spot disease." Speckled char in the same localities are sometimes spotted in the same manner, and Kamloops trout have been so reported at least once. The presence of shiners may increase the probability of infection of trout, but there is no evidence that the spotting is injurious. Black-spot of shiners, which is currently being investigated at the University of British Columbia, is apparently due to a trematode flat-worm which probably also infects snails and waterbirds during its life cycle. The spots on fish are caused by encysted larvae which occur just under the skin, but which apparently do no harm other than by slightly altering the appearance of the host. Presence of black-spot in fish is probably cause for no alarm among sportsmen.

MANAGEMENT POLICY

The relations between shiners and trout, as just outlined, are varied and complex. It cannot be stated categorically that shiners are either "good" or "bad" for trout production. Since ecological conditions, which vary greatly in different British Columbia lakes, affect the type of relationship existing, it is essential in deciding upon management practice to consider each lake as a separate problem.

In general, shiners may be harmful to production of trout by competing for available food and, under some circumstances, by eating trout fry. On the other hand, shiners may benefit trout production by serving as food.

The harmful effects are felt by all sizes of trout, while the beneficial effects apply only to adult trout. Therefore, where choice is possible, it is usually preferable that shiners be absent from a trout-producing lake. Where such choice is not available, management must be such as to derive the maximum benefit and minimum ill effects from the presence of shiners. Following are provisional recommendations for management under various circumstances.

First of all, if shiners are absent from a lake containing trout, it is probably not wise to introduce them. It is quite possible that greater efficiency in trout production may be realized by introducing an intermediate food source which would gather diffuse nutrients (plankton, etc.) and render them available to trout in more concentrated form. However, investigation may disclose an intermediate which is more efficient than the shiner, and which lacks some of the shiner's disadvantages. Suitable intermediates might be found in crustaceans or some species of small fish. It would therefore be unwise to purposely introduce shiners, at the present time, in the hope of improving trout production.

If shiners are already present in a lake there are two main courses open: removal of the shiners; or toleration of shiners and selection of appropriate management policy. These courses will be considered separately.

Attempted removal of shiners by biological control methods is almost certainly ineffectual. The life history of the species renders it particularly immune to such attack as it spawns over a long period and in a variety of places, and as the young select localities unfavourable to predators. Introduction of speckled char in the hope of exterminating shiners is therefore impractical (although it is reasonable to hope to support a good char population in a lake inhabited by shiners). Similarly destruction of spawning areas or spawning runs, seining, use of coarse fish traps, and similar techniques are futile. The high reproductive potential and diffuse nature of a shiner population render its removal impractical except by total extermination.

Complete removal of shiners may be effected by the use of poisons such as rotenone. The decision to poison is, however, subject to several considerations. First, there are the obvious economic considerations of cost of poisoning (which limits the technique to small bodies of water), accessibility to anglers, dollar returns per pound of trout caught, and so forth. Second, there are mechanical considerations such as the ability to poison completely in a short space of time, and the ability to prevent, with certainty, the re-entry of unwanted species. Finally, there are the biological considerations governing the degree of improvement in trout production which can be expected. It is suggested that in general a more spectacular improvement in trout production is likely to result from poisoning lakes containing several species of coarse fish than from poisoning lakes containing only shiners. The adverse effect of competition from shiners when coupled with predation by other species has been mentioned. Several lakes now contain shiners, but maintain fair levels of trout production. Therefore, a lake with only shiners and trout, which is at present a poor trout producer, should not be expected to become an excellent trout producer merely through the removal of shiners.

Lakes likely to benefit most from poisoning are those which now support a variety of coarse fish and which contain at least a few trout (as an indication that the physical and chemical conditions are tolerable). It must be certain that coarse fish cannot re-enter the lake at flood levels. In this regard it has been observed that shiners are capable of ascending as well as descending swift water for considerable distances. A poisoned lake also runs the risk of contamination by shiners used illegally as live bait. If natural spawning facilities are available for trout, the lake should, in addition, be ensured of sufficient fishing pressure to prevent overpopulation of trout after removal of predators. Under conditions such as outlined, poisoning of shiners and other coarse fish populations may prove an economically practicable method of improving trout production.

Removal of existing shiner populations cannot be undertaken in the majority of British Columbia lakes. It therefore remains to select the type of game fish which is best suited to each locality, and then to practise the best methods for its production in the presence of shiners.

It is probably desirable to raise Kamloops trout wherever possible within the Province. The speckled char, however, appears better able to benefit from the presence of shiners. There may therefore be some bodies of water containing shiners which would be more efficiently utilized as good producers of char than as indifferent producers of Kamloops trout. Introduction of char to a lake with shiners and Kamloops trout, however, should be expected to cause further deterioration in production of Kamloops trout.

There are some shallow lakes which can support shiners but are capable of supporting few or no trout or char, due to temperature, oxygen, or other limnological conditions. The potential crop from such lakes is as yet unharvested. The introduction of a predatory species acceptable to anglers might create a fishery where none now exists. Where there is no danger of uncontrolled spread to other watersheds, black bass or maskinonge might be planted. Such experiments must, however, be undertaken with extreme caution and are only advisable in localities eminently unsuitable for native game fish.

In lakes which contain shiners and in which stocking of Kamloops trout is practised, the relative merits of planting eggs, fry, or fingerlings must be decided. It is strongly recommended that, wherever practicable, lakes containing shiners be stocked with fingerlings rather than fry. Loss to predation by shiners is thus eliminated, and the trout are subject to competition for a shorter and less critical period before they become large enough to feed on shiners. A given sum of money used to rear a limited number of yearling trout for stocking may well give a better return than the same sum used to stock a much larger number of fry.

Finally, if finances or hatchery facilities do not allow the rearing of fingerlings, it is recommended that if suitable water is available then, eggs rather than young fry should be stocked. The decreased mortality achieved by allowing fry to emerge in the hatchery is probably offset by the increased vulnerability to shiner predation which fry suffer when suddenly introduced into new surroundings. In addition, the cost of eggs is somewhat less than that of fry, so that more eggs than fry can be stocked for the same sum.

In conclusion, the trout in a lake form part of a complex and highly integrated community of plants and animals. If maximum efficiency in trout production is to be realized, the activities of the rest of the community cannot be ignored. Each lake should be recognized as presenting a unique problem, and the role of each major species present should be known. Under these conditions it should be possible to manipulate management measures so as to turn the presence of shiners from a liability into an asset.