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Studies on the dimorphic salmons, Oncorhynchus masou (Brevoort) and Oncorhynchus rhodurus Jordan & McGregor found in Japan and adjacent territories

by Masamitsu Oshima

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Studies on the Dimorphic Salmons, Oncorhynchus masou (Brevoort) and Oncorhynchus rhodurus Jordan & McGregor, Found in Japan

by

Masamitsu Oshima, M.A., D.Sc.

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This work is dedicated to Dr. Seitaro Itsushima, to whom I am greatly indebted for his guidance in this study, and to the spirit of Kazutaka Ito, the father of the Hokkaido Trout Hatchery.

Author's Preface

The author, whose good fortune it was to have as an uncle Kazutaka Ito, the founder of the Chitose Hatchery, and one of the guiding lights of the Hokkaido fishing world, and who even now still strives to sustain the eminent reputation of Prof. Clarke, whose disciple he was, was born in Sapporo some seventy years ago, the eldest son of Masatake Oshima, D.Litt. Hokkaido then, as Uchimura Kanzo reminisced, was a land not far removed from the hand of the Creator, and nature, far more than any mortal sage, took innocent youth in hand and infused it with ambition. And when the valleys, through which coursed the Toyohira and Chitose Rivers, were adorned in scarlet, the trout and salmon thronged together to ascend the streams to their spawning grounds. The Sadayama River, now sullied by the smoke of hot-spring resorts, was the home of the yamame. Returning for the eightieth anniversary of the founding of Hokkaido University I was astonished at how the elms had grown, but even more so by the fact that Hokkaido's famous yamame had disappeared from the streams where we used to fish as boys in the environs of Sapporo. I still remember the young band of students at the Sapporo School of Agriculture under Dr. Wheeler -- Shigehide Arakawa, Shihonoshin Kuroiwa, Torajiro Watanabe -- off to the mountains to survey for new roads in our summer vacations, we used to encounter bears at times and fish by hand for yamame which abounded in the clear brooks and eat our fill of them. Now, this is only a fond remembrance of things in the distant past. Reminiscing about my native soil in those days long ago, my eyes grow particularly moist when I recall how we discussed the yamabe, whose taste earned it the reputation

of the king of river fish, whether it was a young cherry trout, whether it had river and marine forms, whether it was the same as the yamame which so delighted the anglers of the other islands, the relationship between the Biwa trout, native to Lake Biwa, and cherry trout or between the yamame and the amago, acknowledged river form of the Biwa trout. Is there a man from Hokkaido, where the yamabe is so highly prized, whose ear is not caught by talk of this fish?

The author, who specialized in ichthyology, had always had a predilection for salmon and trout, and was especially interested in these questions. He had the good fortune to study at the time of World War I with such American authorities as Dr. Charles Henry Gilbert under the illustrious professor emeritus David Starr Jordan at Stanford University. When the microscopic examination of scale patterns of fish was finally recognized as ecologically significant and the epoch-making works of Dr. Gilbert on Alaskan salmon were published, the author's work had betaken him to Taiwan, far removed from the world of salmon and trout. However, in 1918 the astonishing discovery in the wilds of Taiwan of a cold-water trout, and the actual capture of a specimen were reported. Dr. Jordan was amazed. The fish later proved to be identical to the yamabe of Hokkaido and suddenly studies of the yamabe tribe was no longer a regional problem confined to Hokkaido.

Thirty years have come and gone since that time and the author has travelled the length of Japan studying Hokkaido's finest fish, the yamabe, and with the conclusion in Kyushu of the remaining problem of distribution, the final lines on this topic were penned.

These years of accumulated data could not be published, however,

and lay buried in a desk drawer as time passed. The author's opportunity came at the time of the Eightieth Anniversary of the founding of Hokkaido University and with the unstinting efforts of Mr. Sadaharu Arai, head of the Hokkaido Trout Hatchery (Japan Fisheries Agency), the assistance of Mr. Seizo Sano, chief of the Hatchery's Research Section, and Mr. Tetsuyuki Akiniwa, chief of the information section, and through the good offices of Nire Shobo publishers, the author's fondest wish has been realized with the publication of this work.

In the course of this research, a large role was played by the late Ken Fujii, head of the Chitose Hatchery, and by Mr. Kakunosuke Kikuchi. The author also imposed heavily on the time of Mr. Isokichi Ono, who is currently serving as the director of the Ohara Fisheries Cooperative in Chiba Prefecture. The author is extremely indebted for assistance in studies of Biwa trout to the late lamented Hikoshiro Kobayashi, of the Shiga Prefectural Fisheries Experiment Station, Mr. Saburo Aoki, former head of the Shiga station, and to Mr. Osamu Hiraki, former head of the Gifu Fisheries Experiment Station. My profound gratitude is expressed to all of them.

Late autumn, 1956 The author

Introduction

Scholars agree that there is no question but that the seaward-migrating sakura trout which abounds along the coast of Hokkaido and the Japan Sea and the freshwater Biwa trout of Lake Biwa are separate species. There has long been disagreement, however, over such questions as whether the fish known as yamabe, which matures while retaining the morphology of the immature cherry trout and is found in the cold rivers and streams of Hokkaido and Sakhalin, is the immature cherry trout or a different species altogether and whether the yamame which lives in the cold river waters of Tohoku, Kanto and Hokuriku and is so popular with fishermen, is the same as Hokkaido's yamabe or not. Similar questions surround the Biwa trout. The young Biwa trout is called amago and the parent is known as amenouo, but in the regions east of Hakone, there is a fish which matures and propagates in the cold water rivers which empty into the Pacific while retaining the same appearance exactly as the amago. Not only is it very difficult to discover the relationship between this fish and the Biwa trout, but there are those fishermen who claim that the yamame and the amago are the same species.

The mature and immature fish of all these types are popular food fishes and are known as the king of the river fish by anglers. These problems must now be resolved on a firm scientific basis.

In 1918 the author was surprised to find that a Taiwan trout, a form of cherry trout, inhabited the upper reaches of the Tachia River in Taiwan. For another 30 years the author explored the mountain streams of Japan itself trying to resolve these problems, and with the final touch on this research -- a trip around Kyushu in 1950-51 -- the results are

presented here for the world to evaluate.

An enormous number of friends have helped in these thirty years of research. Not a few of them, who helped with experiments or collected specimens, have passed on without seeing the results today.

The majority of the data on Hokkaido's yamabe in this paper are based on papers by Mr. Isokichi Ono, formerly of the Hokkaido Fisheries Experiment Station. In connection with Biwa trout, Mr. Mitsuo Aoki, former head of the Shiga Prefectural Fisheries Experiment Station made available part of the Samashigai Trout Farm for experiments and laboured to present their results. Crossing experiments on cherry trout and amago continued from 1924 through 1928 at the Gifu Prefectural Fisheries Experiment Sub-station at Hida-Takayama under the guidance of the station chief, Mr. Osamu Hiraki. Most of the data contained in this paper was obtained with Mr. Hiraki's cooperation.

The author would like to express his deepest gratitude to these three gentlemen and at the same time to dedicate this work to the late Dr. Itsushima for his assistance and inspiration in the years of work required for this study.

July 7, 1951

Preliminary note on terminology.

In rendering Japanese common names for fish, the objective has been to minimize the reader's need to remember unfamiliar-sounding Japanese names, while avoiding the immense confusion involved in trying to correlate Japanese and English common names. Where common English names such as chum, pink, silver salmon are used, these are to be taken as referring to O. keta, gorbuscha, kisutch as usual, and so on. The Japanese sakura-masu has in all cases been rendered "cherry trout". Although Oshima suggests elsewhere that "Biwa salmon" be used for biwa-masu, Biwa trout has been used here for consistency. In the case of the Japanese hime-masu, equated with O. nerka, the rendering "kokanee" is used (O. nerka var. adonis) as hime-masu refers to a land-locked form; ordinary O. nerka is beni-masu in Japanese. The less familiar names of the various forms treated are given in transliteration only, e.g. yamame, amago, amenouo, etc. -- Translator

Chapter I

Studies of Cherry Trout

Section 1 Taxonomic Studies (1)

1. Discussion of scientific names

The salmonid fishes of Japan are frequently assumed to offer no taxonomic incertainties. Dealing only with those fish, other than the five species king salmon Oncorhynchus tschawytscha, red or sockeye salmon Oncorhynchus nerka, silver or coho salmon Oncorhynchus kisutch, pink or humpback salmon Oncorhynchus gorbuscha and the chum or dog salmon Oncorhynchus keta, which were in need of reexamination, the discussion of Japanese salmon on the basis of Jordan and McGregor's names in a 1925 publication by Jordan and Hubbs entitled "Record of Fishes Obtained by David Starr Jordan in Japan 1922" (Mem. Carnegie Mus. Vol. 10, 1925, No. 2) introduced a further degree of confusion into the problem of scientific names, which had been in a state of flux for many years. In that paper, the following nine species of Japanese salmon were mentioned. The long-standing designation of the cherry trout as Oncorhynchus masou (Brevoort) was regarded as synonymous with Oncorhynchus keta (Walbaum) and eliminated.

1. Oncorhynchus nerka (Walbaum)
   benimasu, red, sockeye salmon
2. Oncorhynchus adonis Jordan & McGregor
   new species
3. Oncorhynchus kawamurae Jordan & McGregor
   new species (kunimasu)
4. Oncorhynchus gorbuscha (Walbaum)
   karafuto-masu, pink, humpback salmon
5. Oncorhynchus keta (Walbaum)
   sake, sakura-masu, dog, chum, cherry salmon

6. Oncorhynchus tschawytcha (Walbaum) (2)

masunosuke, chinook, king salmon

7. Oncorhynchus ishikawae Jordan & McGregor

new species yamame (land-locked masu)

8. Oncorhynchus macrostomus (Gunther)

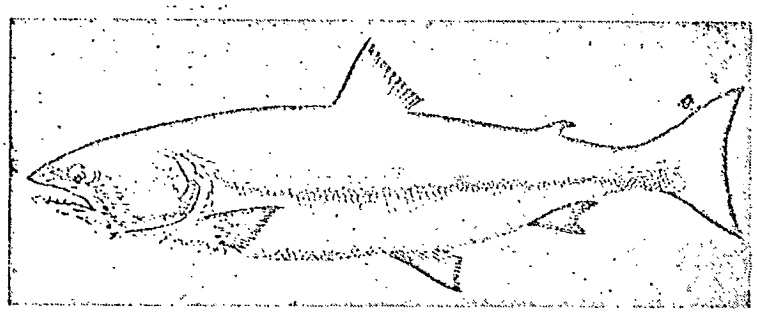
amenouo, amago (Translator's note: amago also called O. milktschitch)

9. Oncorhynchus Jordan & McGregor

new species biwa-masu (Translator's note: original text gives no specific name.)

The paper is shot through with errors because of the mixing of salmon (sake) and trout (masu), which scholars have long considered different. Our first step must be to take up the problem of the scientific name for the sakura-masu, one of the fish studied in this paper, and set right the errors which have accumulated around it.

Brevoort was the first to ascertain that the cherry trout was indigenous to Japan and to describe it under the name of Salmo masou. He obtained it while at anchor in Hakodate and described it on the basis of a coloured sketch. (Salmo masou Brevoort, Exped., Japan, 1856, p. 279, pl. 9 Fig. 2, Hakodate). However, in spite of the plate's bearing the scientific name Salmo masou, the text itself referred to the fish as Salmo orientalis. The latter is a synonym for Oncorhynchus



Salmo masau Brevoort
ペルリ日本遠征記に示された桜鱒の着色図

Salmo masou Brevoort
Coloured plate of cherry trout in Perry's Expedition to Japan

tschawytscha and masou ought properly to be used for the cherry trout. The same report makes reference to a Salmo young (sic Tr.), (3) illustrated as a young trout with a series of black oval markings on the sides. However, this is the young cherry trout, or yamame, and should not be regarded as a separate species.

The late T. Kitahara pointed out that the adult fish in the illustration was the cherry trout, approaching the shore toward early summer about to swim upstream and spawn. Since Perry's ships cast anchor in Hakodate harbour in May, that opinion appears correct.

In Jordan and Snyder's 1902 paper on the salmon and trout of Japan (Proc. U.S. Nat. Mus., 24, 1902, p. 571), Oncorhynchus masou is applied to an illustration of a specimen taken from Aomori. This fish has 190 scales on the lateral line (cherry trout has 140) and is a pink salmon instead of a cherry trout. This illustration continued to be reproduced as that of cherry trout and in the first edition of Dobutsu Zukan (Illustrated Book of Animals), Dr. Shigeo Tanaka* incorporated the

*Japanese names are given in Western order: given name, surname.

illustration in question intact and stated that there were 190 scales on the lateral line. He also declared that the fish from Ise Bay known as kawamasu was the same species. When the book was revised and enlarged in 1947, the picture was identified as Oncorhynchus milktschitch (Walbaum), or masu in Japanese, and the number of scales was changed to 120, thus compounding the error. The scientific name given above is another designation for gin-masu of Oncorhynchus kisutch, which has about 127 scales on the lateral line. Thus, Dr. Tanaka concluded that cherry trout was identical to silver salmon, and rejected the accepted scientific name for the latter in favour of a name, not acceptable to many authors, which apparently referred to the young silver salmon! Not only did he adopt the questionable designation of Salmo milktschitch Walbaum, but he committed the astounding error of concluding that cherry trout, Biwa trout, yamame, AND amago were identical and offered the illustration of seppari-masu, as published by Jordan and Snyder, as that of cherry trout. (seppari-masu and karafuto-masu both generally refer to O. gorbuscha -- Tr.)

Of the specimens described as Oncorhynchus masou by Jordan and Snyder, the salted specimen acquired from Ishikari River in Aomori would seem to be the true cherry trout, judging from the place of origin, and (4)
the specimen captured in Nikko's Daiya River is identical to yamame, the fluvial form of cherry trout. However, in the paper by Jordan and McGregor Salmon masou Brevoort is treated as synonymous with Oncorhynchus keta or chum and the note is appended "Name on a very bad drawing". This is a bad drawing, if one is trying to make a salmon out of a trout, but it is quite apt if properly identified as cherry trout. Identifying

cherry trout with chum or silver salmon is the height of confusion. Cherry trout is definitely an indigenous fish of Japanese waters and it should be designated as Oncorhynchus masou (Brevoort).

As will be discussed in detail later, the cherry trout has a seaward-migrating form and another form that spends its entire life cycle in fresh water. Opinions differ on whether these should be regarded as two distinct species or whether they should continue to be treated as the same species. It is difficult to come down clearly on one side of this question, but the author has chosen to treat both as belonging to the same species Oncorhynchus masou (Brevoort).

Günther described a species of Japanese trout obtained in Yokohama market under the name of Salmo macrostoma in 1880 (Challenger Report, 1, 1880, p. 71, pl. 31, Fig. 8; Yokohama market). Along the side of the fish shown in the figure is a line of black ovular spots and black dots are scattered both above and below the lateral line. Quite clearly this is the yamame, the fluvial form of cherry trout. If 1880 was the year the report was published, then the specimen in question was obtained earlier than that. In older records we find that "In the 11th year of Meiji (1878) a fish farm was established at Kumagai Village, Sakata-gun, Shiga Prefecture for the artificial hatching of lake trout and the lake was stocked with fry". Trout from Lake Biwa were first transplanted to Chukyushi Lake in 1882, so it does not seem likely that Lake Biwa trout had appeared in the Kanto area before that, or that they would be for sale in Yokohama markets. A close examination of Günther's description and plate shows that the characteristics of the fish all resemble those of yamame very closely. T. Kitahara concluded that Salmo macrostoma was

Oncorhynchus masou and maintained that it was identical to the fish known in Southern Japan as amenouo. The author agrees with the first statement, but finds it difficult to do so with the latter.

If we look at Jordan and McGregor's paper, which is the source of confusion over nomenclature, we find that amago, enoha and other river forms of Biwa trout native to the rivers of southwestern Japan are all designated Oncorhynchus macrostomus (Günther) but the fish from the Shibukawa River in Gumma Prefecture is certainly yamame, judging from the scale pattern as shown in Figs. 8 and 9 of Plate 8. The fish from Toyama, Fukui and Kumamoto are also yamame, while the others are amago of the Biwa trout group. The paper states that amago is not found east of Hakone and the fact that the scales of Shibukawa River yamame are figured as those of amago compounds this unpardonable error. In short, Jordan and McGregor's Oncorhynchus macrostomus should be divided up between Oncorhynchus masou (Brevoort) and Oncorhynchus rhodurus Jordan & McGregor.

Finally, a brief mention should be made of Oncorhynchus ishikawae Jordan & McGregor (Mem. Carneg. Mus. 10, 1925, pt. 2, p. 132, pl. 6, Fig. 1, pl. 8, Fig. 6). The description was made on the basis of a type provided by the late Yojiro Wakiya, who caught it in Lake Biwa. However, Mr. Wakiya himself relates "The fish I sent was a seaward-migrating yamame taken from Lake Miyako and has no connection with Lake Biwa. Perhaps the names of the lakes were confused." Therefore, the description "apical third of dorsal (fin)* jet black, paler at base" (6) applies quite clearly to seaward-migrating yamame. It is stated that

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*omitted in English quotation in original, but present in accompanying Japanese. -- Translator.

this species is called yamame and resembles silver salmon, and can be distinguished from the amago by the black colour of the dorsal fin. If Fig. 1 of Plate 6 is taken to illustrate this species, it is amago with distinct red spots on the sides. In view of the origin of the specimens, those from Kitakami River in Hokkaido, Shibukawa River in Gumma Prefecture, Toyama and Kumamoto are yamame while those from the Kiso River and Uwajima are amago. In other words, the two known species have been mixed in description and the new species name was given on the basis of a type which was the seaward-migrating form of yamame and should be discarded, since it is synonymous with Oncorhynchus masou.

The Taiwan trout Salmo formosanus described by Jordan and Oshima in 1919 was later found to be identical to the yamame of Japan proper. ("Japan proper" -- Taiwan was considered a part of Japan at that time. Translator) This name is also synonymous with Oncorhynchus masou (Brevoort).

To summarize the preceding discussion, the scientific name Oncorhynchus masou (Brevoort) for cherry trout was arrived at on the basis of the following:

Oncorhynchus masou (Brevoort)

Seaward-migrating form: sakura-masu (cherry trout)

Fluvial form: yamabe, yamame, yamo, kurosobu, gin-enoha

Salmo masou Brevoort, Exped, Japan, 1856, p. 275, pl. 9, Fig. 2; Hakodate.

Salmo macrostoma Gunther, Chall. Rept., 1, 1880, p. 71 pl. 31, Fig. 8; Yokohama.

Oncorhynchus masou Jordan & Snyder, Proc. U.S. Nat. Mus. 24, 1902, p. 571 (in part), Daiya R., Ishikari R., Jordan, Snyder, & Tanaka, Journ. Coll, Sci., Tokyo Univ., 33, 1913, p. 42 (in part), streams and coast of North Japan. (7)

Salmo perryi Jordan & Snyder (not of Brevoort), Proc. U.S. Nat. Mus., 24, 1902, p. 578 (main part); lake Chuzenji, Aomori, Kinu R., Daiya R., Kitakami R., Hakodate, Tokyo Market - Tanaka, Ichth. Japan, 1919, p. 284, fig. ( ).

Salmo formosanus Jordan & Oshima, Proc. Acad. Nat. Sci. Phila., 1919, p. 122 Saramao, Formosa.

Oncorhynchus macrotomus Jordan & McGregor, Mem. Carneg. Mus., 10. 1925, pt. 2, p. 134, pl. 8, figs. 8,9 (in part); Shibukawa, Toyama.

Oncorhynchus rhodurus Jordan & McGregor, Mem. Carneg. Mus., 10, 1925, pt. 2, p. 137 (in part); Naoetsu.

Oncorhynchus ishikawae Jordan & McGregor, Mem. Carneg. Mus., 10, 1925, pt. 2, p. 132 (in part); Kitakami R., Shibukawa, Hamada, Toyama, Hokkaido.

Salmo milktschitch Tanaka, Mongr. Ill. Encycl. Fauna Jap., 1947, p. 508 fig. 1486.

2. Seaward-migrating and Fluvial Forms

The young cherry trout all appear alike at the time they hatch. But as they grow, some descend to the sea where they grow and mature, and as cherry trout originally did, return upstream to spawn; others spend their entire lives in the cool waters of rivers, retaining the morphology

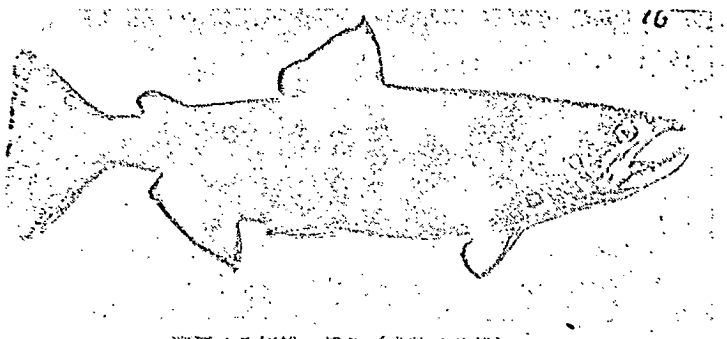
and colouration of their immature stages through the spawning stage. The following is a description of the morphology of these two types.

3. The morphology of the cherry trout differentiated from the seaward-migrating yamabe.

Adult cherry trout, which develop in the ocean, swim upstream to spawn in Hokkaido starting around May. Unlike salmon, however, they feed a great deal in the rivers. Thus, it is possible to catch them by hook and line at this time. These fish are not sexually mature and the inside of the oral cavity is black. They are sometimes known as "black-mouthed trout" in Japanese. Their appearance is different from that during the ocean-dwelling stage. The black colour on the tip of the dorsal fin, characteristic of the immature stages, disappears. The body becomes soot-coloured, with a red tinge below. Cloudy markings appear on the sides. The snout becomes elongated and the teeth sharper, particularly in the males.

The following is a description of a mature male captured October 26, 1928 at the Chitose Egg-Collection Station.

The length of the body excluding the caudal fin is 4.10 times the head length. The head length is 2.72 times the snout length, 9.20 times the eye diameter, 2.45 times the interocular distance, 2.37 times the height of the caudal peduncle and 1.3 times the length of the branchiostegals. The dorsal fin has 15 rays, the anal fin 14, the pectoral fins 13, the ventral fin 9. Scale formula 25+134+25; gill rakers on first gill arch 8 + 11.



溯河せる桜鱒の親魚（成熟せる雄）
1928年10月26日北海道千歳川にて採捕　　（原図）

Adult cherry trout after swimming upstream (mature male)
Captured in Chitose River, Hokkaido, 26 October 1928

The body is large and fat. The ventral margin is much more strongly curved than the dorsal margin. Caudal penduncle is comparatively stout. Maxilla extends backward and the mouth opening extends far behind the posterior margin of the orbit. Eyes small, situated on (9)
anterior portion of head, covered with a thin mucous membrane. Nostrils above and in front of the eyes, adjacent. Single line of small teeth on both jaws, anterior ones slightly larger. Vomerine teeth absent. Small teeth on palatine bones. Gill rakers dense, somewhat slanted.

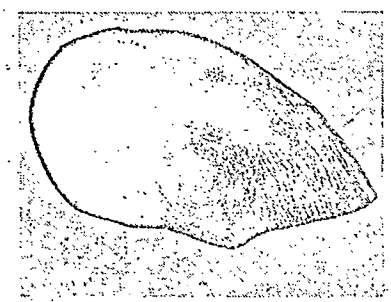
Origin of dorsal fin closer to snout than to base of caudal fin. Dorsal fin triangular. Head length 2.37 times length of longest ray in dorsal fin. Pectoral fins relatively short and rounded. Origin of ventral fin immediately below fourth dorsal ray. Long thin auxiliary scales reaching tip of ventral fin. Anal fin large, 2.37 times the length of the first ray. Caudal fin robust and indented posteriorly.

Lateral line straight and central. Exposed part of scales largely absorbed with no complete ones visible. Distinct winter bands

on outside of portion indicating river-dwelling period.

The colour of the live fish is greenish grey on the back, becoming paler toward the belly. There is a row of pink-red cloudy markings on the sides. The head is uniform grey-brown, with indistinct black spots on the top. The dorsal fin is dark yellow-grey, tinged with yellow-green on the margin. The dorsal fin is grey-brown, tinged with pink at the base. Small black dots are scattered over the back, dorsal fin and adipose fin. The interior oral cavity is black. The total length of the fish is 540 mm.

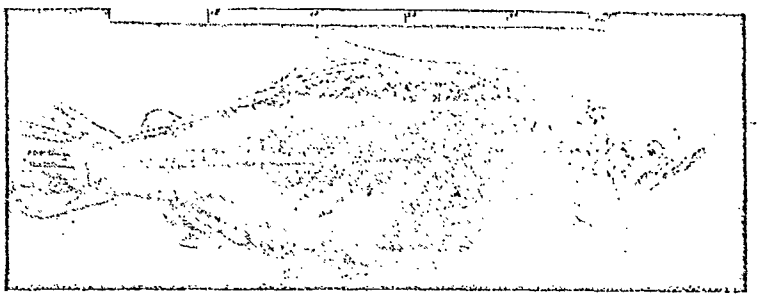
Note: The snout of the mature male is distinctly hooked. The teeth on both jaws are much larger than in the female. The four front teeth on the lower jaw are especially large and hooked.



産卵床に到達せる際のサクラマス雄魚の体鱗（半ば吸収欠損す）（原図）

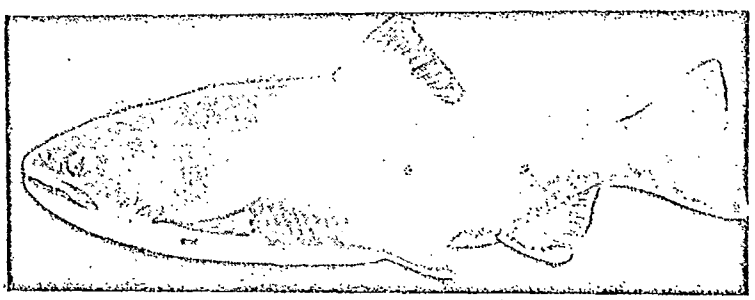
Scale of male cherry trout which has reached spawning ground. (Half of scale is absorbed or missing.)

Forms of cherry trout with unusually great body heights occur, known as itamasu or taikomasu. Some scholars regard these as separate species. However, a study of their development as reflected in their scale patterns by Mr. Isokichi Ono reveals that during the first year when they live in rivers, they resemble cherry trout, but in the second, or ocean-dwelling year they experience rapid growth. The itamasu depicted here appears to live in a habitat different from the ordinary cherry trout, since they are caught only in set nets rather far from the shore. (10)



日高国幌泉にて採捕せるサクラマスの異型イタマス（雄魚）
（大野緑吉氏原図）

Male itamasu, variant of cherry trout, caught at Hidaka-Kunihoro
(Illustration from I. Ono)



琵琶湖に移殖せるサクラマスに現われたイタマス
型の個体　　（青木三雄氏原図）

Itamasu specimen occurring among cherry trout transplanted
to Lake Biwa. (Illustration from M. Aoki)

Such tall specimens also occurred among adult cherry trout transplanted and raised in Lake Biwa. One specimen is illustrated here.

4. Morphology of the river form yamabe or yamame

In late autumn roughly equal numbers of males and females hatched from cherry trout eggs placed in the upper reaches of rivers. The fish which surfaced in April and May of the following year measured about 3 mm (11)

in length. They had 8-10 small black parr marks on each side of the sooty brown body and small black dots on the back and along either side of the lateral line. This appearance is characteristic of the yamame or yamabe. At this stage there are some fish in which the gonads are developed and in which the sex can be readily distinguished. In some this is not the case. The former are male yamabe; the latter include female yamabe and fish which will enter the ocean during the following year. The following is a description of a male yamabe, which spends its entire life-cycle in rivers, caught in the Nishibetsu River in Hokkaido.

Body length excluding caudal fin, 3.95 times head length, 4.05 times body height. Head length 3.65 times snout length, 3.65 times eye diameter, 3.40 times interocular distance, 1.82 times maxilla, 2.29 times height of caudal peduncle. Dorsal fin with 14 rays, anal fin with 15, pectoral fins with 14, ventral fin with 9. Scale formula: 24-130-29. Branchiostegals 13. Gill rakers on first gill arch 7 + 10.

Body is long, thin, tapered with more or less uniform curvature of belly and back. Head relatively short, conical, pointed at snout. Space between eyes wide, slightly convex. Preopercles and opercles curved posteriorly. Suborbital area narrow. Oral fissure slanting. Posterior end of maxilla extends well back of posterior margin of orbit. Both jaws are virtually the same length, each with a single row of fine teeth. Teeth few in number. Vomerine and lingual teeth tiny. Nostrils short, opening on a short fleshy tube. Gill slits large. Gill membranes attached through depression below centre of eye.

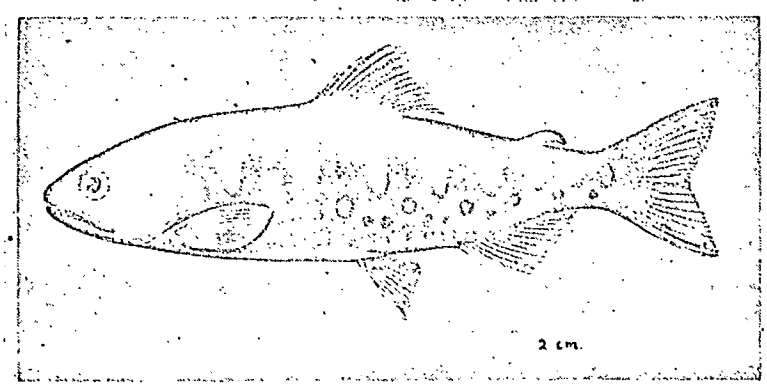
Origin of dorsal fin much closer to snout than to base of caudal fin. Anterior ray(s) largest. Base of fin 1.45 times length of longest

ray. Pectoral and ventral fins comparatively short, with posterior edges of former barely reaching the origin of the latter. Base length 1.88 times length of the longest ray of pectoral fin. Caudal fin forked, with both lobes pointed.

Lateral line straight, running along centre of body. Scales small, adhering to body.

Based on a specimen preserved in formalin, the upper portion of the body is dark blue-grey, becoming paler toward the belly. There is a line of rather unevenly sized black spots on the sides above the (12) lateral line. Near the dorsal line there are similar black markings filling the upper part of the spaces between the small markings. There are scattered irregular-sized round spots on the ventral area below the lateral line. Fine black spots are scattered over the dorsal area. The dorsal fin is grey-black and white on the margin. The pectoral and ventral fins are grey-white; the anal fin is grey, tinged with yellow-green on the anterior margin. The anal fin is grey. When the gonads are mature, the entire body is suffused with sooty-black.

The total length of the fish is 146 mm



西別川産成熟せるヤマベの雄魚（原図）

Mature male yamabe from Nishibetsu River (Hokkaido)

Note: Of 41 male yamabe captured in mid-October 1930 in the Chitose River, Hokkaido, immature gonads were found in 26 (length 87-125 mm) and mature gonads in 15 (length 115-170 mm).

Section 2. Ecological Studies

1. The ecology of seaward-migrating forms

a. Spawning of mature fish and hatching of eggs.

Cherry trout which grow and mature in the sea swim upstream in late spring in the Hokkaido region in which they are found, feeding on the way up from August to October. The fish will use its tail to form a depression in the gravel river bed at a depth of one or two feet in clear, cool water and lay its eggs there. Pairing occurs between one (13) male and one female but, occasionally several yamabe, which have matured and darkened in color, will be observed pursuing a single female, the largest male driving the others off with its tail. A female lays an average of 2,500 eggs. Females, which have finished laying their eggs, and males, which have discharged their milt, are exhausted and spent. The battered bodies drift with the current for a few days before dying.

The fertilized eggs develop eyes after about four weeks at a constant temperature of $8^{\circ}C$ and hatch in two months. Eggs deposited in river spawning grounds under natural conditions require about three months to develop eyes. The newly-hatched fish lurk in the gravelly river bed from late April through early May waiting for their yolk-sacs to be absorbed and when the snows melt and the rivers warm up, they push aside the gravel and rise to the surface near the shore.

b. Appearance of the fry.

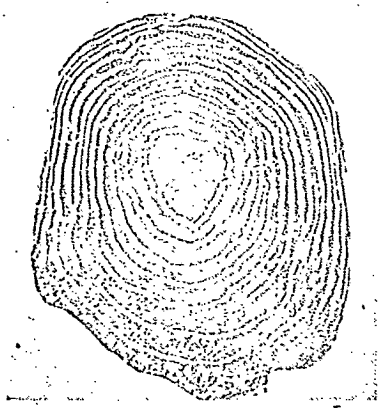
The fry which hatch from eggs laid in the upper reaches of the rivers and streams in late autumn contain about equal numbers of males and females. When they surface toward April and May, they measure approximately 3 cm in length. Eight to ten black parr marks appear on the sooty brown sides of the fish and there are small black spots scattered over the back and other areas. These are the distinctive markings of the yamabe.

游出する稚魚の様相（拡大）（青木三雄氏原図）

Appearance of swimming fry (enlarged) (Photo by M. Aoki)

At this stage, the gonads are differentiated early and the females are distinguishable. In July and August, they reach 7-8 cm and some of the males have rather well-developed gonads and secondary sexual characteristics such as the darker body colour appear. The same phenomenon occurs in the river-dwelling yamame. In the region of Hida- (14)
Takayama they are called kuro-sobu (black sobu) because of the body coloration. The author ascertained that some one-year old yamame have the capacity to discharge milt, on the basis of a specimen captured October 20, 1930 in the Miyakawa river, in the upper reaches of the Jinzu River. The scale patterns show clearly that these are one-year

olds, by the lack of winter bands indicating that they have lived through a winter.



1930年10月20日飛騨宮川上流にて採捕せるクロソブ雄魚の体鱗（原図）

Scale pattern of male kurosobu captured in Miyakawa River, Hida, October 20, 1930.

Thus, while some male one-year olds have mature gonads in the late autumn, the female ovaries are still immature, often difficult for the layman to pick out. This fact accounts for the belief among anglers that yamabe are all males.

In the rivers of Hokkaido, however, neither males or females enter the sea as one-year olds at all but pass the winter in the unfrozen or active waters of the rivers and streams.

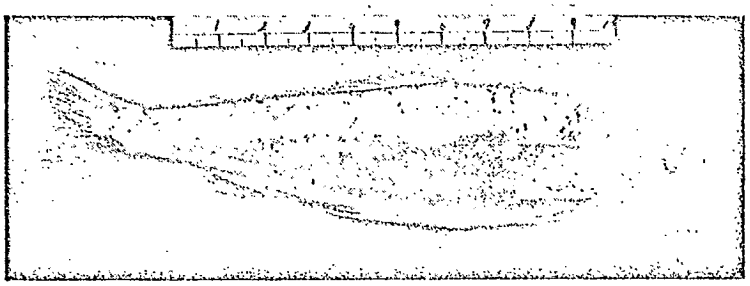
In this case, the fish which live in waters where the temperature does not drop excessively eat but most cease eating during the winter and their growth virtually comes to a stop. Distinct winter bands are visible in the scale patterns.

c. Differentiation of seaward migrating forms.

The young fish which winter in rivers become whitish on the belly and silvery white on the sides toward May of the following spring. Many individuals in which the black spots and other markings have become indistinct appear. When grabbed, the scales come off and stick to the hand. These fish are characterized by the blue-black coloration of the back and the jet-black colour of the tip of the dorsal fin, and are thus readily distinguished from the ordinary yamabe. Mr. Isokichi Ono has (15)

named this form silver yamabe. In fact, the author has caught specimens with jet-black tipped dorsal fins on April 16, 1939 in the upper Kuzuryu River opposite Josho-mura, Ono-gun, Fukui Prefecture.

Yamabe of this type are fish which are just about to migrate to the sea, and include both females, although there are many more females than males. The gonads in either sex are immature.



銀毛ヤマベ（北海道余市町ヌッチ川産）
（昭和7年5月25日採捕）　（大野磯吉氏原図）

Silver yamabe (from Nutchi River, Yoichi, Hokkaido)
(captured May 25, 1932) (photo by Isokichi Ono)

It has already been mentioned that Jordan & McGregor mistakenly regarded a specimen of silver yamabe with a jet-black tipped dorsal fin caught in Miyako Bay as a new species and gave it the name of Oncorhynchus ishikawae.

The fry of chum Oncorhynchus keta (Walbaum) and pink salmon Oncorhynchus gorbuscha (Walbaum) both migrate seaward. When they are about to migrate and while they are still living in the rivers, their sides become silvery-white and the back becomes pale grey. Dr. Ishida mentions that the amemasu (Salvelinus leucomaenis (Pallas)) of Sakhalin includes both seaward-migrating and river-dwelling forms and states that

the young seaward-migrating fish are characterized by a very pronounced black coloration on the tip of the dorsal fin and the posterior margin of the caudal fin is rimmed with black. It is not known why the dorsal fins of the seaward-migrating forms turn black but the same feature occurring in the young of similar salmonid young which migrate to the sea must be a very significant characteristic of the group. (16)

The fact that seaward-migrating forms all have jet-black tipped dorsal fins and silvery white sides is shown by the fact that all the trout fry caught in set-nets at the river mouths from late May through the middle of June share these characteristics. In spite of the fact that the yamabe collected by the author from the Tarampo River on the west coast of Sakhalin in late July of 1930 were all of the ordinary type, the majority of specimens captured in the same place in June of that year were silver yamabe, with jet-black tipped dorsal fins. This would bear out recent information. Mr. Isokichi Ono has conducted some experiments on the seaward-migratory characteristics of the silver yamabe, with its black-tipped dorsal fin, at the Salmon and Trout Hatchery at Nishibetsu, Nemuro. The results are summarized below.

When he visited the hatchery in May of one year, he noticed that many yamabe, with the characteristics of seaward-migrating forms, were forming schools in the enclosed ponds. He opened the metal screen which blocked passage to outside. There are those who believe that the silver yamabe ascend rivers from the sea in early spring, but that theory is clearly disproven by the fact that silver yamabe brought up in ponds with no access to the outside, race outside and downstream as soon as the door is opened. Naturally, some of the ordinary yamabe also swam

downstream, but the percentage was 87.3% for the silver yamabe and 12.7% for the ordinary form.

Every year around the middle of May great numbers of silver yamabe are taken in the neighborhood of the Nishibetsu Fish Hatchery, in the upper reaches of the Nishibetsu River. By the end of the month, the fish have virtually disappeared there, but there is a fishing spot about 24 miles downstream. This fact also indicates that the silver yamabe proceed downstream with time.

There is no question about the fact that, perhaps stimulated by some factor accompanying the development of the gonads, some fry which spring from the eggs of cherry trout develop black-tipped dorsal fins and are differentiated as silver yamabe and show a strong propensity (17) to migrate to the sea. If these fish are prevented from migrating seaward and constrained to stay in fresh water for a long period, what would happen? This was another reason for the Nishibetsu Hatchery experiments. Twenty-four silver yamabe which appeared in the trout ponds were transferred to hatching tanks and raised there. Observations on them and on those in the ponds were initiated simultaneously on May 30. On June 15, the hitherto dark, heavy silver coloration faded (pronounced in fish over 15 cm in length) and on June 30, with the exception of 3-4 fish under 12 cm in length, the silver coloration had largely disappeared and the fish in the hatching tanks resembled those in the ponds. Many of the silver yamabe of both sexes in the trout-culturing ponds prevented from descending rivers died.

The scale patterns show that most of the seaward-migrating yamabe are two-year old smolts, with a very few three-year olds. These are all

females, virtually never males. The silver yamabe raised while confined to the ponds of the Nishibetsu Hatchery included three- and four-year olds of both sexes but the gonads of all of them were immature. Apparently for seaward-migrating fish to be differentiated in fresh-water it is a necessary condition in either sex that the gonads remain immature.

The female cherry trout, which must produce immense numbers of eggs to guarantee the preservation of the species, do not have the chance for their gonads to develop fully if they remain in the rivers for long and they must migrate to the sea where food is abundant. The males, on the other hand, live in the rivers for one year and mature sexually while still retaining the yamabe form. The body coloration turns rusty and they acquire the ability to reproduce. Thus, they do not need to migrate to the sea, and they do not take on the characteristics of the silver yamabe. These factors explain why there are many males among the yamabe that spend their lifetimes in rivers and a majority of females among the seaward-migrating silver yamabe.

d. Growth of the seaward-migrating form.

The yamabe migrating to the sea from mid-May through early June are caught together with salmon in coastal set nets near the river mouths throughout June. The author obtained silver yamabe caught in (18)
set nets opposite Hidaka-Uraga-machi through the courtesy of Mr. Ono. The females measured 156-234 mm, the males 147-159 mm in length.

After entering the sea, the cherry trout, like the other salmonids, does not wander far but grows at a suitable depth offshore and after spending a winter returns upstream, reaching the spawning grounds in

time to spawn in late autumn. As evidence of this, 2-year olds of about 300 mm length are caught all along the coast in October-December. The height of the fishing season in Hokkaido is from mid-May, when the cherry trees are in bloom*, through late June. The fish caught are mature, measuring 400-500 mm. They have lost the markings of their immature stages and the back is pale black; the sides are silvery white and at the tip of the dorsal fin a black smudge marks the traces of the jet-black spot characteristic of the silver yamabe.

The proportion of females among mature cherry trout is similar to that among silver yamabe. The females vastly outnumber the males. However, the stream-ascending period is more or less identical. Each year at the beginning of May, both sexes feed and ascend the rivers. This migration reaches its peak in July-September, at which time the gonads have still not matured. As the fish approach their spawning grounds, the coloration makes a complete change from that of the marine stage. Both sexes have bright mating coloration and the appearance of secondary sexual characteristics has already been mentioned.

e. Scale patterns of cherry trout.

Scales begin to form on cherry trout fry when they reach about 3-3.5 cm in length. Initially, irregular rings form around the centre of the scale. As the fish grows, these become a series of concentric annuli. The table below shows the relationship between body length and the number of scale annuli on yamabe yearlings caught in late October

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*To the Japanese, this indicates the season. In Tokyo they bloom a month or so earlier. It rarely snows after the cherries bloom and spring has arrived. - Translator

1930 near the Chitose Egg-Collection Station in Hokkaido.

Table 1. Relationship of Body Length and Number of Annuli in Yamabe Yearlings

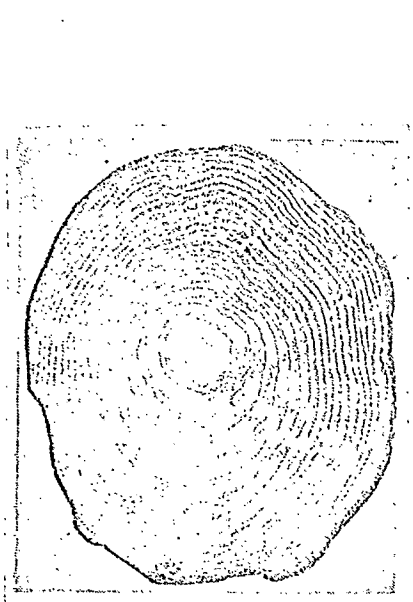
a. Females

Length	87-90	91-100	101-110	111-120	121-130
Avg. no. of annuli	10.1	11.2	11.9	13.6	13.5

b. Males

Length	84-90	91-100	101-110	111-120	121-130
Avg. no. of annuli	10	11	12	14	14

(19)

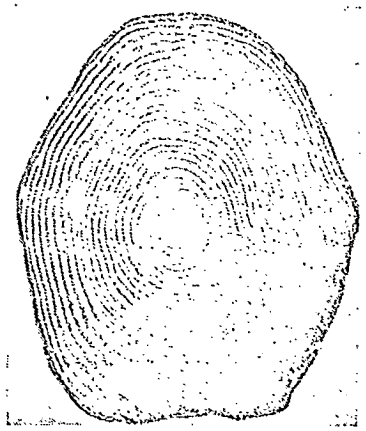


ヤマベ雌魚1年仔の体鱗
(体長128m m) (原図)

Scale of female yamabe yearling (length 128 mm)

Winter bands begin to form on the scales of the yamabe in October and November and final annulus formation takes place from February through March. The number of annuli is strongly affected by the rate of growth, as determined by water temperature, available food and other factors. In an adverse environment growth is poor and the number of annuli will be small. When the winter bands are completed and the water becomes warmer in the spring, growth speeds up and the distance between annuli widens. Formation of spring bands begins. Around the time that

the seaward-migrating cherry trout of both sexes turn to silver yamabe, the newly appeared annuli number 5-8 and the space between them is markedly greater than in the first-year rings. This makes the first-year portion appear as a pronounced "core area". At this point it should be noted that until the complete formation of the winter bands, the scales appear oval in shape and the rings surrounding the central core are continuous. However, when the second summer band is formed, the exposed part is unusually elongated and the scale itself is irregular in shape, like an elongated ellipse. The annuli forming the summer band are broken at the posterior edge, to the extent that the annuli on the exposed portion are detected only with difficulty. As soon as the fish migrate to the sea, feeding conditions improve and the separation between annuli increases rapidly. Eventually a second winter band is formed while they live in the ocean but the number of annuli this time is much smaller than in the first winter band formed in river waters. After forming a second spring band in the sea, the fish start their spawning migration in the late spring of the next year. The three-year olds approach the coast. As they begin ascending the rivers, the exposed part of the scale is absorbed or lost and a microscopic examination of the scales of

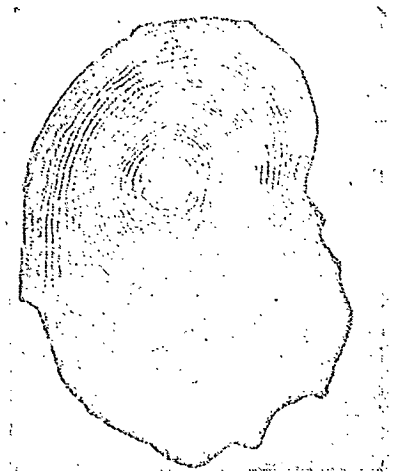


ヤマベ雄魚2年仔の体鱗
(体長170mm, 冬帯1個) (原図)

Scale of 2-year old male yamabe (length 170 mm, 1 winter band)

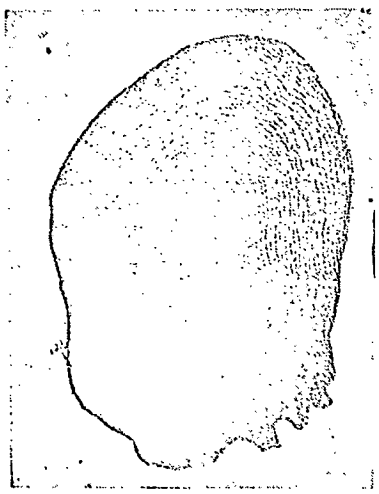
(20)

fish on the way to spawn reveals that the complete scale pattern is difficult to detect.



昭和７年７月下旬日高浦河町地先で採捕せる降海銀毛ヤマベ雌魚の体鱗（原図）

Scale pattern of female yamabe caught late July 1932 near Hidaka-Uragamachi



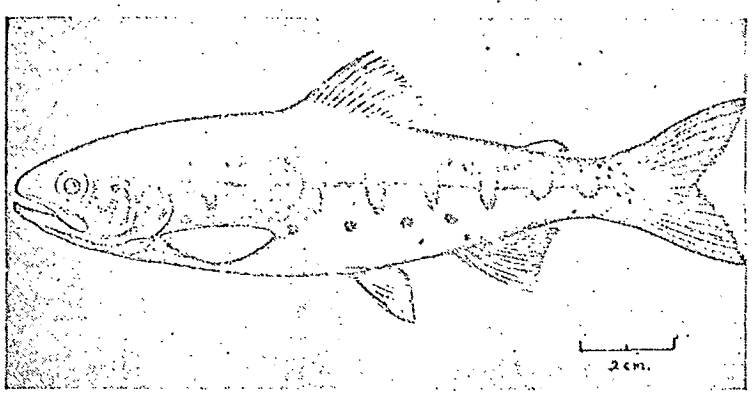
晩春の候北海道余市の沿岸にて採捕されたサクラマス親魚（雌）の体鱗銀毛ヤマベとして降海した際の河川生活を示す部分が核心部に嵌合している（原図）

Scale of adult cherry trout caught in late spring off Yoichi, Hokkaido. Core portion embedded in area indicating river-dwelling period after silver yamabe migrates to sea.

2. The ecology of river-dwelling forms (21)

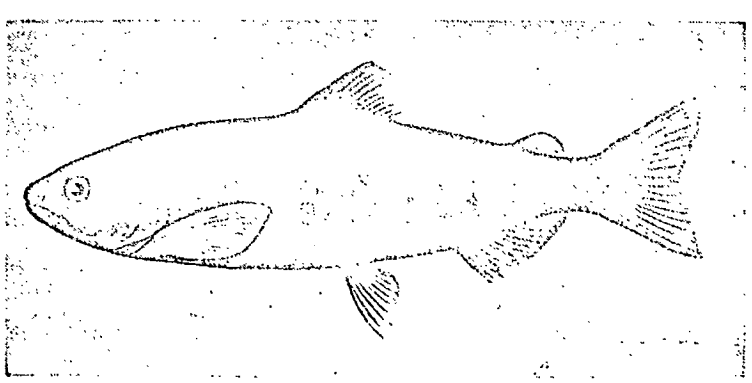
a. Development of immature fish.

Young cherry trout which live in rivers and streams and do not migrate to the sea reach a length of approximately 120 mm as one-year olds (yearlings) and 200 mm as two-year olds (smolt). The rate of growth shows marked variations depending on environmental conditions.



利根川（水上）にて採捕せる未熟ヤマメ雌魚（２年魚）（原図）

Immature female yamame (2-year old) captured in Tone River

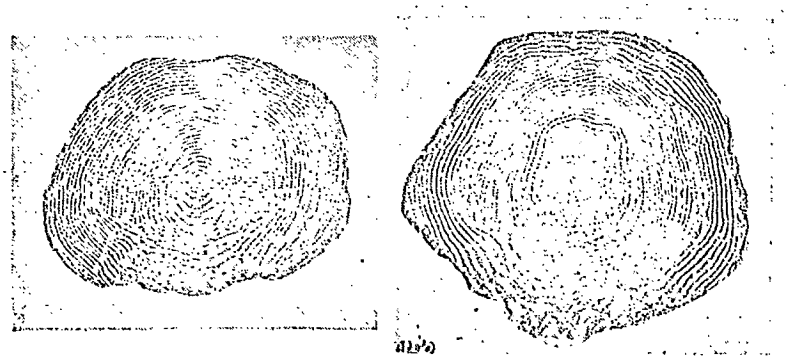


ヤマベの成熟せる雄魚（２年魚）北海道千歳川にて10月下旬採捕（原図）

Mature male (2-year old) yamabe captured in late October in the Chitose River, Hokkaido

River-swelling fish more than two years of age change colour in April or May. The sides are tinged with a yellow-gold colour and the belly turns silvery white. Fine scarlet lines appear on the outer margins of the caudal and anal fins and above the lateral line. However, no jet-black markings are found on the tip of the dorsal fin. When the (22)
gonads mature in summer or autumn, the coloration described above is lost and the entire body is suffused with sooty black. Thus it is that the female cherry trout arriving at the spawning grounds are followed by rust-coloured 1 or 2-year old males.

The eggs carried by the largest of the female yamame or yamabe propagating in the upper reaches of the rivers number approximately 200 and are much smaller than those of marine cherry trout. Cherry trout which swim upstream from the sea die and drift downstream shortly after spawning is completed. However, river-dwelling yamame or yamabe recover their vitality after reproducing for the first time to mature and propagate again in autumn of the following year. The scale patterns shown here clearly indicate that the scale lost during the first spawning season is regenerated and embedded in the scale which is once more eorded.



11月初旬箱根石原早川上流にて採捕せるヤマメ熟魚の鱗相
(2回成熟の状態が明瞭である) a. 雌魚 b. 雄魚 (原図)

Scales of mature yamame caught in upper Hayakawa River, Hakone-sen Ishihara in early November. (Clear evidence of two maturation stages) a. Female. b. Male.

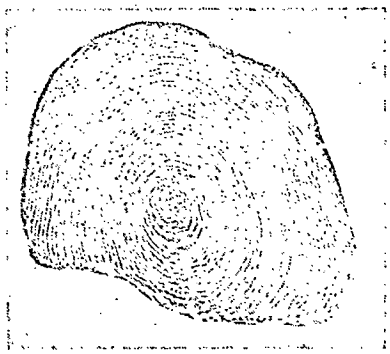
It has already been mentioned that some people around the rivers of Hokkaido, where the seaward-migrating forms live, believe that yamabe are always male because most females migrate to the sea while the males are river-dwelling. However, in the rivers of other parts of Japan, inhabited only by yamame, males and females are found in roughly equal numbers.

b. Cherry trout in lakes.

The growth of cherry trout which spend their entire life-cycle in freshwater is stunted, in comparison with that of cherry trout in the sea. Some are thought to mature while retaining the appearance of juveniles, like yamabe or yamame. This is only half the truth. In relatively deep waters where food is plentiful, there appears to be no question that they will attain about the same size as the ocean-dwelling forms. In November 1922, 136,000 juvenile cherry trout hatched from eggs from the Shiribetsu River in Hokkaido were released into the pure freshwater Lake Biwa. Subsequently 547,680 were released in 1926 and another 373,738 in 1930. After 1926 large numbers of unusual trout were captured from the lake, mixed in with the ordinary species from the lake which the author calls Biwa trout or Oncorhynchus rhodurus Jordan & McGregor. At the request of the late Hikoshiro Kobayashi of the Shiga Prefectural Fisheries Experiment Station, the author went to examine an adult fish caught there. The fish, of unprecedented size, was unquestionably a cherry trout. The scale patterns showed the characteristics of cherry trout. However, while it was not much different in size and appearance from ocean-dwelling forms, there were many more annuli and

much closer together than in the marine form. Since there were two winter bands, the age of maturity was the same as in the sea-dwelling fish.

Since the lake cherry trout and the usual Biwa trout appear quite different, they can both be distinguished at a glance. Not only has the catch of lake-dwelling cherry trout expanded rapidly, but with the advent of lake-stocking with juveniles raised from eggs of the parent species, the lake-dwelling cherry trout appear on the verge of overwhelming the original species. The fishing people along the shores of the lake are enthusiastic about the increase in cherry trout, which is larger than Biwa trout. (24)



琵琶湖に放流せる桜鱒幼魚の成熟せる親魚の体鱗（露出部殆ど吸収缺損，環状線の間隔海産のものより著しく狭し）（原図）

Scale pattern of adult of cherry trout released as juvenile in Lake Biwa. (Most of exposed part absorbed annular separation markedly smaller than marine forms.)

琵琶湖に成育したサクラマス雌魚（未熟魚）（青木三郎氏原図）

Female cherry trout raised in Lake Biwa (immature)
(Photo by Mr. Saburo Aoki)

On the basis of the facts presented, it may be that the cherry trout was originally a freshwater fish which acquired the characteristic of migrating to the sea to forage for food, once presented with the opportunity. Thus, while some people maintain that the yamabe or yamame of the rivers and streams is the land-locked form of cherry trout, the author does not think this theory is justified.

The kokanee or kabacheppo is derived from marine sockeye salmon Oncorhynchus nerka which ascended rivers to spawn and found the return cut off, becoming land-locked. This is why, if they are released in lakes from which the route to the sea is readily open to them, they all rush off to the ocean. The seaward-migrating yamame or yamabe, however, will look askance at the path to the sea until the proper season arrives. This is why they cannot be considered properly a land-locked form of cherry trout.

Chapter II

Studies on Taiwan Trout

Section 1. Historical Considerations

(25)

Very few people imagined that a cold-water fish like the trout would be found in tropical Taiwan but while the author was studying under Jordan at Stanford University in the U.S. in 1917-1918, he received the surprising news from the late Takeo Aoki,who had been the author's assistant when collecting fish in Taiwan, that a specimen, caught by a policeman in the Chungyang Shanmo (central mountain chain) of Northern Taiwan, had been sent to his office during his absence.

In July 1917 Aoki had just arrived in the interior for the purpose of collecting freshwater fish when he heard from an officer Tomomatsu Tsuzaki of the Shikiran station that in the uppermost reaches of the Tachia River, which originates near the western part of Piyanan*Pass and flows down the western slope of the Chungyang Shanmo, there was a fish resembling the Japanese yamame, which the natives caught by hand for food. The fish was said to have rows of small black spots on the sides and to be amazingly tasty. It lives in the Shikayabu and Saramao regions 7,000 ft above sea level and not only are these areas inaccessible during the winter because of the heavy snowfall, but the Taiyal tribe which inhabits the region is one of the most savage in Taiwan, making the area unapproachable for most people. Consequently, Aoki asked to have the fish sent to him if the opportunity presented itself to catch (26) one and on October 15 of the same year officer Tsuzaki, keeping his promise, obtained one of the strange fish from a native and, lacking preservatives, packed it in salt and sent it on. Since the method of

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*Geographical names, such as Shikiran and Piyanan in this paragraph, are the names used by the Japanese when Taiwan was a part of the Japanese Empire. Maps no longer identify them in this fashion, and they are given here only in transliteration.

preservation was inadequate, the precious sample was in rather poor condition when it arrived, but it was still good enough to determine its characteristics. Obviously it was a male freshwater trout. As it was mature, the edge of the mouth was markedly curved and the coloration of the body had darkened.

Together with a report on the discovery of the fish, Aoki sent a brief description, which is how it came to the attention of Jordan, but according to him, "There shouldn't be any such cold-water fish as trout in the tropics of Taiwan." Wasn't it salted? The Japanese often pack salmon and trout in salt and ship them long distances for food purposes. This fish was probably being sent up to the mountain tribes. The boat overturned and the salted goods were washed overboard and a native picked the fish up later. Jordan did not accept the author's report. When the author finished his studies and returned home he found, not a fish salted for food, but a real Taiwan trout on his laboratory table. Aoki said that when the fish had arrived from the interior of Taiwan, he thought he remembered it having scarlet spots on the sides. The author studied its characteristics carefully, appended Aoki's remarks, and sent it along to Jordan with an illustration, saying that there really existed a Taiwan trout. Jordan retracted his previous statement and acknowledged this astonishing fact. Together with the author, he presented a paper on it (Proc. Acad. Nat. Sci. Phila., 1919, p. 122) and gave the hitherto unknown species the scientific name of Salmo formosanus Jordan & Oshima. It was speculated that during the time that Taiwan had been connected to the mainland of China, the fish had come down from the north and remained isolated in Taiwan ever since.

The number of rays in the fins and other characteristics were totally unlike those of

Salmo (Salmo) leptosoma Bleeker

Salmo (Salmo) pomatops Bleeker

which Bleeker had described earlier from China proper, so this species was a completely new one.

The specimen was contributed to the Academy of Natural Science in the U.S. and the need for a second specimen was felt. With the intention of following the Tachia River up to the habitat of the Taiwan trout near Saramao, the author went as far as Wushe in March 1919. Due to unrest among the natives at the time, it was impossible to penetrate any farther into the interior. However, when it was reported (27) that one Taiwan trout was being kept in a pond at the Saramao police station, the author obtained it through the graces of Chief Nagasaki of the Wushe Station. It was a young fish, measuring only 148 mm in length, with distinct rows of small black spots along the sides and scatterings of black dots above and below the lateral line, thus closely resembling the yamame or yamabe of Japan proper. This was the second time a Taiwan trout had turned up and a photograph of it was carried in No. 151 of the Taiwan Nojiho (Taiwan Farming Report). Three similar specimens were later obtained, which had been displayed at the Nantou Commercial Exhibition. One was sent to Stanford University, one to the Chitose Hatchery in Hokkaido, and the remaining one was kept at the Taiwan Government General Research Institute. After the Second World War, there was no way of knowing what happened to the specimen left in Taiwan.

In Jordan and McGregor's paper, which plunged the scientific names

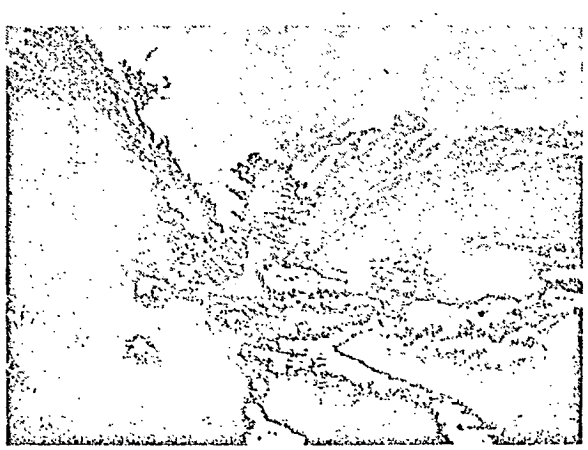
of Japanese salmonids into terrible confusion (Mem. Carneg. Mus., Vol. X, No. 2, 1920), they apparently regarded the Taiwan trout sent to Stanford by the author as an immature fish and stated that it was closest to a Japanese amago or amenouo. This seemed to be based on the mention in the report on the first discovery of the fish that there were vestiges of red spots on the sides of the mature trout. It was reported somewhat later that the geographer Dr. Tadao Kano, surveying the remains of an ancient glacial river in Taiwan's Chungyang Shanmo region, had observed this rare fish when passing through the vicinity of the Taiwan trout's habitat. Since it was reported to have red spots on the sides, the amago theory demanded serious investigation. At that time, an acquaintance of mine, Tsutomu Ninomiya was chief of the police detachment in Taichung Province, in charge of the Tachia river basin where Taiwan trout were found, and he was kind enough to send me a specimen of Taiwan trout from Saramao. The fish that arrived was a splendid male, measuring 260 mm. Its form, colouring, spots, scales, etc. were not like the amago of the Biwa trout group, but very similar to the yamabe or yamame abundantly found from Tohoku to Hokkaido in Japan proper. The red spots fade easily in formalin and a fresh specimen was urgently required if they were to be studied properly. (28)

Ten years or so after the discovery of the Taiwan trout, unrest among the natives in the mountainous regions of Taiwan had abated completely and the opportunity arose to cross to the Chungyang Shanmo. In mid-July of 1935 the author set out to dispel the mystery shrouding the Taiwan trout. From Lotung on the East China Sea Coast, across the Piyanan Pass, the author penetrated the precipitous slopes of the

Chungyang Shanmo as far as the region around the source of the Tachia river. After collecting numerous specimens of Taiwan trout, it became evident that the red spots on the sides of the fish reported by so many people had no basis in fact. This rare fish was not a new species but was identical to the yamabe or yamame indigenous to Hokkaido and its proper scientific name ought then to be Oncorhynchus masou (Brevoort).

Section 2. Physical Geography of the Habitat

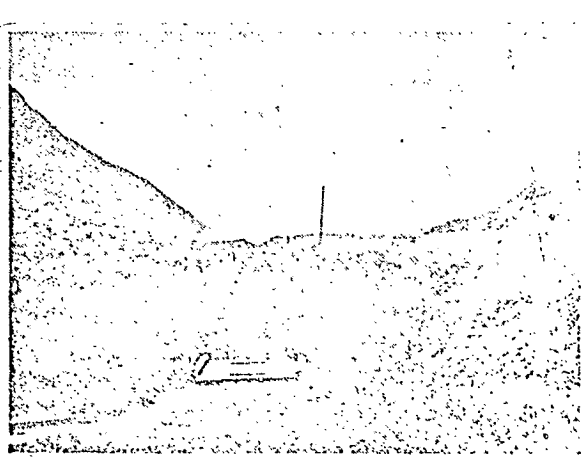
The Tachia River, where the Taiwan trout -- known to the natives as bumban -- lives, has its source in the Piyanan Pass in the north-eastern part of the Chungyang Shanmo, whence it flows southwest through the narrow highland region, 5,000 ft. above sea level, between the Shirubiya Mountains and the Chungyang Shanmo as far as Kueiyang and then around the foothills of Pahsienshan, forming a rather deep and narrow valley, to Tungshihchieh. It then turns west and flows between the towns of Tachia and Ch'ingshui into the Taiwan Straits.



台湾鱒が棲息する大甲渓の最上流（ピヤナン峻部を
越えてシカヤウ社に向う途上）　　（原図）

Upper reaches of Tachia River where Taiwan trout lives
(Heading toward Shikayau Temple just beyond Piyanan Pass)

More specifically the origin of the river is in a small valley at 6,000 ft. above sea-level in the hills west of the site of the Piyanan Station during the time of the occupation of Taiwan. The river flows gently through the Piyanan highlands dotted with green grassy hills to the southwest. The width of the river where it passes the station is only several feet. This knee-deep, cool stream murmurs its way through the grassy meadows, an unsurpassed environment for cold-water river fish. Piyanan is 6,222 feet above sea-level. Still, anybody would be astonished at the ever-changing aspects of the scenery as one leaves the region of Lotung on the coast of the East China Sea, passing through Meilang, Ekiju, Tulung, climbing the steep slopes covered with luxuriant broad-leaved trees and through the pass to gaze out over the slopes of the western Chungyang Shanmo. Daihasen-zan looming to the northwest and the mountains of the Shirubiya range form a cloud-mantled mountainous chain. Looking to the southeast, Nanhutashan, as high as Fuji, stretches out at one's feet, covered with thick forest, untouched by the woodsman's axe for centuries.

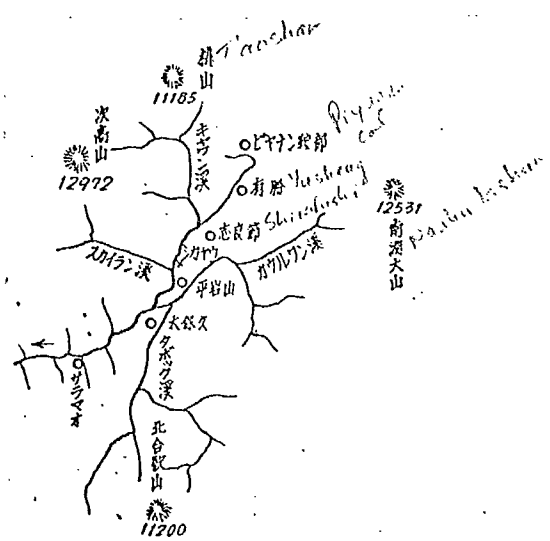


ピヤナン鞍部を東より西に越えた直後の景観（原図）

View just after crossing Piyanan Pass from east to west

Surrounded on all sides by this succession of hills, the Kawanau River, as the uppermost reaches of the Tachia River is known, flows along like the very embodiment of tranquility through the meadows. This region has been the dwelling place of the Taiwan trout probably since the Third Century. But as one proceeds, the Kiyawan River, flowing down from T'aoshan, the Sukairan River, which has its source in the towering peaks of the Shirubiya mountains, the Kaurawan River, flowing down from Nanhutashan, come together with other streams and are suddenly transformed into the most raging river in Taiwan, the Tachia River, which etches deep narrow valleys into the land until it finally rushes out into the western plains. (30)

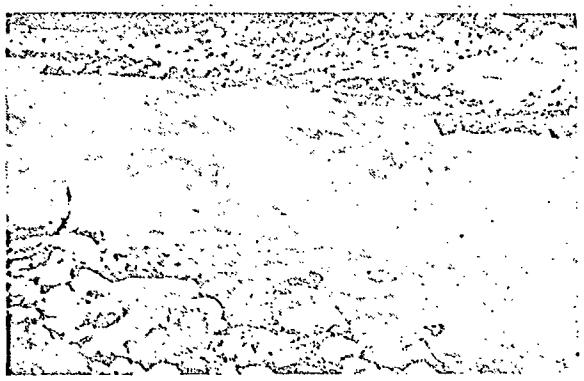
In the vicinity of Yusheng, about 1 ri 8 cho (approx. 2 1/2 miles - Trans.) from Piyanan Pass and at an altitude of 6,000 feet above sea level, the river broadens a little bit. In this area the river bed is flat and covered with fine sand. Some small rocks make the current flow faster around them.



大甲渓上流略図（原図）

Upper Tachia River

The water temperature on noon of July 23, when the author passed by, was 16.1°C, making the area ideal for the spawning of Taiwan trout. In late autumn, the adult fish which have been hidden away in the gorges downstream are reported to band together and ascend the river. In the vicinity of Shirafushi, over 1 ri 9 cho (more than 2 1/2 miles) from Yusheng, the river is joined by the Kiyawan River which flows down from the direction of T'aoshan (alt. 11,185). At the confluence, the riverbed is 5,300 feet above sea level, forming a small canyon far below the level of the road. Advancing another 1 ri 9 cho up the moderately sloping mountain path from Shirafushi, one finds Pingyanshan Station, which used to be a police outpost in the native region, and farther down a 4 cho (475 yds.) steep slope is Shikayau Shinsha. From a point 8,200 ft. above sea level in the southern foothills of the steep Shirubia mountain, the Sukairan River joins the other rivers. The river (31) bed in this region is 5,050 ft. above sea level, 1000 ft lower than at Piyanan Pass.



シカヤウ新社附近にてスカイラン渓の水を併せた
大甲渓本流（台湾鱒多数を採捕）　（原図）

Tachia River joined by waters of Sukairan River near Shikayau Shinsha (many Taiwan trout caught here)

The rivers are joined 25 cho (approx. 1 3/4 miles) downstream by the Kauruwan River, flowing down from Nanhutashan (12,331 ft.), and the Tabokku River, flowing down from Fanghekuanshan (11,200 ft.) in the south. Proceeding downstream, the amount of water and the current strength gradually increase until, in the area of Pisutan, Kozawa-dai and Wulai, they form mighty gorges and the river takes on all the characteristics of the rushing Tachia, as it races toward the table-land in the west. (32)

大甲渓本流とカウルワン渓との合流点（これより下流に台湾鱒を見ず） （原図）

Confluence of Tachia River and Kaurawan River (Taiwan trout not seen farther downstream than this)

The author's own investigations found no Taiwan trout in the main course of the Tachia River downstream from the junction of the Tabokku River or in the tributaries joining it (the Tachia) farther down. Taiwan trout were caught in nets or weirs in the Kauruwan, Tabokku, Sukairan, Kiyawan Rivers and the Tachia River upstream of Shikayau Shinsha. Immature fish of the type known as yamame in Japan inhabited the small streams around Piyanan Pass in large numbers. The greatest

number of adult fish were found in the Sukairan and Kiyawan Rivers, while rather full-grown 2-year olds were taken abundantly in the Kauruwan River. Perhaps because of the stronger current and the slightly higher temperature (17.2°C below the confluence of the Tabokku River, the only species of fish which were collected were the mikanoo*, Scaphesthes tamsuiensis Oshima, and the shiyāsun*, Acrossocheilus formosanus Oshima, but not a single Taiwan trout.

As mentioned already, the adult Taiwan trout migrate upstream to the vicinity of Yusheng on the Tachia River to spawn. Ordinarily, the adult fish are not found in shallow streams. Rather they appear to swim in the deep gorges of the Sukairan and Kiyawan Rivers.

The average sizes of specimens captured by the author were 115 mm for both male and female 1-year olds, 214 mm for female 2-year olds and 229 mm for male 2-year olds. All of the 2-year olds were captured in the Sukairan and Kiyawan Rivers. Just as the only ayu or sweetfish in Taiwan are found in the upper reaches of the freshwater Hsintien River, which traverses the city of Taipei, Taiwan trout are confined to the high waters of the Tachia River. Many Taiwanese rivers spring from elevations of 10,000 feet or more and contain cold water, ideal habitats for salmon, but the riverbeds are all precipitous, occasionally with plunging waterfalls, (33) and none has the quiet flow of cool water suitable for spawning and the growth of young trout that the upper Tachia River has. It is exceedingly interesting that the cherry trout which currently inhabit tropical Taiwan first arrived during the Ice Ages and, finding a suitable environment to live and propagate only in the headwaters of the Tachia River, survive there to this day.

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*Native Taiwanese names - Trans.

Section 3. Morphology of the Taiwan Trout

It has long been disputed whether the yamame, the freshwater form of the cherry trout which occurs throughout Japan, and the amago, the fluvial form of the Biwa trout, belong to the same or different species. On the basis of scale patterns and the coloration of the spots along the sides of the body, the author maintains that they are of differing species. The immature cherry trout have black spots scattered along their sides, while the Biwa trout young have brilliant red spots on their sides. Some scholars maintain that these are aberrant features caused by the environment and as such cannot serve as taxonomic characteristics. However, when eggs of the cherry trout, the parent strain of the yamame, were imported from Hokkaido and eggs of the Biwa trout, the parent strain of the amago, were brought in to the Samashigai Trout Farm in Shiga Prefecture and identical numbers of hatched fish were raised in adjacent ponds of the same size, under identical conditions, observations showed that all of the former grew into black-spotted yamame and all of the latter grew into red-spotted amago. Clearly, red or black maculation is a hereditary characteristic, unaffected by environment. Some scholars also insist that the structure and distribution of growth lines and the shapes of scales are of no value taxonomically but a detailed study by Dr. C. H. Gilbert (Bull. U.S. Fish. Bur., 32, 1912, pp. 1-22, pls. 17) demonstrated clearly that in the case of the salmons, if nowhere else, the study of scale characteristics plays an extremely important role in taxonomy. However, since there are great differences in the scale patterns of immature, mature and parent fish in the same species, observations must take these into

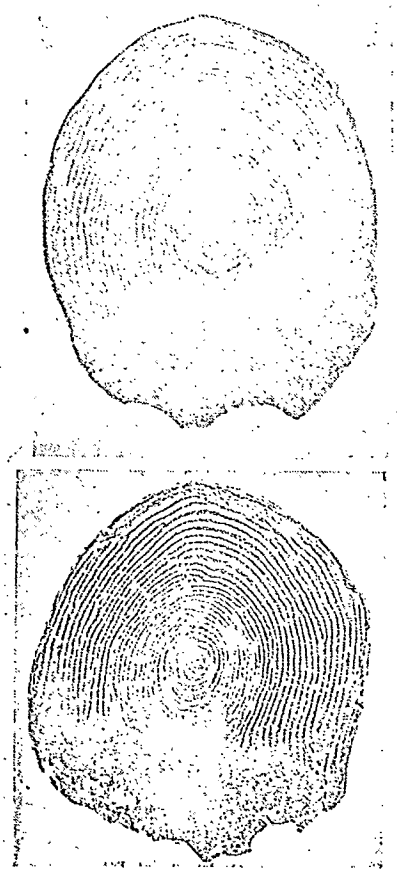
careful consideration.

The confusion over the scientific nomenclature of the Taiwan trout arose because the number of specimens originally available was small and it was difficult to determine the colours and markings of the live fish due to the poor preservation method. Initial reliance on hearsay reports led to confusion. The author went to Taiwan and collected numerous specimens and found the reported red spots to be nonexistent. The young Taiwan trout has small black parr marks on the sides. Black dots are scattered above and below the lateral line and the scale patterns were found to resemble those of the fluvial form of cherry trout. The author concluded that the fish did not belong to a new species but was none other than a fluvial form of cherry trout or Oncorhynchus masou (Brevoort).

If the scale patterns of the 2-year old male and female shown in the illustrations are compared with those of 2-year old yamabe from Hokkaido, one finds them identical. There are 6-7 rings around the nucleus and the outer growth rings are broken at the ends and do not form rings. Another characteristic in common with cherry trout is that there is only one winter band. The following contain descriptions of adult male Taiwan trout. Oncorhynchus masou (Brevoort) Saramao trout, Taiwan trout Salmo masou (Brevoort) Exped. Japan, 1856, pl. 9, fig. 2; Hakodate.

Salmo orientalis Brevoort Exped. Japan. 1856, p. 275 (changed on pl. 9 to Salmo masou, Hakodate) (35)

Oncorhynchus essoensis Hilgendorf, Monatsb. Ges. Ostasien, vol. 11,



昭和10年7月25日採補台湾鱒2年魚の体鱗
上　雌魚（体長232ミ.メ）
下　雄魚（体長272ミ.メ）（原図）

Scales of 2-yr. old Taiwan trout caught 25 July 1935. Above: female, 232 mm. Below: male, 272 mm.

1876, p. 25; Hokkaido; Jordan, Annot. Zool. Jap. Vol. 4, Pl. 2, 1902, p. 70 (in part), Daiya R., Ishikari R.

Salmo macrostoma Gunther, Chall. Rept., Vol. 1, 1880, p. 71, pl. 31, fig. 8; Yokohama Market.

Oncorhynchus masou Jordan & Snyder, Proc. U.S. Nat. Mus., Vol. 24, (in part), 1902, p. 571; Daiya R. Ishikari R.

Salmo formosanus Jordan & Oshima, Proc. Acad. Nat. Sci. Phila., 1919, p. 122; Saramao, Formosa.

Oncorhynchus ishikawae Jordan & McGregor, Mem. Carneg. Mus., Vol. 10, 1925, p. 132 (in part), Hokkaido, Kitakami R., Shibukawa, Toyama, Hamada.

大甲渓のヤマメ（台湾鱒）　（原図）

Yamame from Tachia River (Taiwan trout)

The length of the body excluding the caudal fin is 3.42 times the length of the head and 3.75 times the height. The head is 5.40 times as long as the snout, 6.70 times the diameter of the eye, 3.40 times the interorbital distance, 1.62 times the length of the maxilla, 1.54 times the length of the pectoral fins, and 1.78 times the length of the ventral fin. The dorsal fin has 13 rays, the pectoral fin 13, ventral fin 9, anal fin 14. Scale formula: 25-143-23. Gill rakers of first gill arch: 8 + 11.

The body is somewhat tall, conical in the head region and rather (36)
pointed in the snout. The mouth angle is wide, with the posterior edge of the maxilla extending farther back than the orbit. The interorbital space is broad and convex. Eyes comparatively small, and located in upper anterior portion of head. Nostrils situated between tip of snout and eyes. Teeth on both jaws small and in a single line. Numerous small teeth on tongue surface. Vomerine teeth minute. One line of small teeth on palatines. Preopercle and opercle rounded posteriorly. Gill rakers short and small.

Origin of dorsal fin midway between tip of snout and base of caudal fin. Length 1.78 times length of longest ray. Ventral fin directly below centre of base of caudal fin and with minute auxiliary scales. Pectoral fin large and somewhat rounded. Anal fin triangular with length twice length of longest ray. Caudal fin comparatively large with posterior margin slightly concave. Lateral line straight, running along centre of body.

Upper portion of body blue-black. Ventral portion lead-white. Small round black spots scattered over head and back. Approximately 10

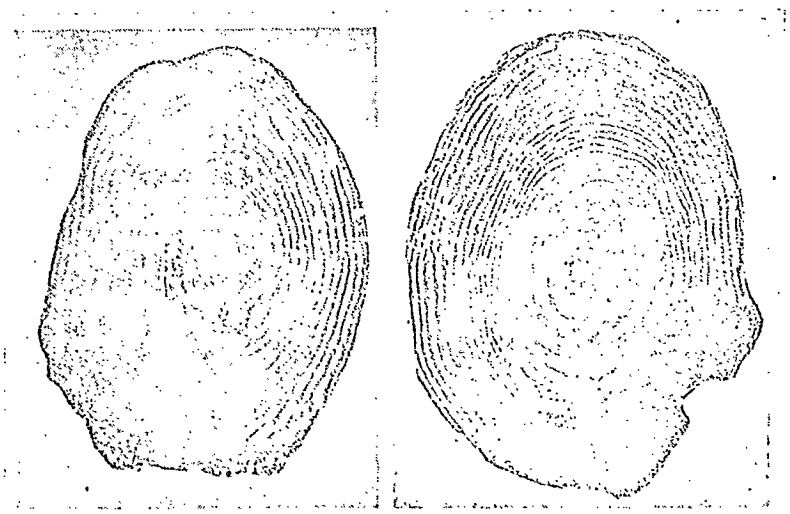
small black parr marks on lateral line. Distinct black dots on lower abdomen. Fins all pale grey. Length 260 mm.

The description above is based on a mature male specimen captured in the vicinity of Saramao in the upper Tachia River in September 1932. (Sample sent by Mr. Tsutomu Ninomiya)

Note: Numerous specimens caught by the author were all of the yamame type, 80-289 mm in length for the males and 110-232 mm for the females. As mentioned before, not a single one of them had red spots on the sides.

Section 4. Ecology of the Taiwan Trout

An examination of the scales of Taiwan trout showed a mixture of 1-year olds with no traces of winter zones and 2-year olds with winter bands, indicating that the fish had lived through one winter. They were collected in July and the scales of the 1-year olds showed the type pattern of cherry trout.



1 年 魚　　2 年 魚

昭和10年7月採捕せる台湾鱒産魚の体鱗（原図）

1-year old　　2-year old

Scale patterns of Taiwan trout captured July 1935

The scale pattern around the time that winter zones appear in 2-year old fish as shown in the illustration is exactly the same as for the 1-year olds. There is absolutely no loss of exposed portions due to having undergone spawning, so these fish are assumed to be ones, which like yamabe or yamame, have lived through one winter to become 2-year olds and will mature in late autumn. However, the scale patterns also show some one-year olds which have matured and show loss of exposed portions of the scales and will pass one winter and enter a second period of maturation. This, however, is an exceptional case: most fish winter as immature one-year olds and mature in the autumn as two-year olds. (37)

Below are the measurements of the author's specimens.

One-year old fish

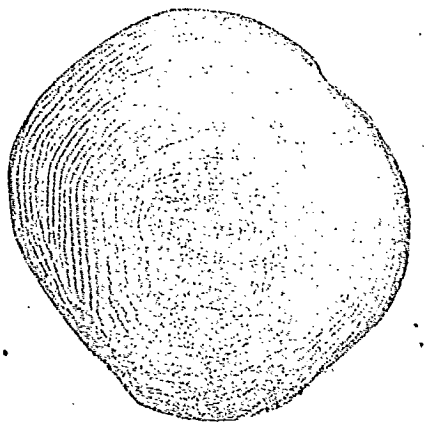
Females	Length	110	111	111	115	116	116	120	122	avg	115
	Height	24	22	27	26	24	28	29	26	avg	26

Males	Length	80	101	102	105	106	108	109	109	116	122	131	132	155	avg 114
	Height	17	23	24	22	23	23	24	25	26	26	30	31	155	avg 25

Two-year old fish (38)

Females	Length	197	209	220	230	232	avg	214				
	Height	45	51	50	56	53	avg	52.5				

Males	Length	200	201	204	220	220	226	230	272	289	avg 229
	Height	48	48	47	53	54	52	47	64	70	avg 54



第一次成熟期を経過せる鱗が嵌合せる
二年魚の体鱗　　(原図)

Scale pattern of 2-year old with incorporated scale from first maturation period.

The figures given above show an average length of 115 mm for females and 114 mm for males and an average height of 26 mm for females and 25 mm for males, indicating more or less identical growth. The yamame of Japan proper has two males forms, one which matures early, as a one-year old in late autumn, and one which matures only in its second year. The same is true of the Taiwan trout. However, the greater number matures in the second year. The females, however, all mature as two-year olds, just as the yamabe or yamame in Japan.

In view of the morphological details presented here, it is thought that cherry trout ascended the Tachia River in an era when cold currents washed the western shores of Taiwan and when geological changes occurred, the fluvial fish found itself locked in a certain ideal environment, where it endures to this day.

Chapter III

Studies on Biwa Trout

Section 1. Taxonomic Studies

a. Discussion of Scientific Nomenclature

The fish which the author designates Biwa trout has always inhabited Lake Biwa. The local people call the adult fish amenouo and refer to the young fish as amago or amego. The fish called kawamasu along the lower Kiso River is a form of the same fish which enters the Bay of Ise and grows in the area around the mouth of the Kiso River. It is said to ascend the river as far as Tekkyo every year around May. Like the silvery yamabe, it loses its immature colouring and assumes a blue-black colour on the back and a silvery whitish tint on the ventral area. The red spots, characteristic of the immature stages, disappear completely from the sides.

The young Biwa trout, like the yamame, has a line of distinct black parr marks along the lateral line, but it is readily distinguished from yamame by the scattering of bright red spots on the sides. No other species of the Pacific Ocean salmon genus Oncorhynchus has these red spots in its immature stages and this feature, as mentioned earlier, is hereditary.

This species is confined to the colder waters of rivers and lakes. Cut off from the deep lake waters, it will mature and enter the spawning stage with its spots and other immature features intact. This is in contrast to the yamabe or yamame of the cherry trout group. It is generally called amago but in Chugoku (western provinces of Honshu) it may be called hirabe or hirame (which means "flounder" in standard Japanese -- Translator) or enoha in Kyushu. Unlike the cherry trout group, this species has no seaward-migrating form with the anterior

margin of the dorsal fin tinged with black.

On the basis of the points brought out in the preceding paragraphs, let us examine Jordan & McGregor's papers on the salmonids of Japan. (40)

On page 127, the name Oncorhynchus rhodurus Jordan & McGregor is given to a 20.25-inch mature male captured in Lake Ashinoko on November 25, 1922. A comparison of this fish with the Biwa trout captured by the author in Lake Biwa shows that they are altogether identical in appearance and there is no question but that the fish described was a Biwa trout transplanted to Lake Ashinoko.

Trout from Lake Biwa have been transplanted to Lake Ashinoko any number of times and it would not be at all surprising to find their descendants still living in Ashinoko. It was a fortunate accident that the Biwa trout, which hitherto had not been given an accurate scientific name, was given this new species name. Salmonids did not originally inhabit Lake Ashinoko, but beginning in the early years of the Meiji period (1868-1912), there were frequent transplants of salmon and kokanee from Hokkaido and Biwa trout, which had been transplanted originally to Lake Chuzenji. These efforts were not rewarded with success, nor could salt-water salmonids be expected to flourish there, and so the fish that Dr. Jordan acquired at Hakone upon his return to Japan could well have been either kokanee or Biwa trout. It does not seem likely that he would have taken the former, Oncorhynchus nerka, for a new species and its characteristics do not resemble those of O. rhodurus. In point of fact, the new species description referred to Biwa trout and it may be surmised that the hitherto nameless trout from

Lake Biwa was captured in a place other than its type locality and given a new scientific name.

With reference to O. rhodurus, Jordan and McGregor write that the fish figured under Jordan & Thomson's name in a report on the fish of Japan (Mem. Carneg. Mus., Vol. 6, 1913, p. 211, pl. 24, fig. 3) was misidentified and was actually the immature form of O. masou. Since the specimen in question was from Lake Chuzenji, the author feels that this correction was probably true. The trout from Echigo-Naoetsu in the possession of Stanford University was also identified as O. Rhodurus, but this was certainly another instance of misidentification of the salt-water cherry trout.

b. Morphology of Biwa Trout, Kawa-masu and Amago (41)

Biwa trout has never been discovered in salt water, with the exception of the area around the mouth of the Kiso River where it empties into the Bay of Ise. It is reasonable to regard the Biwa trout as a freshwater trout which lives in lake Biwa, just as the kuni-masu lives in Lake Tazawa. In cold waters of the proper temperature where food is plentiful, the fish will grow into a fully normal adult, but fish inhabiting the upper reaches of rivers where animal food is scanty will retain their immature features while the reproductive glands mature, in the fashion of the yamabe or yamame of the cherry trout group. Regardless of the easy access to the sea from their river habitats, these fish have no pattern of seaward-migration and such forms do not develop. In this sense, they are unlike cherry trout. In view of the exceptional instance of a seaward-migrating kawa-masu, confined to the region around the mouth of the Kiso River, when the water temperature

drops in the winter, it may well be that the higher temperature of the sea where the rivers glow into it prevents the fluvial Biwa trout or amago from leaving the river.

The following contain descriptions of the appearance of the mature Biwa trout and amago.

Oncorhynchus rhodurus Jordan & McGregor Biwa trout, kawa-masu, amenouo, amago, amego, hirame, hirabe, kin-enoha

Salmo perryi Jordan & Snyder (not of Brevoort), Proc. U.S. Nat. Mus., Vol. 24, 1902, p. 578; Lake Biwa.

Oncorhynchus rhodurus Jordan & McGregor, Mem. Carneg. Mus., Vol. 10, 1925, No. 2., p. 127, pl. 5, fig. 2, pl. 8, fig. 4; Lake Hakone.

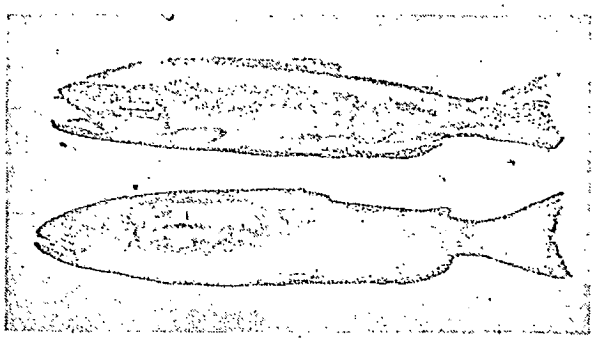
Oncorhynchus macrostomus Jordan & McGregor (not of Günther) Mem. Carneg. Mus., Vol. 10, 1925, No. 2, p. 134, pl. 6, figs, 2, 3; Nagara R., Hiki R., Himeji, Uwajima, Lake Hakone, Lake Biwa.

Oncorhynchus ishikawae Jordan & McGregor (in part), Mem. Carneg. Mus., Vol. 10, 1925, No. 2, p. 132, pl. 6, fig. 1, pl. 13, fig. 6; Lake Biwa, Lake Hakone, Uwajima, Kiso R. (42)

A. Biwa trout

Length excluding caudal fin 4.02 times head length, 4.56 times body height. Head length 6.20 times eye diameter, 3.20 times inter-ocular distance, 3.20 times snout length, 1.65 times maxilla. Dorsal fin 14 rays, anal fin 13 rays, pectoral fin 16 rays, ventral fin 9 rays. 135 scales on lateral line. 12 branchiostegals. 8 + 12 gill

rakers on first gill arch.



琵琶湖産ビワマス 上 雄魚，下 雌魚（原図）

Biwa trout from Lake Biwa. Top: male. Bottom: female.

Body long and thin, very short in height. Head short with conical snout, rounded at front. Maxilla hooked at tip, covering tip of lower jaw. Interocular space broad and convex. Posterior margin of opercle and preopercle curved. Isthmus wide, narrowing beneath the eyes. Maxilla long and thin, with posterior tip extending well behind the posterior margin of the orbit. Vomerine teeth minute and sparse. Maxillary teeth form a single line, becoming larger toward the front. Teeth on lower jaw small and in single line. Teeth on tongue small and arranged in a V, opening to the back.

Lateral line more or less straight, running along center of body. Annuli concentric around core.

All fins small. Origin of dorsal fin midway between tip of snout and base of caudal fin. Shorter than the dorsal fin of the cherry trout and jagged on outer edge. Length 1.42 times the length of the longest ray. Dorsal and ventral fins short. Ventral fin originates (43)
below the base of the caudal fin and is long and thin with pointed

accessory scales. The tip does not reach as far as the vent. Anal fin short with straight outer edge. Anterior rays are long; length of fin 2.50 times that of longest ray.

The specimen preserved in formalin is blue-black on the head and dorsal areas, becoming paler toward the silvery ventral area. There are cloudy green markings on the sides and small black dots are scattered above and below the lateral line. The area between green spots is pinkish in colour. The anal fin is dark brownish grey and milky white at the edge. The caudal fin is grey, with a scattering of small black dots, and white at the outer edge. The adipose fin is grey with small black dots. The inside of the oral cavity is black.

The body is a total of 368 mm long.

This description is based on a mature male captured in Lake Biwa.

B. Kawa-masu

The next description is of a male trout, known locally as kawa-masu, captured in May 1930 in the Kiso River near Sasamatsu after having come upstream from the Bay of Ise. It is the seaward-migrating form of Biwa trout, known to the world on the basis of only a single specimen.

The water temperature at the mouth of the Kiso River in the winter is extraordinarily low and the headwaters are located in a region renowned for its snowfall. Thus, when the water downstream where the amago lives is as cold as the waters of Hokkaido, there is no reason why the fish should not move to saltwater areas, as the silvery yamabe does.

The kawa-masu (the Japanese term translates as river or brook trout, but the Japanese name has been used to avoid confusion with the

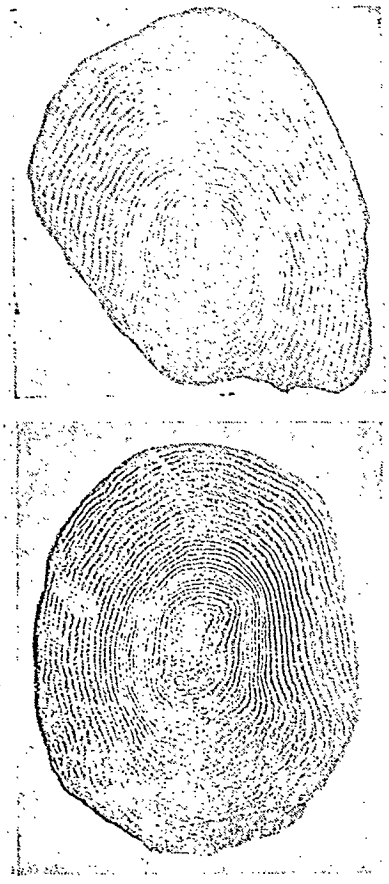
American brook trout Salvelinus fontinalis -- Tran.) poses a number of interesting ecological problems for further study.

The specimens obtained by the author were kept at the Ogaki trout farm and a description of the fish was acquired through the cooperation of Mr. Osamu Hiraki, the chief of the farm, twenty years ago. (44)

The length of the body excluding the caudal fin is 4.15 times the length of the head and 4.50 times the height of the body. The head was 3.82 times as long as the snout, 5.90 times the eye diameter, 2.95 times the interocular distance, 1.76 times the size of the maxilla and 2.60 times the height of the caudal peduncle. The dorsal fin had 13 rays, the anal fin 14, the pectoral fin 14, the ventral fin 10. Gill rakers on the first gill arch: 7 + 10. Scale formula: 30-140-22.

The body is long and narrow; height is short. The head is conical and somewhat pointed in the snout. The end of the maxilla extends far behind the anterior margin of the orbit. The interocular space is convex. The teeth of both jaws are minute, but those of the lower jaw are longer than those of the upper jaw. The vomerine teeth are few in number and small. The posterior edge of the opercles and preopercles are strongly curved.

The lateral line is straight and runs along the centre of the body. Because of reproductive maturity, the exposed portions of the scales are almost totally absorbed, but the rings form distinct concentric circles around the core. To corroborate this, the scale of an immature female caught in the same place on the same day is shown.



木曾川を溯上せるカワマスの体鱗
上 成熟せる 雄魚（露出部欠損）
下 未熟雌魚（環状線同心円を描き確実にビワマスの様相を現わす）(原図)

Scales of kawa-masu which has ascended Kiso R.
Top: adult male, exposed portions missing.
Bottom: immature female, rings concentric, clearly the Biwa trout pattern.

The rings are perfectly concentric and there are no broken rings as observed in cherry trout. Moreover, unlike the young amago which lives in the upper reaches of rivers, this fish appears to have wintered in the river, and after the appearance of winter bands, entered the sea, where it grew very rapidly.

The origin of the dorsal fin is (45)
midway between the snout and the base of the caudal fin. It is rather tall and 1.62 times the length of its longest ray. The pectoral and ventral fins are short, the latter attaching directly below the base of the caudal fin. The accessory scales of the ventral fin are long and narrow, pointed at the ends, and are half as long as the fin. The anal fin is triangular and 2.24 times the length of the longest ray. The posterior margin of the anal fin is semicircular and concave.

The specimen preserved in formalin was blue-black on the dorsal region and silvery white on the ventral area. Small black dots are scattered over the top of the head and the back. Red spots are visible

here and there on the sides. The top of the head is dark grey and the dorsal and anal fins are grey with scattered black dots. The posterior margin of the dorsal fin is pale yellowish white while the adipose and other fins are all greyish white in colour. The length is 308 mm.

Note: The marine form of Biwa trout known as kawa-masu is reported to be fleshier than the lake-dwelling parent fish. Cherry trout raised in Lake Biwa grow to about the same size as those in the ocean. Since river-dwelling amago which happen to swim into the sea grow to about the same size as those in Lake Biwa, the important factor in the growth of all of these trouts appears to be the water temperature and the availability of abundant animal food. Whether the habitat is freshwater or saltwater seems immaterial.

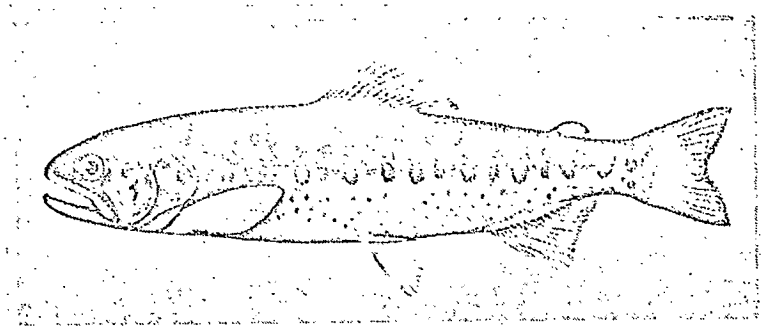
C. Amago

This fish is land-locked in the cold upstream waters of rivers. It is a form of Biwa trout which matures and reproduces while retaining an immature appearance. In the Kansai region it is called amago or amego, in the Chugoku region it is hirabe or hirame, while in some parts of Kyushu, it is called kin-enoha. The following description is based on a female two-year old caught in Sagashio Springs in the upper reaches of the Hikawa River, a tributary of the Fuebuki River, in eastern Yamanashi Prefecture.

The body length excluding the caudal fin is 4.10 times the length of the head and 4.69 times the height. The head is 3.30 times the snout length, 5.90 times the eye diameter, 3.20 times the interocular distance, 1.79 times the length of the maxilla, 1.56 times the pectoral fin, 2.12

times the ventral fin, 2.80 times the height of the caudal peduncle. The dorsal fin has 15 rays, the anal fin 14, the pectoral fin 15, the ventral fin 14. 7 - 10 gill rakers on the first gill arch. Scale formula: 30-130-23.

The body is long and thin. The height is comparatively low, reaching its maximum at the origin of the dorsal fin. The head is (46) conical and rounded at the snout.



笛吹川支流日川（雁坂塩温泉附近）にて採捕せるアマゴの未熟雌魚，
白点は新鮮時の朱色斑点を現わす（原図）

Immature female amago captured in Hikawa -- Fuebuki R. (near Sagashio Springs) White spots are red when fresh.

The eyes are ordinary in size and situated in the middle of the forward part of the head. The tip of the maxilla extends far to the rear of the posterior m rgin of the orbit. The teeth of both jaws are tiny. Palatine and vomerine teeth are small. There are lines of tiny teeth along both outer edges of the tongue. The posterior edges of the pre-opercles and opercles are curved.

Origin of dorsal fin closer to tip of snout than to base of caudal fin. Pectoral fin comparatively small with anterior tip reaching roughly half the distance to the ventral fin. Ventral fin small,

originating below middle of base of dorsal fin. Auxiliary scales narrow and long, pointed at tips. Anal fin roughly triangular, tall, concave posterior margin. Caudal fin comparatively short with posterior margin indented. Tips of both lobes pointed. Lateral line runs straight along the centre of the body.

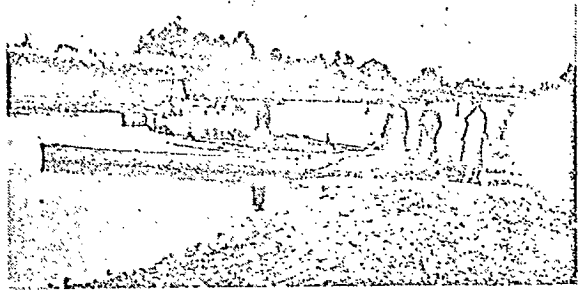
The body is blue-black on the dorsal surface, tending toward grey and then silvery on the lower abdomen. There is a line of 12 small black parr marks along the lateral line but they are rather blurred. Scattered between these marks are small, almost circular black spots. The top of the head is uniformly sooty black. Distinct red spots are scattered over the sides, densely above the lateral line and sparsely below it. The dorsal fin is grey, somewhat paler at the margin. The adipose fin is uniformly pale grey and the caudal fin is dark grey all over, tinged with yellowish red on both margins. The pectoral fins are pale yellow, and milky white on the margin. The ventral fin is almost colourless, with a slight yellow tinge. The anal fin is grey with slight yellow in the middle. The anterior margin is milky white. The total length of the fish is 250 mm.

Note: In addition to the specimen described, eight female (47)
two-year olds (161-219 mm), four male two-year olds (149-185 mm), five female one-year olds (70-96 mm) and thirteen male one-year olds (74-112 mm) were caught. The one shown in the figure is the largest of the female two-year olds.

C. Scale patterns

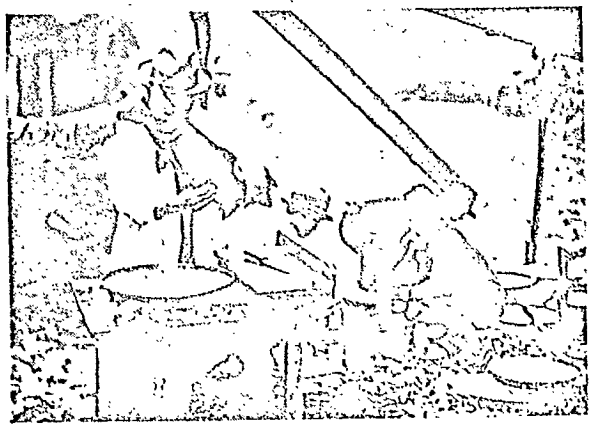
The Biwa trout matures from late October through late November.

At this time, it ascends from the lake depths and approaches the shore. Seeking out the rivers, it swims upstream to spawn. The Shiga Prefectural Fisheries Experiment Station collects eggs at the mouths of (48)



姉川採卵場の親魚捕獲築（最後から３人目故五島清太郎博士）（原図）

Collecting eggs at Anekawa (third from rear, the late Dr. Kiyotaro Itsushima)



姉川採卵場に於ける採卵受精作業（原図）

Fertilization of collected roe at Anekawa Station

the Chinai and Anekawa Rivers. A weir is set across the river to catch the ascending fish. The roe and milt collected are hatched at the Chinai and Samashigaihatcheries, and when the fish attain a certain size, they are released into the lake. The Biwa trout reaches maturity at the same time as the lake-dwelling cherry trout and the fry hatch and swim at the same time. Scales are first formed when the fish reaches approximately 3 cm in length. First, a single ring appears around the scale core and from spring through autumn of the first year, several concentric rings appear around it. At this point there is no difference between these and cherry trout during the river stage. Similarly, from autumn through winter, many rings form very close together in winter bands. If we look at subsequent development in the case of the amago, we find that even when the habitats are far apart, the scale pattern is completely identical, as is shown by the illustration of a two-year old which has wintered once. Both were caught in early fall,

アマゴ雌魚2年仔の体鱗　左　岐阜県益田川　右　山梨県日川（原図）

Scales of 2-year old female amago. Left: Mashita River, Gifu Pref. Right: Hikawa River, Yamanashi Pref.

but the one from the Mashita River is the type. The proper form of the (49)
scale is conical. The growth lines, which form around the first-year scale and indicate growth, are concentric and form complete circles. In cherry trout the growth rings around the outside edge of the winter band does not form a full circle but are broken at the exposed portion of the scale. This is a marked difference between the two and the author's exhaustive studies of amago have turned up not a single male or female three-year old, i.e. with two winter zones.

成熟したアマゴの雌魚（２年魚）の体鱗
露出部吸収せられて鱗形不正となる
（原図）

Scale of mature 2-year old female amago. Pattern imperfect due to indentation of exposed portion of scale.

欠損せる第二年目の鱗が癒合せるアマゴ雄魚の体鱗（岐阜県益田川産，11月初旬採捕）　（原図）

Scale of male amago with partial 2nd-year scale imposed (caught in early November, Mashita River, Gifu Prefecture).

Therefore, the amago is thought to mature in the late autumn of its second year. Like the genetically mature yamame, the exposed portion of the scale is absorbed and the outer portion of the rings around the winter zone does not form an unbroken ring. In some cases, the author found individuals with scale formations indicating a second period of

maturation. It was thus ascertained that, like the yamame, the amago may mature twice.

In summary, both the lake and river forms of Biwa trout have growth rings around the nucleus which form unbroken circles and the scales are roughly conical in shape.

産卵期に姉川に遡上せるビワマス雌魚（3年魚）の体鱗　冬帯2個あり（原図）.

Scale of 3-year old female Biwa trout which ascended the Anekawa River to spawn. 2 winter zones.

姉川に遡上せるビワマス雄魚の成熟せるものの体鱗（露出部吸収欠損）（原図）

Mature male Biwa trout which ascended Anekawa River to spawn. Absorption of exposed portion)

The silver yamame, which goes down to the colder ocean waters, is surrounded with an abundant food supply and grows much larger than the river variety. It also lives longer, carrying out its spawning migration in its third year. Similarly, the Biwa trout enters its spawning season after living through two winters. Adult fish which approach the shore to spawn every year are almost always three-year olds. They have many more rings much closer together than the lake-dwelling variety. A loss of the exposed portion of the scale at sexual maturity is a common feature of the salmonids. The originally unbroken rings are broken as the fish proceeds to grow.

Chapter IV

Experiments on Parallel Culturing of Cherry Trout and Biwa Trout

Cherry trout and Biwa trout belong to the same species. Even (51)
though the river form of cherry trout, known as yamabe or yamame, and the river form of Biwa trout, known as amago, show some morphological differences, the variations are governed by their different environments but are not sufficient, some scholars and fishermen maintain, to justify distinguishing them as separate species. To determine the rightness of the claim, eggs of both cherry trout and Biwa trout were hatched in the same hatchery and the fish that hatched were raised for two years in two ponds under identical conditions. The experiments described in this chapter were carried out at the Shiga Prefectural Fisheries Experiment Station with the cooperation of its director Mr. Mitsuo Aoki to determine whether these features were hereditary or environmentally controlled.

1. Experimental Procedure

The environmental and other conditions were kept as identical as possible in the two ponds. Ponds 7 and 8, 60 m^2 x 1 m deep, at the Samashigai Trout Farm, attached to the Shiga Prefectural Fisheries Experiment Station. Water was supplied at the rate of 70 m^3/min. Each pond had one inlet and outlet for water. The sides and bottom of the pond were of coal and clay.

The fish raised were Biwa trout, collected as eggs from adult fish in Lake Biwa in November 1929 and hatched at the Chinai Hatchery, and cherry trout obtained as eggs from adult fish from the Akafuto River in Hokkiado in October 1929 and held for hatching and raising at the Samashigai Trout Farm on November 16 of the same year.

On August 8, 1930, 360 of the above fish were selected for

experimentation. The Biwa trout were placed in pond 8 and the cherry trout in pond 7. On October 17, 1931, both types were examined to determine their habits, growth and morphological changes.

2. Differences in Habits (52)

The Biwa trout generally were dispersed about the bottom of the pond. They responded strongly to external stimuli and were difficult to tame. When fed, they were sluggish about taking the food and were very difficult to raise. Cherry trout on the other hand, were quite gregarious and seized at their food very actively. The time at which they attained maturity was naturally affected to a certain extent by temperature, food, and the like. The male Biwa trout, unlike the yamame, never matured in the first year, but always in the second. It was found that the females, like the parent species, matured for the first time in their third year.

琵琶鱒雄魚（1年仔）晩秋の頃の体鱗　生殖線未熟にして欠損せず（原図）

昭和6年10月12日採捕せる琵琶鱒雄魚（2年仔）の体鱗　冬帯1個あり露出部欠損，生殖線成熟　（原図）

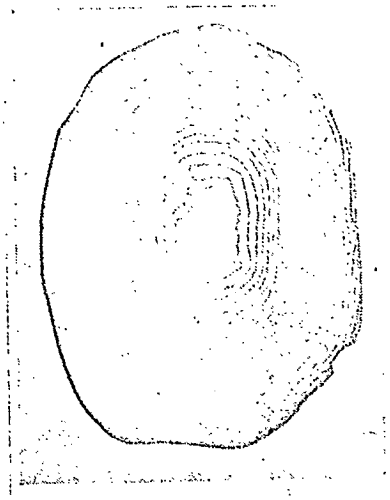
Scale of 1-year old male Biwa trout in late autumn. Sexually immature, shows no missing areas.

2-year old male Biwa trout caught Oct. 12, 1931. Scale shows 1 winter band, part of exposed portion missing, sexually mature.

On October 7, 1931 all the fish were examined. There were 49 males in the 233, all completely mature. Of the fifteen identified as females, only one had mature ovaries with 300 5.6 mm diameter eggs. Four were expected to mature in late autumn and had roe in the ovaries. The remaining 310 were totally immature, and showed no indications of maturing within the year. Another 159 were so immature that their sex could not be readily distinguished, but external and other characteristics indicated that they were probably females. In the end, there was a total of 174 females and only 2.3% of the two-year olds matured. The vast majority apparently mature in the third year. (53)

Now as to the question of concluding immediately that, on the basis of the findings given above, the amago or river form of Biwa trout will mature largely in the third year, the author's observations of a number of amago taken in the upper reaches of the Hikawa River in Yamanashi Prefecture indicate that this is not the case. The amago living in rivers have very little chance of meeting as three-year olds. On July 19, one three-year old and eight two-year olds were taken. The four males appeared certain to mature by autumn, but this does not necessarily mean that all males mature during the first year as in the case of pond-cultured Biwa trout. Of the nine females, one three-year old and four two-year olds had mature eggs; three two-year olds were about to mature and one would winter as an immature fish and mature as a three-year old. This means that the majority of those that would mature and spawn were two-year olds. The reason for such a difference is that the descendants of the lake-dwelling fish were genetically destined to grow to adulthood in the lake depths, while the other was an established

river form, land-locked for years in rivers where food was scarce.



昭和6年10月12日採捕せる琵琶鱒 雌魚（未熟2仔）の体鱗　冬帯1個あり生殖腺未熟にして体鱗欠損せず（原図）

Scale of immature 2-year old female Biwa trout caught October 12, 1931. One winter zone. No scale imperfection, due to sexual immaturity.

One hundred eleven cherry trout were examined, 69 males and 42 females. All of the males were fully mature. Of the females, 5 had 4.0 mm diameter eggs, 16 showed signs of maturing in late autumn and about 50% appeared likely to mature as 3-year olds. This indicated one form, which descends to the sea, where the males mature early and the females as 3-year olds, and a river form, maturing in the second year, as in the case of cherry trout eggs reared in ponds in the Hokkaido experiments. (54)

山梨県日川上流にて採捕せるアマゴ雌魚の体鱗（7月19日採捕）　（原図）
2年魚（冬帯1個）　3年魚（冬帯2個）何れも熟卵あり

Scales of female amago caught in upper reaches of Hikawa River, Yamanashi Prefecture. l. 2-year old (with winter band) r. 3-year old (2 winter zones). Both with mature eggs.

左　未熟魚　　右　熟魚（露出部欠損）

桜鱒雄２年仔の体鱗（冬帯１個あり）　　（原図）

left: immature. Scales of 2-year old female cherry trout

right: mature (imperfect exposed area). (one winter band)

3. Differences in Morphology

A. Markings and Colouration

The immature Biwa trout, known as amago, commonly has a series of 7-10 long elliptical black parr marks on the sides of the body and a scattering of black spots. These are accompanied by bright red spots here and there, which become indistinct as the fish grows. Both the parr marks and the red spots gradually disappear and the sides take on a silvery white colour. Fish approaching maturity tend to be blackish in colour and parent fish will have irregular bright red cloudy markings, with grassy colouration in between them.

Like the preceding fish, the young cherry trout has small black parr marks along the lateral line and black semicircular markings of uniform size on the back. Between the two is found a scattering of black

circular dots. There are no red spots on the belly, but there clearly appear to be rather large black round spots. A red band-like strip is seen along the lateral line. As the fish mature, they are distinguishable as the river-dwelling and seaward-migrating forms, whose colouration and other features are described in Chapter 1.

In the present series of culturing experiments, the greatest (56)
emphasis was on the question of whether the red spots on the sides of the amago and the black dots on the sides of the yamame were variant features appearing as a result of environmental changes. Dr. Shigeo Tanaka steadfastly stands by the variation theory. The facts are abundantly clear. The young Biwa trout in Pond 8 all show bright red spots on their sides and the young cherry trout in Pond 7 have only black spots and not the slightest trace of red spots. This shows that red or black spots are in no way dependent on environment.

B. Appearance

The Biwa trout is comparatively short in height, and long and thin. The cherry trout is very tall. The head of the Biwa trout is also shorter than that of the latter, as is the snout length. The eye diameter of the Biwa trout is conspicuously greater than that of cherry trout. The measurements of the fish selected on October 7, 1931 are given in the tables below.

Table 1. Length, Height, Weight (Average)

Fish	When stocked				When removed			
	Total length	body length	height	weight	Total length	body length	weight	weight
	cm	cm	cm	gr	cm	cm	cm	gr
Biwa trout	8.20	7.30	1.40	5.10	23.40	20.91	4.57	127.17
Cherry trout	7.80	6.60	1.40	3.90	25.20	22.45	5.18	200.84

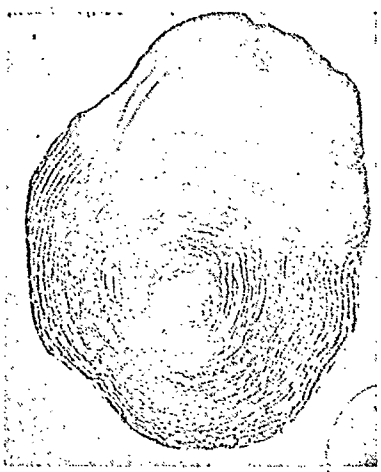
Table 2. Head length, snout length, eye diameter (average)

	Biwa trout			Cherry trout		
	fem.	male	avg.	fem.	male	avg.
	cm	cm	cm	cm	cm	cm
Head length	4.85	5.32	5.09	5.04	5.61	5.33
Snout length	1.21	1.37	1.29	1.42	1.74	1.58
Eye diameter	1.09	1.10	1.10	0.91	0.85	0.88

C. Scale Patterns (57)

The arrangement and structure of growth rings on the scales of Biwa trout and cherry trout are virtually the same in the first year. Until the appearance of the last ring forming the first winter zone, both scales are ovular in shape with the growth rings concentric around the core. This pattern is permanent in Biwa trout: growth rings continue to be circular until maturity. In the case of cherry trout, however, the scales become irregular. The exposed portion grows to a marked extent and the concentric growth rings produced around the outside of the first

winter zone are incomplete. The rings are broken and only the outer margin of the scale from the growth period remains of the exposed portion, as stated previously.



昭和6年10月17日第7号池より取揚げたる桜鱒未熟雌魚（2年仔）の体鱗（原図）

Cherry trout scale pattern Immature 2-year old female taken from pond 7, 17 Oct. 1931

第8号池より取揚げたる琵琶鱒未熟雌魚（2年仔）の体鱗（原図）

Biwa trout scale pattern. Immature 2-year old female from pond 8.

One of the purposes of these culturing experiments was to corroborate factually that these differences are hereditary. The results have been stated and no further explanation is necessary. The structure of the scales of parent Biwa or cherry trout in natural conditions is hereditary and is a legitimate grounds for distinguishing between them. (58)

4. Conclusion

Facts supported by the results of two year's culturing experiments with young cherry and Biwa trout are the following:

1. The black spots on the sides of young cherry trout and the red spots on the sides of young Biwa trout are hereditary features.

2. The appearance and distribution patterns of growth rings on the scales of cherry and Biwa trout are hereditary features.

3. Compared to the cherry trout, the Biwa trout is shorter in height, in average head length and average snout length but the eye diameter is markedly greater.

4. Male Biwa trout raised in the pond were fully mature in two years and females matured in the third year. Male cherry trout were fully mature in two years, but some females matured in the second year, some in the third year.

5. On the basis of these findings, the parent species cherry trout and Biwa trout (amenouo) and their respective offshoots yamame or yamabe and amago are distinctly different species.

Chapter V.

Experiments on Crossing Cherry Trout and Amago

In 1924 crossing of cherry trout, ascending the Jinzu River, and amago, from the Kiso river system was carried out under the supervision of Osamu Hiraki, then director of the Gifu Prefectural Fisheries Experiment Station, using the trout-hatching facilities of the Hida-Takayama sub-station. New species of trout, which would remain in rivers and propagate, were raised through crosses of kawa-masu and amago or cherry trout, or of iwana* and cherry trout. The purpose was to raise a new trout which did not swim to the sea and which could readily be propagated in an area like Gifu, where there is no ocean, by crossing female cherry trout, which are large and carry large numbers of eggs --- a species which swims upstream from the Sea of Japan --- with male amago, which are confined to rivers and streams. The author had the good fortune to look over the crossing operations at the Hida-Takayama hatchery twice and, thanks to Mr. Hiraki, was provided with specimens of the hybrids and experimental data, making possible a genetic study of the characteristics of the hybrids. The following is a description of the author's studies of the cherry trout and amago hybrids, based on the material provided by Mr. Hiraki.

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*Salvelinus pulvius - Trans.

Section 1. First Generation Hybrids F_1

The first experimental crossings of cherry trout and amago were made in late autumn of 1924. Female cherry trout from the Kawakami River, the uppermost reaches of the Jinzu River (opposite Kiyomi Village, Ono-gun, Gifu Prefecture) and male amago from the Mase River where it joins the Kiso River were used. On October 22, 15,000 hybrid eggs were obtained. Eyes appeared on November 3 and hatching was complete on December 2. Hatching required 42 days. Dead eggs accounted for 780, dead fish for 279. Thus, 13,941 fish were raised in the hatching tanks. One hundred fifty eyed eggs were sent to the Ogaki Trout Farm for observation of their development process. (60)

In spite of the fact that the hatch results were very good, an attack of white spots killed them all. The fish which developed from the other eggs were released into rivers in the area around Takayama when grown.

The following year 1925, 9,700 eggs were obtained from a female cherry trout which had ascended the Miyakawa River on the upper Jinzu River. They were fertilized with milt from amago from the Masuda River, which empties into the Kiso River. After a hatching period of about 50 days, 8,488 young fish were obtained. One thousand five hundred eyed eggs were shipped to the Ogaki Trout Farm for culturing and experimentation. The fish were raised for two full years, from December 10, 1925 to the end of 1927. The specimens examined by the author belonged to this group.

During shipment from Takayama to Ogaki, 46 eggs perished. Hatching began on November 19 and lasted until November 30. At hatching,

the infant fish averaged 1.75 cm long and 0.13 g in weight. Thirty-two days after hatching, when the yolk-sacs had been absorbed, the fish were fed powdered silkworm cocoons. For fifty-five days they were raised in the hatching tank, after which they were transferred to an 8-tsubo* pond at the trout farm (1,150 fish). They were fed twice a day with a 6:4:1 mixture of powdered cocoons, rice-bran and wheat flour kneaded with water.

Measurements were taken 430 days later, on March 24, 1927. The average length of the fish was 17.53 cm, average height 3.61 cm, average weight 53.43 g. In form and colouration, 61.8% resembled cherry trout; 28.5% were very similar to the river form, yamame, with tiny red spots, and 9.5% resembled amago, according to Mr. Hiraki. Some of the young cherry trout had a thin pale red stripe along the lateral line, and a sparse scattering of tiny red dots (the amago has bright scarlet dots on its sides. Thus the first two groups may be regarded as belonging to the same group, in which case, as far as markings are concerned, the majority of the first generation hybrids are of the yamame type. The scales of the specimens brought back by the author all (61) are of the Biwa trout type, which therefore must be dominant over the cherry trout type. The situation regarding growth rings until the formation of the first winter band is identical for both parent species, so no determination as to dominance can be made here. However, the two can be readily distinguished according to whether or not the growth rings formed around the outer edge of the winter band after the immature fish has passed one winter.

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*The tsubo is a Japanese area measure, equivalent to 3.952 yd^2.

A
桜鱒雌とアマゴ雄との交配種の体鱗　B 未熟雌（2年魚）

B
A 未熟雄（1年魚）（原図）

A B

Scales of cherry trout-amago hybrids. A. immature 1-year old male; B. immature 2-year old female.

The pattern and form of the illustrated scale of a 2-year old is clearly of the Biwa trout form.

In view of the preceding remarks, we may conclude that the black spots of the cherry trout are dominant over the red spots of the Biwa trout, while the scale pattern of the Biwa trout is dominant over that of the cherry trout.

(62)

Section 2. Back-Crosses

The first generation hybrid F_1 produced by fertilizing eggs of female cherry trout with milt from amago matured as anticipated in November 1927. At this point, it was found that they were identical to the river yamame and amago, so back-crossing experiments were tried between the hybrid and the parent amago. Due to a high mortality rate

among female hybrids, only a single specimen was available for testing.

Egg collection and crossing	Fish used to cross	Egg diameter mm	No. of eggs	No. of fish	
				♀	♂
Nov. 7	amago♀ x F_1♂	4.9	740	3	1
"	F_1♀ x amago♂	7.0	199	1	1
"	amago♀ x amago♂	4.2	1,700	7	4

Crosses between female amago and male hybrids completed eyeing on November 25 and began hatching on December 12. There were 347 hatched fish and 393 dead eggs, for a hatch rate of 46.7%. Crosses between female hybrids and male amago completed eyeing on November 27, but all eggs died by the 5th of December. The control strain amago crossed with amago, began hatching on December 9. There were 364 dead eggs and 1,336 hatched fish, for a hatch rate of 78.6%. The results were much more successful than in the case of the back-crosses.

In view of these results, back crossing between hybrid eggs and amago milt produced eyed eggs which did.not hatch. Back crosses between amago eggs and hybrid milt produced some hatched fish, but the percentage was very low. These crosses rre certainly not worth recommending.

These facts indicate that there is virtually no chanceof hybrids released back into the streams inhabited by amago producing an intermediate form with the existing amago.

(63)

Section 3. Reciprocal F_1 Hybrids

The number of specimens available for experimentation was very small and exact data on characteristics were not obtainable, but hybridization experiments were made using surviving males and females of the mature hybrids. The eggs measured 6.9 mm and 267 were collected. Eyeing was complete on November 27 and 11 eggs died, yielding 256 fish. This hatch rate of 95.9% surpassed that of the reciprocal hybrids of amago.

The question of how the relative characteristics of yamame and amago would be distinguished in the second generation hybrids was very interesting but since there was only one pair of fish available for experimentation, other than the fact that the hatch rate was good, nothing was discoverable about the development and so on of the juvenile fish.

This was not wasted effort, however, in that it corroborated Mr. Hiraki's idea that a hybrid produced by crossing a female cherry trout with a male amago would have an excellent propagation capacity, be river-dwelling by nature, and mature in two years. Some people say that there is a kind of amago called "Hiraki trout" in the rivers of Gifu Prefecture and these may be hybrids which have been released into the rivers and reproduced there.

Chapter VI

Distribution of Yamamè and Amago

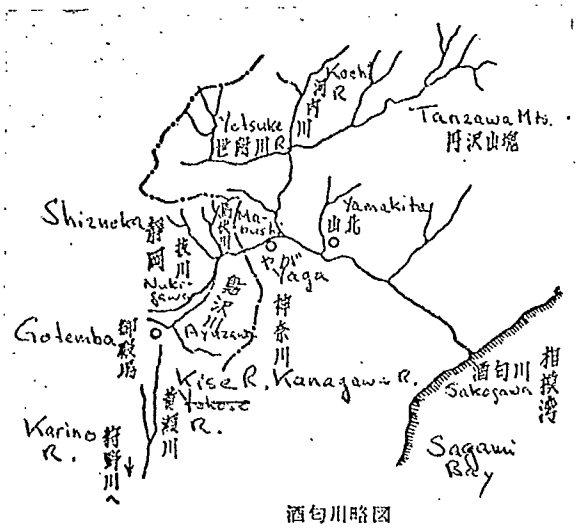
Section 1. Yamame and Amago in the Sakogawa River

With regard to whether or not the river form of cherry trout, or yamame, and the river form of Biwa trout, or amago, intermingle when they dwell in the same rivers, facts must be given to the contrary. Under natural conditions, the rivers inhabited by yamame and amago are determined geographically, probably by temperature, and both are not found inhabiting the same area of the same river nor do hybrids between the two occur in nature. However, facts observed by the author in the course of a study of the Sakogawa River are distinctly at variance with previous views on this subject.

The Sakogawa River flows along the Japan National Railways' Gotemba line and empties into Sagami Bay. The Ayusawa River, which has its source in the plains upstream in the direction of Gotemba, and the Nukigawa and Mabushi Rivers, which gather the waters flowing down from the southern foothills of Sangoku Pass, flow together and as they near Koyama-machi, the waters become slightly warmer and flow together with the cooler waters of the Yotsuke and Kochi Rivers in the vicinity of Tanigaeki in Kanagawa Prefecture. Gathering water from the small streams in the Tanzawa-Ashie region, it flows down to Yamakita and Matsuda. In Shizuoka Prefecture it flows through the plains at the foot of Mt. Fuji, where it is scarcely a cold-water river. Joining with the Tanzawa-Ashie waters in Kanagawa Prefecture, it becomes clear and rapid. It should be noted here that the source of the Kise River, which joins the Karino River flowing down from Oku-Izu at Numazu, and the source of the Ayuzawa river, which flows into the Sakogawa, bracket the

town of Gotemba to the north and south. However, there is no watershed there: perhaps the heavy rainfall just runs off in all directions, forming two rivers. Thus, it may be that the Karino and Sakogawa were joined at the source ages ago through the Ayuzawa and Kise. This would have provided many chances for the fish populations of the two rivers to mix.

In terms of zoological geography, the temperature relationships in the areas west of Tokyo Bay, where the Oyashio current from the North and the Kuroshio from the South, collide have an immense effect on such cold-water, anadromous fish as the salmons and trouts. This would be a quite natural reason for the absence of such fish populations west of the mouth of the Tone River.



酒匂川略図

Sakogawa Area

The yamame, the river form of cherry trout found primarily in Hokkaido, prefers cold water regions, and the amago, land-locked in slightly warmer rivers and streams, have habitats which are clearly separated by a line running through the Hakone-Ashie-Tanzawa mountains which form a watershed between the rivers flowing into Sagami Bay and those flowing into Suruga Bay. This must be a result of the strong effects of the relationship between the Oyashio and the Kuroshio.

The reason that the amago, the river form of Biwa trout, which

grows fat in the deep waters of the Biwa Lake basin, never migrates to the sea (except for the kawa-masu in the Kiso River) is thought to be that the temperature in the river mouths connecting to the ocean are too high due to the effects of the Kuroshio. At any rate, as one proceeds west from the Sagami, Sakogawa, Hayase and other Kanto-area rivers inhabited by yamame, one encounters the areas where the amago live, in the upper reaches of the Karino, Fuji and other rivers. The conventional wisdom had it that the Yotsuke, Kochi and other rivers (66) feeding into the Sakogawa would contain yamame. However, while yamame are certainly found in the main river and tributaries in Kanagawa Prefecture, once the prefectural border is crossed into Shizuoka, it is the amago which one finds in the Mabushi, Nukigawa, Ayuzawa and other rivers. Those who fish in the streams of Tanzawa say there is not a single amago and in fact, it is only the yamame that is caught in the main part of the Sakogawa, below Yaga where the cold waters of the Tanzawa-Ashie flow into it. Even in the same river, where the temperature is different, the yamame and amago will inhabit different regions and never mix, a very astounding fact.

There are some scholars who would crow and prate about variability if amago and yamame were said to coexist in the same river, but where the upper reaches of the Sakogawa joined the Kise, a cold-water habitat of the amago, it is possible that the two mixed in ancient times. If one considers the geographic circumstances, there is nothing unusual at all in the possibility of such an occurrence.

Section 2. Distribution of Yamame and Amago in Kyushu

It has long been well-known that there is a fluvial land-locked trout dwelling in the rivers in Kyushu, locally called enoha. It was considered a type of amago, but a precise scientific designation had not been arrived at. In the oft-reviewed paper by Jordan & McGregor on the salmonids of Japan, the fish from Kyuma River was called Oncorhynchus macrostomus and the specimens caught in Kumamoto were described as Oncorhynchus ishikawae. However, these names were synonymous with the scientific name for the cherry trout Oncorhynchus masou (Brevoort). The latter in particular was mistakenly applied to the seaward-migrating silver yamame on the assumption that it was a new species, and clearly ought to be abolished. It was pure good luck that Jordan & McGregor did not identify the fluvial land-locked trout reported from the rivers of Kyushu as amago. To this day nobody has been able to determine exactly what this fish, commonly called enoha, (67) actually is.

The author enjoyed the opportunity to study the freshwater fish of southern Kyushu in the summers of 1949 and 1950. He first obtained an immature enoha caught by former General Takeshi Furunori, an avid fisherman, in the Takedachi River which flows from the foothills of Mt. Aso into the Chikugo River. He later obtained several mature specimens caught by the famous fisherman, Hajime Yoshimura, of Hitoyoshi, in the Kyuma River. After a detailed study of their morphology, the fish proved to be without question a form of yamame, or Oncorhynchus masou (Brevoort), and the author expressed his admiration

for Jordan and McGregor who avoided mistakenly identifying it as amago.

上，鹿児島県出水鍋野川産ヤマメ　　九州のニノハ
下，大分県大分川のアマゴ（白点は褪色せる朱点）（原図）

Enoha from Kyushu
Above: Yamame from Nabeno River, Kagoshima Prefecture.
Below: Amago from Oita River, Oita Prefecture (white spots are red spots which have faded)

Later the author had the opportunity to visit the Faculty of Fisheries at Kagoshima University. Through the kindness of Prof. Sadahiko Imai, he was able to examine a number of specimens of enoha caught all over Kyushu by the capable student-fisherman Mr. Kiyoaki Kimura. It was found that the enoha population of Kyushu consisted of a mixture of amago and yamame. Amago were known as golden enoha and yamame as silver enoha, depending on the locality.

Two years' collection and examination of enoha specimens (68)
revealed that those dwelling in the rivers emptying into the Pacific off Kyushu were yamame or Oncorhynchus masou (Brevoort) and those dwelling in rivers emptying into the Inland Sea were amago or

Oncorhynchus rhodurus Jordan & McGregor. The specific distribution of each species is as shown below.

A. Habitats of yamame (cherry trout) in Kyushu

1. Iwaya, Chikujo-gun, Fukuoka Prefecture.
2. Upper reaches of Enga River.
3. Yu-no-E (Sakai R.) Nankorai-gun, Nagasaki Pref.
4. Takedachi R., Aso-gun, Kumamoto Pref.
5. Kyuma R. (near Hitoyoshi), Kyuma-gun, Kumamoto Pref.
6. Nabeno R., (branch of Yonenotsu), Kagoshima Prefecture.
7. Upper reaches of Oyodo R., Miyazaki Pref.
8. Mimi R. (below Suiyo Dam), Miyazaki Pref.
9. Upper Mirakawa, Miyazaki Pref.

B. Habitats of amago (Biwa trout) in Kyushu

1. Yamakuni R., Oita Pref.
2. Asono R., Oita Pref.
3. Upper Oita R., Oita Pref.
4. Upper Ono R., Oita Pref.
5. Saikawa, Oita Pref.

In the regions facing Miyazaki and Kagoshima across the Pacific, there are no long rivers. Such large rivers as the Yoshino and Shimando all flow into the Inland Sea and are inhabited by amago. The yamame occurs no where in the area. Unlike the situation on the Kii Peninsula, the coloration of the Biwa trout group is darker. Below Kumamoto Pref. there are the remains of marine algae from the Ice Ages. Recently,

fossil molars of stegodon have been found in Amagusa-nada and it is (69)
easy to imagine that the Pacific Coast must have been bathed by cold currents during the Ice Ages. However, since the yamame is now found all along the Japan Sea coast, there must have been a rather strong cold current flowing west through the Japan Sea, the main part of which went as far as the west coast of Taiwan, through the Taiwan Straits. While the ancestors of the Taiwan trout, land-locked near the source of the Tachia River, were penetrating that area, a branch current must have washed back along the Pacific coast of Kyushu, giving the seaward-migrating cherry trout a chance to swim upstream and spawn in the various rivers of Kyushu.

It has recently been found that in late autumn very small numbers of salmon spawn in the Tamajima River (opposite Shichiyama Village, Hamazaki-cho, Higashi-Matsuura-gun) which flows into Karatsu Bay (Saga Prefecture) and the Izumi River, which flows into Kaburi Bay (Itoshima-gun, Fukuoka Prefectore). The author has similarly had reports of a dozen or so salmon ascending the Abukawa around Ogi City, Yamaguchi Prefecture, on the Japan Sea Coast in late autumn. This suggests that the limit of salmon distribution is much farther south than ichthyologists currently believe. It may even be possible to find cherry trout, which coexist with salmon in northern waters, along the Pacific coast of Kyushu. The number of yamame caught in Kyushu so far has been extremely small, so it is impossible to know if they include the silver yamame, characterized by the jet black-tipped dorsal fin, or not. The question of whether or not the cherry trout, which occurs throughout the Japan Sea area, can be shown to exist along

with salmon in Kyushu is a very interesting one in terms of zoological geography.

Section 3. Distribution of Yamame and Amago

Certainly the centre of yamame or yamabe distribution is the Hokkaido region. Dr. Tamezo Mori has shown that the areas of Sakhalin, Enkaishu, eastern Korea and the areas facing the Northeastern Japan Sea constitute the range of distribution of the yamabe. The Biwa trout is found naturally enough in Lake Biwa and since it is peculiar to Japan, the distribution of its river form, the amago, is limited to Japan proper. Since the preferred temperatures are slightly higher than for the former, its range is confined to the rivers flowing into the Pacific from west of Hakone, the rivers flowing into the Inland Sea from Kinai, San'yo, Shikoku and Kyushu. This means that the rivers containing yamame and those containing amago are clearly distinct from one another. There are no exceptions, aside from the preceding instance of the Sakogawa, where the two occur in separate areas of the same river.

Naturally the yamame lives and propagates in cold streams throughout the Hokkaido and Tohoku regions. One may therefore omit a complete list of the rivers in those areas in which it occurs. First, a list of rivers, in the upper reaches of which live yamame, from the Kanto Region westward is given, followed by those rivers with sources beyond the watershed, which flow into the Pacific or the Inland Sea, and which often contain amago. This should clarify the relative distributions of the amago and yamame in Japan. The list combines areas explored by such famed river fishermen as Junsaburo Takeuchi, Goseki

Sato, Gyoshin Suzuki and areas which the author has been fortunate enough to explore personally. Thus, there may be many omissions. Data are particularly scarce on yamame distribution in the San'in region, where detailed research remains to be done.

I. Rivers inhabited by yamame*

A. Kanto Region

1. Hayakawa
   - Mainstream, upper reaches
   - Sukumo R.

2. Sakogawa
   - Yotsuke R.
   - Kochi R.
   - Sone R.
   - Nakatsu R.

3. Sagami R. (Umairi R.)
   - Koayu R.
   - Nakatsu R.
     - Sato R.
     - Minasawa R.

   Katsura R. (mainstream) (71)
   - Toshi R.
   - Akiyama R.
   - Katsuno R.
   - Sasako R.

4. Tama R. (upper reaches: Tamba R.)
   - Hibara R.
   - Akikawa
   - Otamba R.

*The correct reading of proper names in Japanese is not always readily determined and some of the river names in this list have not been verified, i.e. they are "educated guesses". Also, where kawa (=river) is part of the name as used in English, River has not been duplicated. Tr.

5. Arakawa

- Ashigekubo R.
- Urayama R.
- Ohchi R.
- Nakatsu R.
- Otsutsu R.
- Nakuri R.
- Korei R.

6. Tone River

- Katajina R.
  - Nurikawa
  - Tone R. (characters reversed in original -- Tr.)
  - Kurihara R.
  - Hirakawa
  - Ojiri R.
  - Kasajina R.
- Shinryu R.
- Usukori R.
- Ukawa
- Azuma R.
- Atsukawa
- Torase R.

7. Naka R.

- Hoki R.
- Ojika R.
- Kuriyama R.
- Daiya

B. Shin'etsu Region

1. Shinano R.

- Chimagari R.
- Saikawa
- Susohana R.
- Nakatsu R.

2. Akano R.

- Tadami R.
- Okawa

3. Mitsura R.

Takane R.

C. Hokuriku-San'in Region

1. Joganji R.
2. Jinzu R.
   - Miyakawa
   - Takahara R.
3. Irimi R.
4. Tettori R.
   - Ushikubi R.
   - Ozoe R.
5. Kuzuryu R.
   - Uchinami R.
   - Michina R.
   - Ashibane R.
6. (---?---)
7. Yurakawa
   - Ono R.
   - Tanano R.
8. Maruyama R.
   - Asekawa
   - Yatsuki R.
9. Kaigawa
10. Kamikado R.
11. Hino R.

    Shin'atsu R.
12. Enokawa

    (mainstream, Kae R.)
13. Takatsu R.
    - Hikimi R.
    - Yoshika R.
14. Misumi R.

D. Kyushu Region

(already described in preceding section)

II. Rivers inhabited by amago (73)

A. Kanto Region

1. Upper reaches of Sakogawa (in Shizuoka Pref.)
   - Mabushi R.
   - Nukigawa
   - Ayuzawa

2. Karino R.

   Omikawa

   - Hiyakawa
   - Genpo R.
   - Ikadaba R.
   - Chizodo R.

   Kise R.

3. Fuji R.

   - Shibakawa
   - Inago R.
   - Sano R.
   - Fukushi R.
   - Toguri R.
   - Namikii R.
   - Hayakawa
   - (Amabata R.)
   - Kabukawa
   - Nabenashi R.
     - Shiokawa
     - Otake R.
   - Fuebuki R.
     - Arakawa
     - Kanekawa
     - Hikawa

4. Okitsu R.

5. Abekawa

   Warajina R.

6. Oikawa (upper reaches, Tashiro R.)

   Morimata R.

7. Tenryu R.

   - Kitakawa
   - Minakubo R.
   - Achikawa
   - Koshibu R.
   - Mimine R.

8. Toyokawa

   Kankyo R.

9. Yazukuri R.

   Asuke R.

11. Imben R.

12. Ano R.

10. Kiso R.
    - Hida R.
      - Masuda R.
      - Mase R.
      - Shirakawa
    - Nagarakawa
      - Itatori R.
      - Yoshida R.
    - Kajii R.
    - Neo R.

13. Izumo R. (74)
14. Kushida R.
15. Miyakawa

B. Kinki and Chugoku Regions

1. Yakumo R.
2. Aichi R.
3. Anekawa
4. Kamo R.
   - Takano R.
   - Kumogabatake R.
5. Oseki R.
   - Kiyotaki
   - Ashimaya R.
   - Yumizori R.
   - Tahara R.
6. Kumano R.
   - Kitayama R.
   - Totsu R.
7. Hioki R.
8. Tomita R.
9. Hidaka R.
10. Arita R.
11. Kinokawa (upper Yoshino R.)
12. Kakogawa (upper reaches, Saji R.)
13. Ichikawa
    - Echikawa
    - Odawara R.

14. Kaiho R.
    - Mikata R.
    - Hikibara R.

15. Yoshiikawa (75)

16. Asahikawa
    - Hikigawa
    - Shin'atsu R.

17. Kawatoyo R.
    - Nariba R.
    - Nishikawa

18. Ota R.

19. Sawa R.

20. Sawarano R.

C. Shikoku Region

1. Yoshino R.
2. Nagakawa
3. Niyodo R.
4. Shimando R.
    - Umehara R.
    - Yoshino R.

D. Kyushu Region

(already described in preceding section)

The preceding list gives a general picture of the distribution of the yamame and amago and shows that water temperature and the effects of inflowing tides are dominant. Yamame and amago are discontinuously distributed and very rarely occur in the same river area.

Lake Chuzenji has been stocked with cherry and Biwa trout eggs since 1882. Hakone Ashinoko has similarly been stocked with eggs since early Meiji times and, under the assumption that the Biwa and cherry trouts were the same species, both have been raised together. Not

infrequently, various prefectures have hatched and raised fry to obtain a supply of eggs from Lake Chuzenji. Inevitably this has led to the occurrence of amago in the distributional area of yamame, but recently as the transplanting and raising of freshwater trout has become a nationwide operation, amago have been transported along with freshwater trout to the most surprising areas. As soon as sites with appropriate water temperatures are found, the amago are found to propagate vigorously, producing a pattern of discontinuous distribution. Specific examples such as the Koyabe River in Toyama Pref., the Kido River in Ibaragi Pref., the Koyoshi River in Akita Pref., may be cited and I have also heard that a considerable number of amago were included in a mass of freshwater trout which were released in the Tama River. In the future, since there is no choice but to depend on freshwater trout from Lake Biwa in areas unsuitable for the propagation of ocean trout, the tendency of amago to penetrate the yamame range should become stronger.

The most urgent problem is to determine the borderline between the natural distribution ranges of the yamame and amago. As previously stated, Sakhalin, Hokkaido and Tohoku are the primary habitat of the yamame or yamabe and any occurrence there of amago may be assumed to involve transplanting. However, as one proceeds south to areas such as the Kanto where both yamame and amago appear together in different environments of the same river (the Sakogawa), one must be very cautious in attempting to determine whether the presence of amago in a yamame area is natural or due to artificial stocking.

As far as is known at present, although the Hayakawa and

Sakogawa (in Kanagawa Pref.) and other rivers east of Hakone-Ashie are exclusively inhabited by yamame, just beyond Hakone in Shizuoka Prefecture, such rivers as the Karino and the upper Sakogawa tributaries, the Ayuzawa and Mafushi, see the yamame replaced by the amago. Thus, the Hakone mountain range may be regarded as a starting point for the boundary between the ranges of the two fish. Similarly, the Sagami and Tama Rivers are yamame areas, but once beyond the Kanto Range, the Fuji River and its tributaries are all amago areas. The Shinano River which flows north to the Japan Sea from the Kobushin, Hachigaoka, Norikura mountain watershed is the habitat of the yamame, while the (77) Fuji, Oikawa and Tenryu Rivers flowing south to the Pacific are inhabited by the amago. In the Hida-Takayame Plain, the boundary is the watershed which runs west along the southern portion of Takayama, extending as far as Ohi Mt. at the Fukui Prefecture border. The Miyakawa (upper Jinzu River), Atsukawa (upper Irimikawa), etc., which run into the Japan Sea, are inhabited by yamame, while the Hida, Masuda, Nagara and other tributaries of the Kiso River system, are inhabited by amago. West of that, the boundary runs along the prefectural borders of Fukui and Gifu, dividing the waters of the Tamba into the Yurakawa and Hozu River, running along the crest of the San'in San'yo mountain range, and eventually disappearing in the Shimonoseki Strait.

In Kyushu, this boundary may be considered to produce an outcropping where the Enga and Tsurikawa Rivers cut through the Chikuho Mountain Range. The line extends to the southeast, rounding the western foothills of Mt. Hidehiko, passing through the watershed which separates the waters of the Chikugo and Oita Rivers, running along the prefectural

border between Kumamoto and Oita in the western foothills of Hisazumi Mountain. It runs east across the eastern slope of the Aso Range as far as Soboyama and divides the waters of the Itsugase River, which flows toward the Pacific in northern Kyushu, from those of the Ono River, which flows toward the Inland Sea in Oita Prefecture. It finally ends at Chizogahana.

In short, the longer rivers of cold water which flows into the Pacific, primarily from the Aso Range, are yamame areas and Kyushu may be divided into two distinct distributional areas.

The upper cold waters of the Yoshino, Niyodo and Shimando Rivers in Shikoku are all amago areas. In the areas facing the Inland Sea, however, there are no locations inhabited by amago. In general, the whole of Shikoku may be regarded as an amago area, corresponding in nature to the Kii Peninsula.

With reference to Shikoku amago, special thanks are due to Prof. Urahara of Takachi University for the specimens he forwarded.

Chapter VII

Conclusion

1. Cherry trout and Biwa trout are different species with different genetic characteristics. (78)
2. The black spots on the sides of the cherry trout and the red spots on the sides of the Biwa trout are hereditary features and do not depend on the environment.
3. There are distinct differences in the arrangement of growth rings on the scales of adult cherry trout and adult Biwa trout.
4. The black spots on the sides of immature cherry trout are dominant with respect to the red spots on the sides of Biwa trout. The red spots are recessive.
5. The completed scale pattern of mature cherry trout is recessive with respect to the completed scale pattern of adult Biwa trout. In reciprocal hybrids of cherry trout and Biwa trout, it is the scale pattern of Biwa trout which appears.
6. The scientific name of cherry trout is Oncorhynchus masou (Brevoort) and it has two varieties, one which descends to the sea and one which dwells in rivers and streams. The former, which develops in the sea, is called cherry trout. The latter which lives its entire life cycle in rivers and streams, maturing and reproducing while maintaining the coloration and markings of the immature stages, is called yamabe or yamame.
7. A form of yamabe or yamame which descends to the sea is jet black on the tip of the dorsal fin. When it enters the sea, the immature coloration and markings become faint and turn silvery. This is called a silver yamabe.
8. Both male and female silver yamabe enter the sea as immature two-year

olds. They mature in the third year and return upstream to spawn.

9. Some male yamabe or yamame mature as one-year olds.

10. The majority of yamame or yamabe remain in rivers or streams and do not enter the sea, maturing with the females in the second year.

11. Some male and female yamame or yamabe mature twice. (79)

12. The river-dwelling form of cherry trout is not land-locked. Although the rivers or streams in which they are born communicate with the sea, only the marine form descends to the sea. The river-dwelling form matures early and spends its entire life-cycle in rivers or streams.

13. The Taiwan trout which inhabits the Tachia River in Taiwan is the river form of cherry trout or yamame and its scientific name should be changed to Oncorhynchus masou (Brevoort).

14. The Biwa trout has two forms, one which grows quite fat in rather deep cold water areas, salt or fresh, where animal foods are abundant, and one which lives primarily in rivers and streams with immature colours and markings throughout its life cycle. The former is called amenouo and the latter is called amago or amego.

15. Whether the water is fresh or saltwater has no effect on the growth of cherry or Biwa trout. Splendid growth is exhibited by cherry trout in Lake Biwa or by Biwa trout in the Bay of Ise.

16. Reciprocal hybrids of amago and the first generation hybrid develop successfully.

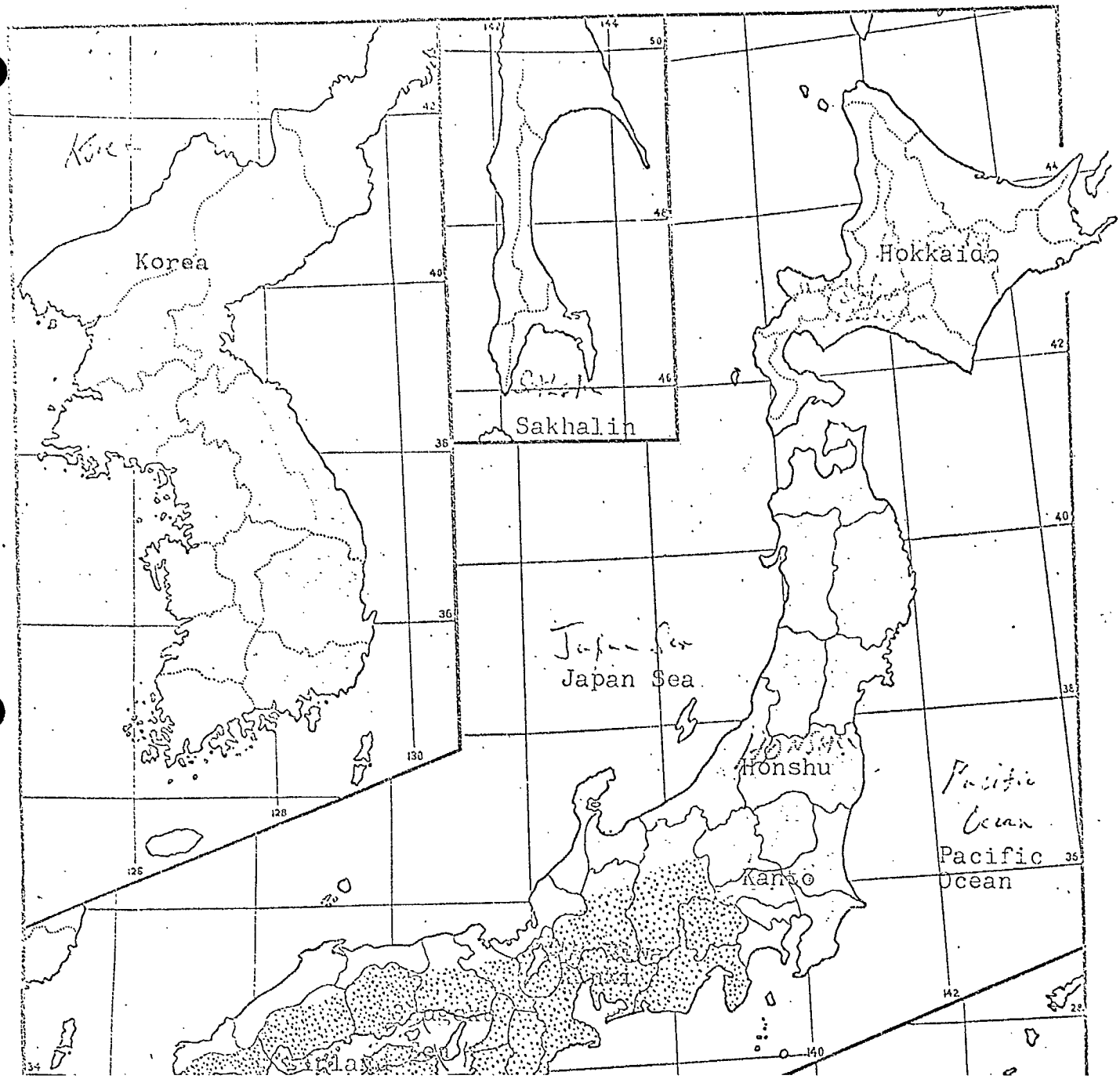
17. Even within the same river, yamame and amago inhabit different areas.

18. Yamame are found in all the cold-water rivers of the Kanto, Tohoku,

Hokkaido, Hokuriku and San'in regions east of Lake Hakone, as well as the cold water rivers of Kyushu which empty into the Pacific.

19. Amago are found in the cold-water rivers west of Hakone which empty into the Pacific and the cold-water rivers of Kinki, Shikoku and Kyushu, which empty into the Inland Sea.

20. In the upper reaches of the Sakogawa, some tributaries are inhabited only by yamame and some only by amago.


Korea
Hokkaido
Sakhalin
Japan Sea
Honshu
Pacific Ocean
Kanto
Shikoku
130
128
126
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