Japanese Journal of Ichthyology
Vol. 19, No. 4 December 25, 1972

魚類学雑誌
19巻4号 1972年12月25日

Studies on Japanese Chars of the Genus *Salvelinus*—VI. The Food of S. *leucomaenis**

Yoshiharu Honma, Nobuo Hokari, and Eimitsu Tamura

(Received February 3, 1972)

Abstract Stomach contents were examined in 106 individuals of *Salvelinus leucomaenis* collected in the mountain tributary of the Seki-gawa River near the foot of Mt. Myōkō during the period from April through December, 1964. From autumn to spring, stomachs mainly contained aquatic and benthic animals, whereas the land insects were dominant in mid-May through August. Most of these insects were nest-builders and dwellers in and near the river banks, but not good flying ones. Among the aquatic insects taken, the case-bearing caddis worms occupy the highest percentage. This evidence seems to be correlated with the morphological devices of mouth and feeding behavior and accessibility rather than with the preference for food. The fact that the mature fish takes the diet continuously even in the breeding season might be one of the causal factors of no post-spawning death in the land-locked (non-migratory) form.

It is well known that the species of the genus *Salvelinus* are voraciously carnivorous, and usually feed on aquatic insect larvae, submarged land insects, and various animals in the clear streams, lakes, and open seas (Clemens and Wilby, 1949: 94–96,: McPhail and Lindsey, 1970: 142–153; Nilsson, 1965; Roos, 1959; Leim and Scott, 1966: 112–114). In Japanese streamlets both adult Dolly Varden (*S. malma*) and char (*S. leucomaenis*) have a nundeserved reputation as the rapacious predators on the eggs and young of other salmonids, sculpins, minnows, crustaceans, and molluscs (Okada, 1959–1960 : 326–338). Occasionally, anglers find comparatively large vertebrates, such as snakes, salamanders, newts, and frogs, in stomachs of the char, and one of the authors (E. T.) found a smaller char which indicates cannibalism.

Although there are several reports on the food of Japanese chars (Nishio, 1934; Suyehiro, 1942; Kawai, 1959; Sato, 1963; Tsuda, 1967; Komatsu, 1970), all these papers dealt only with no more than 15 material in summer season.

During the course of our histo-endocrinological investigation on the chars, a number of specimens were obtained from Hokkaido through Honshū (the Japanese mainland). Since 1964, more than 300 individuals of fish were collected in the mountain tributaries of the Sekigawa River near the foot of Mt. Myōkō, throughout the year excepting in midwinter with heavy snow. The analysis of stomach contents was then undertaken for these specimens to clarify the seasonal changes of emergences and quantities of the faunal elements. Further, several investigators have suggested that the close relationship exists between the feeding and histo-physiology of the organs and tissues (and more the life-span) of the spawning salmonids and ice-goby (Robertson et al., 1961; McBride et al. 1963; McBride et al., 1965; Tamura and Honma, 1971). Although non-migratory Japanese char survive after their spawning (Honma and Tamura, 1965), the actual amount of diet during the maturation period is unknown. Apart from our serial histological examination, therefore, the second aim of this study is concerned with this aspect.

* Contributions from the Sado Marine Biological Station, Niigata University. (This paper is dedicated to the late Professor Doctor Kiyomatsu Matsubara, for his cordial encouragement.)

Materials and methods

As stated above, the selected material, 106 stomach contents in all, used in this study have been collected in one of the mountain tributaries that flow through the area of Jōshin-etsu Plateau National Park, since April, 1964. As these were previously used for our endocrinological researches, the length and weight of each individual have already been recorded by us, but present material were 5.7–21.6 cm in body length, of both sexes, and in various stages of development. After evisceration, the weight of entire digestive tract was measured. Following this procedure, the tract without contents was weighed. The amount of food contents was then obtained from the difference between them.

The food items of each individual were roughly classified into five groups and weighed: larvae of aquatic insect, land insects, land animals other than insects, aquatic animals other than insects, and remainders. Under the binocular stereomicroscope, the identification of these animals in the process of digestion was attempted to specific or generic levels.

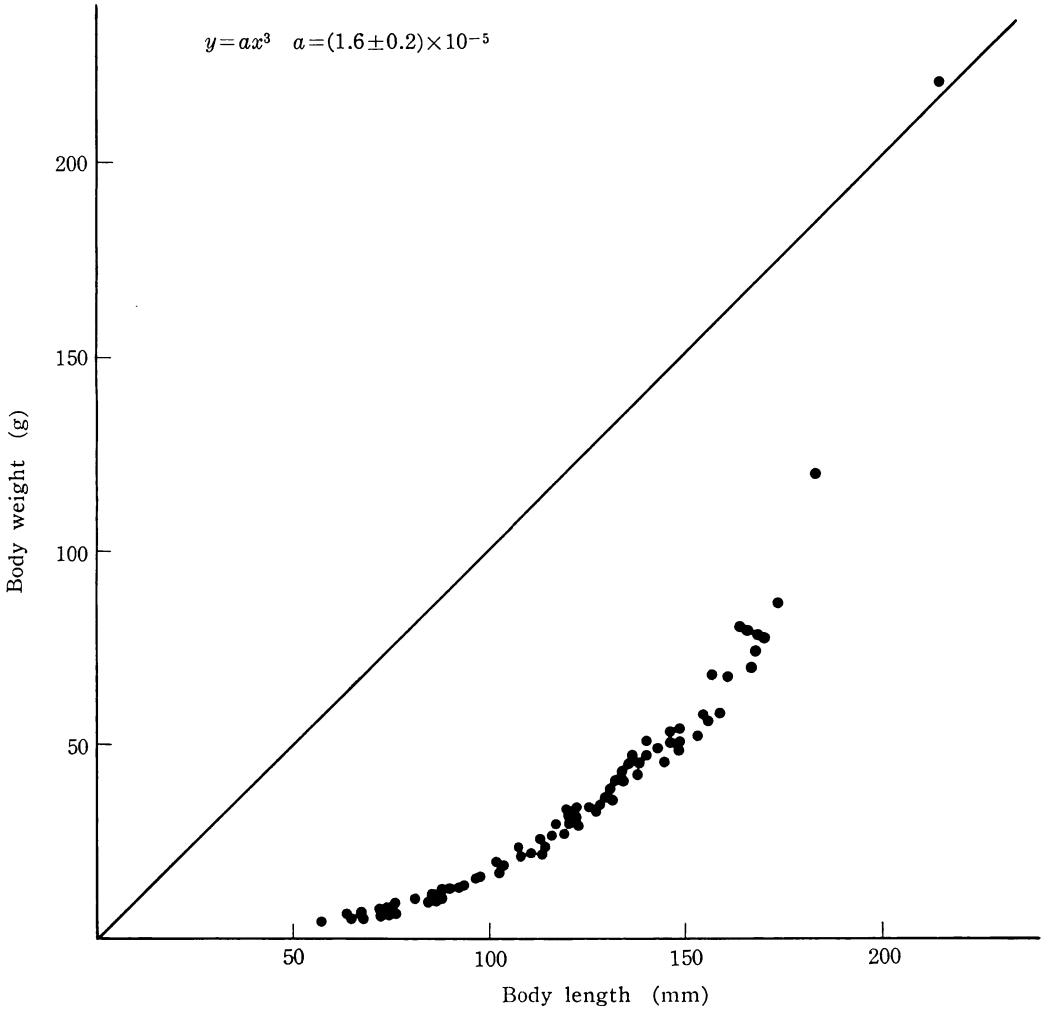

Fig. 1. The relationship between the body length (x) and body weight (y) in the Japanese char, *Salvelinus leucomaenis*.

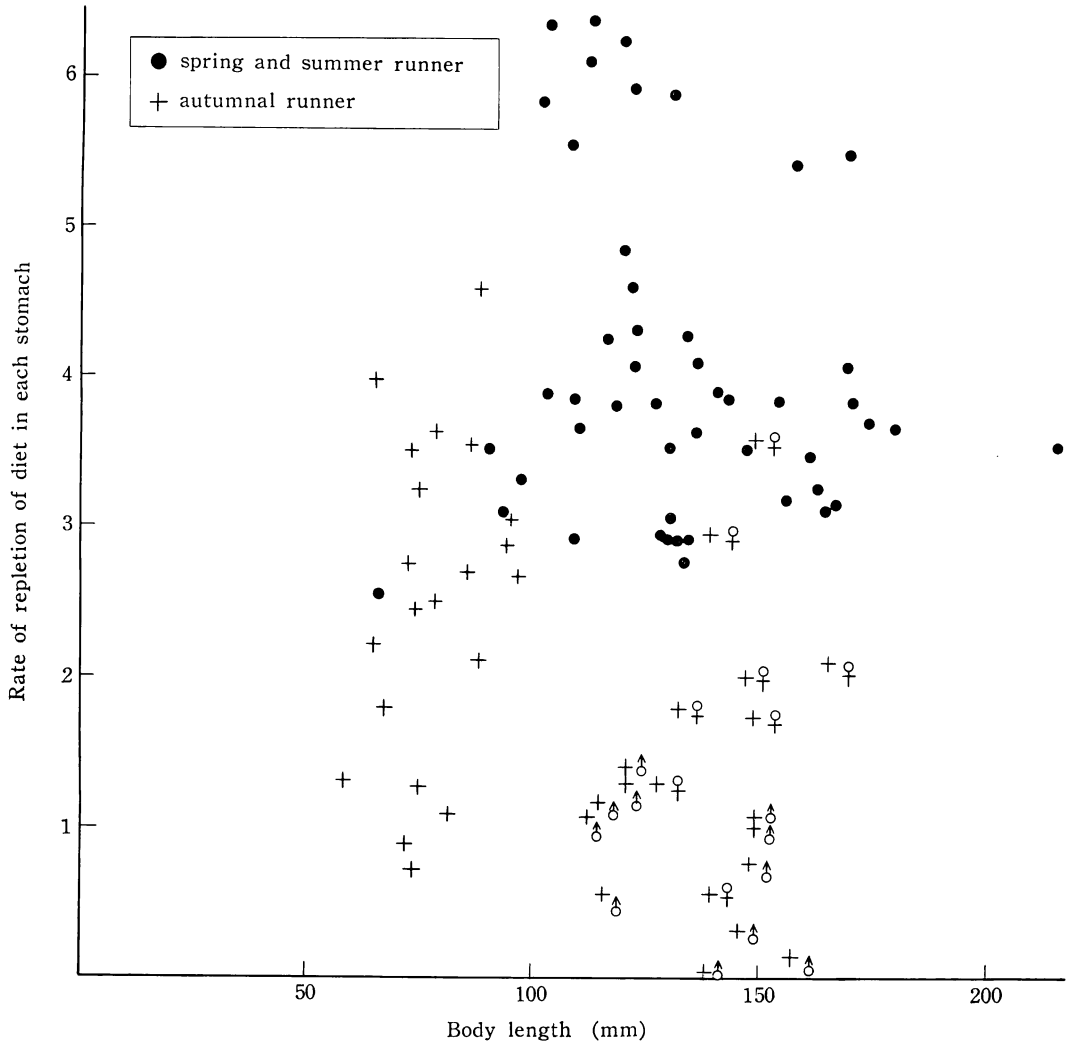

Fig. 2. Relation between the body length and rate of repletion of diet in each stomach of the char.

Results

To know the relationship between the body length (x) and the weight (y), all samples examined were plotted (Fig. 1), and the following formula was secured: $y=ax^3$. $a=(1.6\pm 0.2)\times 10^{-5}$.

For the amount of diets, the rate of repletion in each stomach (weight of stomach contents/ weight of body $\times$ 100) was tentatively adopted, and plotted in relation to the length of body and seasons (Fig. 2). A small number of individuals with empty stomachs and similar condition were omitted in this examination. In general, the rate of repletion of individuals caught in April to July was higher than that of ones in August to October, and it is noticed that the small amount of diets was contained in the larger males.

The volumetric displacement of food organisms in the stomach contents in every month was illustrated in Fig. 3. Unexpectedly, the percentage of land insects taken is somewhat higher than that of aquatic insects. These

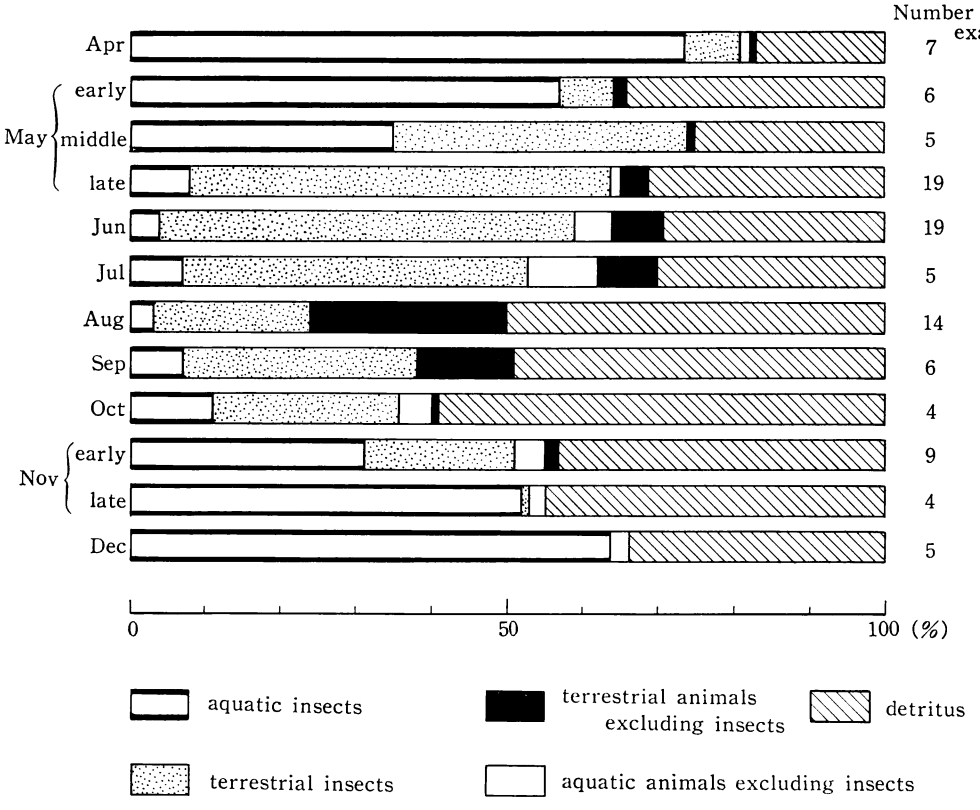

Fig. 3. The volumetric displacement of food organisms in the stomach contents.

organisms cover a comparatively wide range of animals: tree frog, freshwater crab, snail, spiders, millipeds, and others. In spring a large amount of the aquatic insects was taken by the medium sized fish, while a small amount of them was in early summer to autumn. On the other hand, a vast volume of land insects was contained in the stomachs of the fish caught in the latter part of May to July. Noticeably, from August to September, i. e., during the period of the highest atmospheric and water temperatures, a considerable amount of the land animals other than insects was included. The stomach contents of autumnal and winter fish composed again of a relatively high percentage of aquatic insects. Occasionally in spring, a respectable volume of sand and mud were detected in the digestive tract of some of the fish which ate a lot of aquatic insects, and more, the fragmental plants were also found in the summer fish.

According to their mode of life, 70 species of aquatic animals identified from the material of the stomach contents were classified into six subgroups: case-bearing, creeping, swimming, burrowing, net-spinning, and attaching. The average number of these baits per one individual of fish in each month was then plotted in Fig. 4. Among them, the case-bearing caddis worms, such as *Apatania* sp., *Neophylax* sp., *Micrasema quadriloba*, and so on, are the most abundant. The second grade of good baits is the swimming mayflies, *Baëtis thermicus* and *Isonychia japonica*, etc., and the third grade the creeping forms, such as stoneflies, hellgrammite (*Protohermes grandis*), a spotted mayfly (*Ephemerella basalis*), etc. On the other hand, it was difficult to see the net-spinning and attaching forms, and also the depressed larva belonging to the creeping

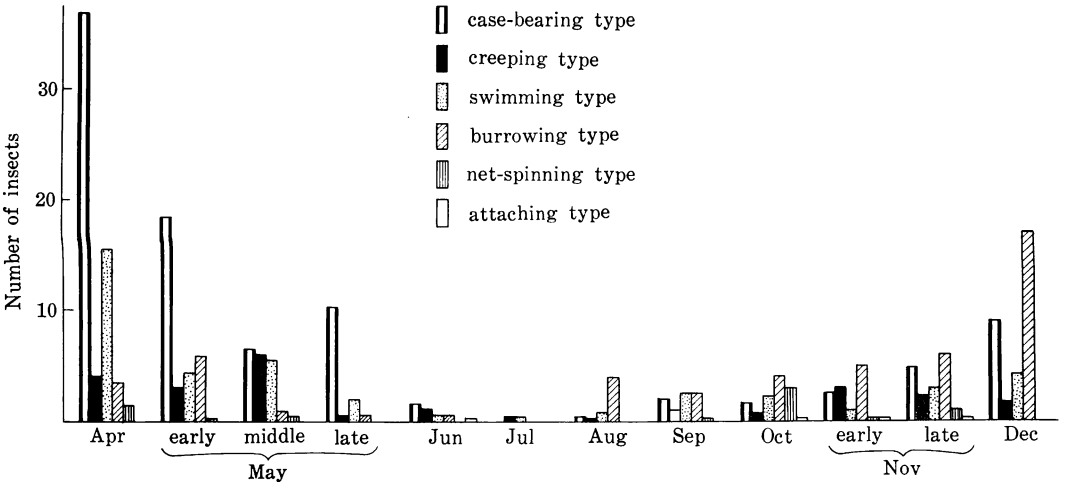

Fig. 4. The average number of the aquatic insects per one individual of fish.

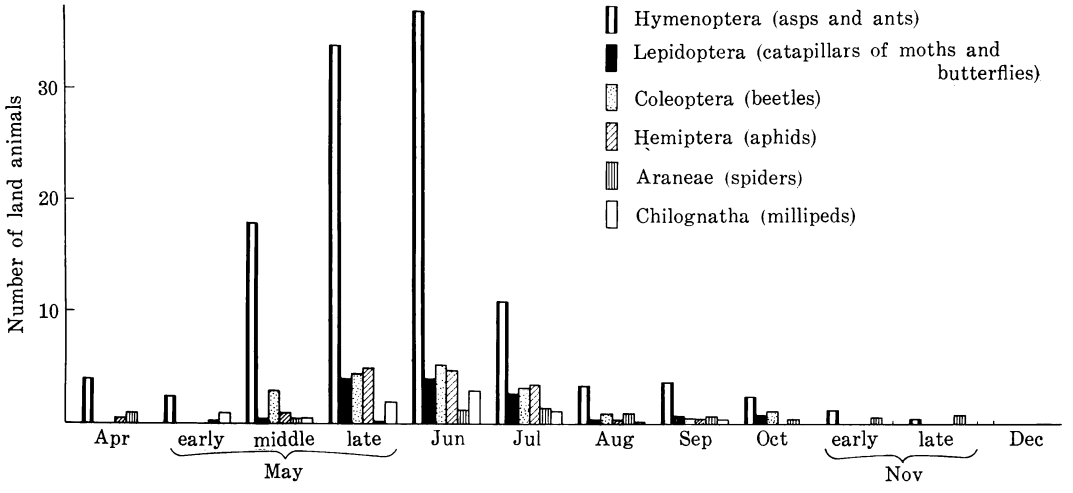

Fig. 5. The average number of the land animals per one individual of fish.

form that has a remarkably flat body. The occurrence of small burrowing worms, such as midge larvae (*Spaniotoma* sp. and *Pentaneura* sp.) in the diet of small young fish caught in autumn is remarkable in relation to the difference of the favorite food by age.

More than 140 species of land animals were taken by the char caught in spring to autumn. However, no land animals were encountered in the stomach contents of the fish in December, which might be related to disappearance of these animals in the vicinity of this tributary. Throughout the months examined, the volume and frequency of occurrence of several kinds of spiders, such as *Araneus* sp., *Tibellus* sp., *Tetragnatha praedonia*, and so on, do not show a marked seasonal change, while others reveal a tendency to concentrate toward the middle of May to July (Fig. 5). These findings might be parallel well to the period of emergence and activity of land animals. Although the highest number of individuals of smaller insects belonging to Hymenoptera (ants and wasps) and Hemiptera (*Marroscytus japonicus*,

Bothrogonia japonica, and aphids) was estimated, the volume of larval Lepidoptera (*Idiotephria ameria* and *Scythris* sp.) occupied the highest percentage of stomach contents. In this point of view, the milliped (*Oxidus* sp.) revealed a fairly high percentage. The coleopteran (*Plagiodera versicolora, Rhagonycha japonica, Rodolia limbata* and *Othiellus medius* etc.) and orthopteran (*Acrydium japonicum*) insects were also detected frequently.

Most of these species taken by the char as food are the nest-builders in and near the riverbank, and inhabitants in the moist, grassy and surface of grounds and in plant leaves. However, they include none of nicely flying insects in adult stage, such as dragonflies, cicadas, moths, and butterflies. The same is encountered in the hymenopterans: while the ichneumon flies and dirk wasps living near the riverbank, digger wasps building the underground hole as nest, and larval saw flies attached to plant leaves falled the victims to the char, no good flying wasps, such as hornet and brown one, were made a prey in the present examination.

Discussion

Generally speaking, for food analysis, samples of char obtained in the tributary of Sekigawa River both in spring and autumnal seasons contained abundant aquatic insects, whereas they included small land invertebrates inclusive of insects in summer. As these small animals emerge abundantly during early summer to midsummer in the mountainous area, this season seems to be referable to the active period of animals. Therefore, it is very natural to see that the most voluminous diet is in full accord with the species that occurs in a most abundance. The result of dominant animals from the stomach contents do not indicate the favorite foods themselves with the char. On account of no nicely flying insects as food, most of land animals eaten by the char might be derived from the individuals that are thrown down and carried away into the tributary by some physical factors or natural phenomena, such as the strong wind and a rapid flood. The fact that pieces of leaves found in the digestive tract of the char that feeds an abundance of land animals, therefore, might be interpreted as an unexpected matter on the occasion for taking the animals. The number and volume of the falling organic matters submerging or drifting in the tributary seem to be enormous, and seasonal changes of stomach contents indicate a part of changes of insect fauna in the area concerned.

If the deficiency of food in the source of the surface of water occurs in autumn to next early spring, the aquatic benthos become a single source of the prey of the char. The case-bearing caddis worms appears to be the most available one, while in addition to the creeping mayflies the net-spinning caddis and attaching gnat larvae are very scarce. Nearly identical results of feeding habits of the char have been reported by several investigators based on the materials of mountainous streamlets in the Honshū Island (Kawai, 1959; Sato, 1963; Tsuda, 1957; Komatsu, 1970). Komatsu (1970) considered that the high percentage frequency of occurrence of case-bearing caddis worms was due to the indigestion of the case or the fastidiousness of the fish. However, owing to the morphological devices of mouth of the char, it is not convenient to catch the attaching benthic animals. Further, as described previously (Honma and Tamura, 1965), the fact that the spawning male has a hooked lower jaw (kype) directed upward may be added to the situation mentioned above. Anyhow, it is necessary to secure the entire picture of fauna including drifting animals and standing crops of various environments that bring about the chars, because the feeding constituents might be varied with the characteristic of each environment or ecosystem of geographic location.

In view of the cause of postspawning death of migratory fishes under the starvation and emaciation, the appetite and feeding habit of fishes during the breeding season is of im-

portance. Although the amount of stomach contents of the mature char, in particular the larger males, is considerably little, not a single individual under the entire starvation is detected. Some of the females, on the contrary, show a comparatively large amount of contents. These findings give support to our previous interpretation from the histo-endocrinological point of view (Honma and Tamura, 1965; Tamura and Honma, 1971). Due to their continuous feeding throughout the year round, most of spent chars can survive after breeding and tide over the winter. This habit is quite different from those of migrating or annual fishes, such as Pacific salmon and ice-goby (Robertson et al., 1961; Tamura and Honma, 1970).

Literature cited

Clemens, W. A., and G. V. Wilby. 1949. Fishes of the Pacific coast of Canada. Fish. Res. Bd. Canada, Bull., 68 : 1–368, figs. 1–253, pl. 1.

Honma, Y. and E. Tamura. 1965. Studies on the Japanese chars, the Iwana (Genus *Salvelinus*). I. Seasonal changes in the endocrine glands of the Nikkō-iwana, *Salvelinus leucomaenis pluvius* (Hilgendorf). Bull. Japan. Soc. Sci. Fish., 31(11) : 867–877, figs. 1–16.

Kawai, T. 1959. Foods of *Salvelinus pluvius* of the streams connecting with Lake Otori-ike. Japan. J. Limnol., 20(4), 167–173, figs. 1–2. In Japanese with English summary.

Komatsu, T. 1970. Foods of *Salvelinus leucomaenis pluvius* (Hilgendorf), *Oncorhynchus rhodurus* f. *macrostomus* (Günther) and *Tribolodon hakonensis* (Günther) in the river Otakigawa, Nagano Prefecture, Japan. Collect. Breed., 32(6) : 202–206, figs. 1–9. In Japanese.

Leim, A. H., and W. B. Scott. 1966. Fishes of the Atlantic coast of Canada. Fish. Res. Bd. Canada, Bull., 155 : 1–484, figs. 1–263, pls. 1–4.

McBride, J. R., U. H. M. Fagerlund, M. Smith, and N. Tomlinson. 1963. Resumption of feeding by and survival of adult sockeye salmon (*Oncorhynchus nerka*) following advanced gonad development. J. Fish. Res. Bd. Canada, 20 (1) : 95–100, figs. 1–5.

McBride, J. R., U. H. M. Fagerlund, M. Smith, and N. Tomlinson. 1965. Post-spawning death of Pacific salmon: sockeye salmon (*Oncorhynchus nerka*) maturing and spawning in captivity. J. Fish. Res. Bd. Canada, 22(3) : 775–782, figs. 1–6.

McPhail, J. D., and C. C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fish. Res. Bd. Canada, Bull., 173 : 1–381, figs. 125, pls. 165.

Nilsson, N. A. 1965. Food segregation between salmonoid species in north Sweden. Rep. Inst. Freshwater Res. Drottningholm, 46 : 58–78.

Nishio, S. 1934. Studies on feeding habits of the Dolly Varden (*Salvelinus malma* Walbaum) in summer season. Japan. J. Limnol., 3(3) : 62–70. In Japanese.

Okada, Y. 1959–1960. Studies on the freshwater fishes of Japan. pts. 1–3, 1–860, 61 pls.

Robertson, O. H., M. A. Krupp, S. F. Thomas, C. B. Favour, S. Hane, and B. C. Wexler. 1961. Hyperadrenocorticism in spawning migratory and nonmigratory rainbow trout (*Salmo gairdnerii*); comparison with Pacific salmon (Genus *Oncorhynchus*). Gen. Comp. Endocrin., 1(5) : 473–484, figs. 1–7.

Roos, J. F. 1959. Feeding habits of the Dolly Varden, *Salvelinus malma* (Walbaum), at Chignik, Alaska. Trans. Am. Fish. Soc., 88 : 253–260.

Sato, T. 1963. Studies on so-called gogi (*Salvelinus pluvius* (Hilgendorf)) in Hiroshima Prefecture. Mem. Cultur. Prop. Hiroshima Pref., Ser. 3, Nat. Monum., 3–30, 5 pls. In Japanese.

Suyehiro, Y. 1942. A study on the digestive system and feeding habits of fishes. Japan. J. Zool., 10(11) : 1–303, figs. 1–190, pls. 1–15.

Tamura, E., and Y. Honma. 1970. Histological changes in the organs and tissues of the gobiid fishes throughout the life-span—II. The hypophysial target organs of the ice-goby, *Leucopsarion petersi* Hilgendorf. Japan. J. Ichthyol., 17(1) : 29–36, fig. 1, pls. 1–2.

Tamura, E. and Y. Honma. 1971. Histological changes in the organs and tissues of the gobiid fishes throughout the life-span—IV. Digestive organs of the ice-goby, *Leucopsarion petersi* Hilgendorf. Bull Japan. Soc. Sci. Fish., 37(9) : 831–839, figs. 1–16.

Tsuda, M. 1967. Consideration on the contents of alimentary canals of *Salvelinus leucomaenis pluvius* and *Oncorhynchus masou* f. *masou* from the Ina-gawa River system. Japan. J. Limnol., 28(1) : 51–55, fig. 1. In Japanese with English summary.

(Department of Biology, Faculty of Science, Niigata University, Niigata, Japan)

日本産イワナ属魚類に関する研究—VI. イワナの食性

本間 義治・帆苅 信夫・田村 栄光

1964 年 4 月から 12 月までの間に，上信越高原国立公園の妙高山麓を流れる関川の 1 支流から採集したイワナ 106 個体の消化管内容物を調べた．秋から翌春までの冬

季は，水生底生動物が主要食餌であり，5 月中旬から盛夏にかけては，陸上昆虫の摂食量が増加する．これらの陸上昆虫は，川岸近辺に巣孔をもつ種類が多く，好飛翔性のものは含まれていない．また，捕食されていた水生昆虫は，携巣型のトビケラが大半を占めていた．このことは，イワナが好んで選択的にトビケラなどを捕えるのではなく，むしろ餌料生物のおかれた状態に基づく利用容易性に起因しているらしい．なお，産卵期でも成熟成魚が摂食活動を続けていることは，非洄遊性イワナに産後斃死の現象が見当らないこ卵とと関連して，注目される．

(新潟市五十嵐二ノ町8050　新潟大学理学部生物学教室)