

XXXIV.—THE FOOD AND MODE OF LIVING OF THE SALMON, THE TROUT, AND THE SHAD.

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PREFATORY NOTE.

A few preliminary remarks are demanded in explanation of this article. The question investigated is whether the catching of what is called "Rümpchen" in certain parts of Germany (and in this case in the vicinity of Bonn) is injurious in reference to the species of economical importance. As the investigation has reference to forms or combinations which have certain technical designations without exact English synonyms, those designations are retained in the translation. They may be explained as follows :

"Rümpchen" is the collective name for small fresh-water fishes in Western Germany, and under it are confounded small full-grown fishes as well as the young of larger species. There is no exact English equivalent for the term ; the word "minnows" being restricted properly to small cyprinoids, while "fry," although sometimes used as a collective name for small fishes, is in intention applicable rather to the very young of various species.

It has been also deemed expedient to retain the German names of the several species in question. These, however, have exact English synonyms, viz :

The "Lutter-Rümpchen," or "Süsse Rümpchen," (*Cobitis barbatula*,) is the "loach" of the English.

The "Riedlingchen," or "Bitter-Rümpchen," (*Phoxinus phoxinus*,) is the "minnow" of the English.

The "Güwehen" (*Gobio flunaticus*) is the "gudgeon" of the English.

The "Kaulkopf" (*Uranidea* or *Cottus gobio*) is the "miller's-thumb" of the English.

The word "Gesams" corresponds as nearly as may be with the English word "fry."

The species whose food has been especially examined have been named in accordance with the views of Siebold, and are respectively

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(1) the salmon, (2) the sea-trout, (3) the common river-trout of Europe, and (4) the Alice shad. These, in accordance with the nomenclature generally prevalent, are (1) *Salmo salar*, (2) *Salmo trutta*, (3) *Salmo fario*, and (4) *Alosa vulgaris*. The old genus *Salmo* has been differentiated by Siebold into two genera: (1) *Salmo*, including the charrs and hucho, distinguished by the vomer being abbreviated, the anterior short portion thereof alone armed with teeth, the hinder longer portion (shaft) being wholly toothless in the old as well as in the young; and (2) *Trutta*, including the salmon, sea-trout, river-trout, and related species, whose vomer is elongated, (the anterior short portion being with or without teeth,) and the hinder elongated portion (shaft) armed along its entire length with teeth, which, however, in the very old are more or less lost. These would respectively correspond to (1) *Salvelinus* Bon. emend. (= *Salmo* Siebold) and (2) *Salmio* Linn. Bon. emend. (= *Trutta* Siebold).

The "Maifische" of the Germans is the common shad or Alice shad of the English, (*Alosa vulgaris*), and is very closely related to the shad of the American coast (*Alosa sapidissima*).

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INTRODUCTION.

In the year 1852, the Prussian government proposed to forbid the "Rümpchen-fishery," as it was believed that, in consequence of such fishery, species which when larger might be useful were destroyed. Professor Troschel, of Bonn, thereupon examined the young fish which, under the name of "Rümpchen," are brought to market, and found that the "Lutter-Rümpchen," or "Süsse Rumpchen," was the *Cobitis barbatula* L., the "Riedlingeßen" or "Bitter-Rümpchen," the *Phoxinus phoxinus* Ag., the "Güwchen," the *Gobio fluviatilis* C., and the "Kaulkopf," the *Cottus gobio* L. The "Rümpchen," brought to market under the name of "Gesams," consist, according to Troschel, of the young of all the fish living in the river Ahr; consequently, besides the young of the species mentioned, those of *Alburnus lucidus* H., *Squalius cephalus* L., *Leuciscus rutilus* L., *Barbus fluviatilis* Ag., and *Trutta fario* Lin.¹ (Siebold.) On the strength of these investigations,² Troschel declared that, as most of the "Rümpchen" are entirely worthless for fishery-purposes, they might be caught without any injury to the fisheries. But when this problem had been solved, the assertion was made that it would, nevertheless, be injurious to catch the "Rümpchen," because thereby the better kinds of fish were deprived of their necessary food,³ and the philosophical faculty of the Friedrich-Wilhelms University of Bonn, during the year 1873-74, proposed a prize for answering the following questions:

"It is asserted that the catching of 'Rümpchen,' although these fish are in themselves worthless, still proves injurious to the Rhine fisheries, because the larger fish, *Salmo salar*, *Salmo hamatus*, and *Salmo fario*, are thereby deprived of their most necessary food. The salmon go into the sea, where they feed on other fish, and only come into the rivers for the purpose of spawning. The trout always keep in the mountain-brooks. By examining the entrails of the above-mentioned fish at different seasons of the year, it is to be ascertained of what their food consists while in fresh water, in order to decide whether it is injurious to the fisheries to catch 'Rümpchen.' It is desired to extend these investigations to the 'Maifische,' (*Alausa vulgaris*,) as these likewise live in the sea and only ascend the rivers in May."

¹*Salmo fario* of most authors, the common trout of Europe.

²Published in "Verhandlungen des naturhistorischen Vereins der Preussischen Rheinlande und Westphalens," 8 Jahrg., Bonn, 1851, p. 563.

³Siebold, Die Süßwasserfische von Mitteleuropa, Leipzig, 1863, p. 420.

With a view to answering the above questions as far as possible satisfactorily, I have made the following investigations:

I.

THE FOOD OF TRUTTA SALAR SIEBOLD, (*Salmo salar* AND *hamatus* Val.) AND TRUTTA TRUTTA SIEBOLD (*Fario argenteus* Val.) IN THE RIVER RHINE.

The fishes belonging to the genus *Salmo* occurring in the Rhine are, by the fishermen, distinguished as "Salm," "Lachs," and "Lachsforelle." The Lachsforelle has been described as *Fario argenteus* by Valenciennes,¹ and as *Trutta trutta* by Siebold.² But, respecting the proper ichthyological definition of the species which are brought to market under the popular name of "Salm" and "Lachs," the views of zoologists still differ considerably. Cuvier was the first to distinguish two species, and Valenciennes described them at length as *Salmo salmo*, *le saumon commun*,³ and *Salmo hamatus*, *le bécard*.⁴ He was followed by Heckel and Kner,⁵ Troschel,⁶ and others; while Agassiz considered the *Salmo hamatus* as the old male of the *Salmo salar*, and recognized only this latter species. The same view was taken by Siebold,⁷ Günther,⁸ and many others.

Such a diversity of opinions seems surprising, as the question is about such valuable and well-known fishes. It must, however, be remarked that no other genus of fishes has given the ichthyologists so much trouble as the genus *Salmo*. Even such a thorough systematist as Günther⁹ says: "There is no other group of fishes which offers so many difficulties to the ichthyologist with regard to the distinction of the species, as well as to certain points in their life-history, as this genus."

Although a critical examination of these different views, properly speaking, does not come within the reach of this treatise, and would lead us too far, the nature of the question demands that I take my part in this dispute.

After the investigations which I have made in this matter, I agree with Agassiz and Siebold; *i. e.*, I recognize only one species, viz, the *Salmo salar*. My reasons for this I will state in brief.

Valenciennes mentions the following chief distinguishing marks between *Salmo salar* and *Salmo hamatus*:

1. The *Salmo hamatus* has more pyloric cœca (*appendices pyloricæ*) than the *Salmo salar*.¹⁰

¹ Valenciennes, Histoire naturelle des poissons, Paris, 1848, tome xxi, p. 294.

² Siebold, op. cit., p. 314.

³ Valenciennes, op. cit., p. 169.

⁴ Valenciennes, op. cit., p. 212.

⁵ Heckel and Kner, Die Süßwasserfische der österreichischen Monarchie, Leipzig, 1858, pp. 273 and 276.

⁶ Troschel, Handbuch der Zoologie, 7th ed., 1871, p. 266.

⁷ Siebold, op. cit., p. 293.

⁸ Günther, Catalogue of the fishes in the British Museum, London, 1866, vol. vi, p. 11.

⁹ Günther, op. cit., p. 3.

¹⁰ Valenciennes, op. cit., pp. 176 and 217.

2. The *Salmo hamatus* has invariably only one tooth on the front plate of the vomer, while the *Salmo salar* has several teeth.¹

3. The *Salmo hamatus* has a reddish-gray back, the color becoming more lively on the lower portions of the sides; the color of the belly is a dull white. The *Salmo salar*, on the other hand, is slate-colored on the back, of a subdued silver-color on the sides, and of a silvery-white, shining like mother of pearl, on the belly.²

4. The flesh of the *Salmo hamatus* has much less color and is drier than that of the *Salmo salar*.³

5. The *Salmo hamatus* has at the end of the lower jaw a protuberance, ("tubercule,") which, when the mouth is closed, fits exactly into a considerable concavity ("enfoncement considérable") of the upper jaw.⁴ The lower jaw thus forms a projecting hook, so that the upper and lower jaws cannot be pressed against each other. The *Salmo salar* does not have this hook.

With regard to the above assertions, the following remarks are to be made:

To 1: The number of pyloric cæca in one and the same species of salmon varies greatly.⁵

Valenciennes found in the *Salmo salar* 60 and in the *Salmo hamatus* 67 *appendices pyloricæ*. In the enumerations which I have made, I was led to the result that in the salmonoids which *Valenciennes* differentiated as two species, the number of cæca is no safe distinctive character, as it varied from 56 to 72, and was frequently larger in those which had no hook than in the so-called "hook-salmon." *Günther* states that the number of cæca varies from 53 to 77; *Richardson*,⁶ from 63 to 68. *Kner*⁷ has also shown that the number of cæca in one and the same species of salmonoids is extremely varying.

To 2: The arrangement of the teeth on the vomer has been erroneously described by *Valenciennes*, as has been shown by *Siebold*.⁸ The short front plate (*chevron*) of the vomer of the *Salmo salar* (and the *S. hamatus*) is invariably toothless, and only the long point of the vomer has teeth. But, as the fish grows older, these teeth fall out gradually, and no new ones take their place, so that an entirely toothless vomer is frequently found in old fish. It is evident from this—as I also found in my investigations—that the number of vomerine teeth differs very much. In our Bonn Museum, there are two old specimens, labeled

¹ *Valenciennes*, op. cit., pp. 172 and 213.

² *Valenciennes*, op. cit., pp. 174 and 217.

³ *Valenciennes*, op. cit., p. 222.

⁴ *Valenciennes*, op. cit., p. 215.

⁵ *Siebold*, op. cit., p. 314.

⁶ *Günther*, op. cit., p. 13.

⁷ *R. Kner*, Über die Verschiedenheiten der Blinddärme bei den Salmonen (in "Sitzungsberichte der mathem.-naturw. Classe der kaiserl. Akademie der Wissenschaften," vol. viii, 1852, p. 201).

⁸ *Siebold*, op. cit., p. 301.

"*Salmo hamatus*," of which the one has only two teeth in the vomer, and the other none at all. A younger specimen, marked likewise *Salmo hamatus*, has four teeth in two rows, one behind the other; while another somewhat younger specimen, marked *Salmo salar*, has only two vomerine teeth.

It is not necessary to go into further details, as *Siebold* has explained this whole matter sufficiently, and has satisfactorily proved *Valenciennes's* errors.

To 3: "In none of our native fish is there such variety of color, according to the different influences of food, water, light, and temperature, as in the toothed salmon."¹ *Günther* likewise lays special stress on this change of color in the *Salmo salar*. Scientifically, we are scarcely justified in distinguishing two different species merely on account of this difference in color, when the other distinguishing marks cannot be sustained.²

To 4: *Bloch* has shown how much the color and quality of the flesh varies in one and the same species of salmonoids.³ *Siebold* likewise, in several places,⁴ has directed attention to this peculiar variation. It must also be borne in mind that in all species of animals the flesh of old ones⁵ which have propagated for many years has become of an inferior quality. It is well known that the Rhine salmon is more savory than that of the Oder, the Weser, and the Vistula; but nobody ever entertained the idea that they were different species.

To 5: The projecting hook of the lower jaw in some specimens is so peculiar, that certain ichthyologists were thereby induced to distinguish a separate species—*Salmo hamatus*, *i. e.*, the hooked salmon. But *Bloch* had already proved that these hooks occur only in old male fish. *Agassiz*, all the modern English ichthyologists,⁶ *Siebold*,⁷ *Schlegel*,⁸ and others are of the same opinion. The observations which I made on this point, and the information which I gathered from experienced fishermen, led to the same result: the hook is only found in male fishes, and—I must emphasize it—only in such as have milt nearly ready for impregnation. I have, by observing a large number of specimens, convinced myself that this hook gradually forms in the male fish as it is growing old and the milt is getting mature; fishermen, by this mark, distinguish even the young male from the young female. If, therefore, *Valenciennes* (p. 213)

¹ *Siebold*, *op. cit.*, p. 276.

² I may as well remark here that, according to my observations, this difference of color, which *Valenciennes* considered as a distinguishing mark of the species, can only serve as such for distinguishing the fruitful specimens of the *Salmo salar* from temporarily barren ones.

³ *Bloch*, *Oekonomische Naturgeschichte der Fische*, Berlin, 1782, p. 139.

⁴ *Siebold*, *op. cit.*, pp. 276, 299, &c.

⁵ It will be presently seen why I only speak of old animals.

⁶ *Valenciennes*, *op. cit.*, p. 224.

⁷ *Siebold*, *op. cit.*, p. 293.

⁸ *Schlegel*, *De Dieren van Nederland; Visschen*, p. 127.

says that the female has just as strongly curved a hook, it must be considered an error. Why this peculiarity occurs only in the one sex and not in the other has not yet been explained. It has been said that too long a sojourn in fresh water, and swimming against the stream, had caused it; but there is no reason why the hook should not develop itself just as much in the female as in the male.

This hook occurs likewise in the lower jaw of the males of other species of salmonoids. Thus, *Wartmann*¹ has found it in *Trutta lacustris* (*Siebold*); *Heckel*,² in *Trutta fario* (*Siebold*); he also thinks that this peculiarity is found in most of the species of the salmonoids.

On the strength of these facts, I must presume that of the salmonoids belonging to the ocean only two species occur in the Rhine: 1. The "Lachsforelle," (sea-trout,) *Fario argenteus* Val.; *Trutta trutta* according to *Siebold*; 2. The "Salm," (salmon,) *Salmo salar* Lin.; *Trutta salar* according to *Siebold*. I cannot in this place refrain from making the remark that people have been induced to accept the two species, *Salmo salar* and *Salmo hamatus*, only by the occurrence together of fruitful and temporarily barren specimens of one and the same species of *Salmo salar*.

Henceforth, I shall exclusively use *Siebold's* nomenclature, as by his investigations the position of our salmonoids in the general system has been definitely settled.

I now turn to the investigation of the food of *Trutta trutta* and *Trutta salar* in fresh water—the Rhine.

The question, What is the food of our salmonoids in fresh water and in the ocean, is not only of scientific but also of great economical interest. It is, however, very strange that the ichthyological works contain scarcely any or wrong data regarding this point.

Valenciennes speaks only in one place of the food of *Trutta salar*:³ "La nourriture consiste en poissons et l'on dit qu'il préfère l'ammodite—*Ammodytes tobianus*." As the fish in question (Sard-launce) lives in the North Sea and in the Baltic, this fact would refer to the food of the fish while in the ocean; but nothing is said regarding its food in fresh water.

Figuièr, on the other hand, says:⁵ "On n'a pu faire jusqu'ici que des conjectures sur leur genre d'alimentation dans la mer, mais on est plus instruit de leur manière de vivre dans les eaux douces (?). Pendant leur premier âge, ils vivent d'insectes, de frai, et aussi de petits poissons, des qu'ils ont atteint une certaine taille. À l'état de grilse et à l'état

¹ *Wartmann*, Von den Rheinanken oder Ilanken, in "Schriften der Berlinischen Gesellschaft naturforschender Freunde," vol. iv, 1783, p. 55. (Quoted from *Siebold*, op. cit., p. 32.)

² *Heckel*, Bericht einer ichthyologischen Reise, in the "Sitzungsberichte der kaiserl. Akademie der Wissenschaften," vol. viii, 1852, p. 355.

³ *Valenciennes*, op. cit., p. 197.

⁴ Its food consists of fish, and it is said that it prefers the Sard-launce-*Ammodytes tobianus*.

⁵ *Figuièr*, La vie et les mœurs des animaux, Paris, 1868, p. 106.

adulte ils devorent une foule de poisson (?)."¹ *Bloch*² says that the salmon lives on small fish, aquatic insects, and worms, and that it could be enticed by dragon-flies, worms, and small fish if these were attached to the hook (?).

In *Heckel and Kner's* work,³ I find, regarding the food of *Trutta trutta*, only the very general remark that "it is a powerful fish of prey." *Siebold's* excellent work⁴ contains several observations regarding the food of our salmonoids while in fresh water.⁵ The most important, and, as will be seen afterward, the most correct, (p. 246,) is the following: "I cannot in this place pass over in silence the fact that in observing and describing the digestive organs of the salmonoids, no attention whatever has been paid to the circumstance that these fishes do not eat anything before and during their spawning-season, but are merely intent upon spawning, during which process their empty stomach is unusually contracted; the '*appendices pyloricæ*' and the gut itself being filled only with the different secretions of the digestive organs." From the following, it will be seen whether and in how far the remarks of the above-quoted ichthyologists are correct.

On the 20th September, 1873, I examined the stomachs of the first two specimens of *Trutta salar*, which had been caught in the Rhine, in the neighborhood of Bonn. They were female spawn-salmon ("*Laichsalme*"); *i. e.*, salmon which had ascended the Rhine for the purpose of spawning. The eggs of both these specimens were of the size of a pea, and ripe for impregnation. The sides of the stomach were strongly contracted, and the pyloric cœca were exposed; *i. e.*, they were not covered with masses of fat, as is the case with other specimens—as I shall detail later—of the same species. The section of the whole digestive organs showed the following: The œsophagus and the stomach itself contained nothing but the secretion of the mucous membrane, a white and mostly very sticky mucus, which is always there, whether there is food in the stomach or not. At the place where the stomach proper joins the intestine, and where the "*appendices pyloricæ*" commence, this mucus increased in quantity, and at the same time assumed a yellowish-green

¹ So far, we have only been able to to make conjectures regarding their food while in the ocean, but we are better informed regarding the mode of living while in fresh water (?). When quite young, they feed on insects, spawn, and small fish, until they have attained to a certain size. In their third year and when fully grown, they devour great quantities of fish (?).

² *Bloch*, *Oekonomische Naturgeschichte der Fische*, Berlin, 1782, pp. 135 and 137.

³ *Heckel and Kner*, *op. cit.*; p. 266.

⁴ *Siebold*, *op. cit.*, pp. 246, 276, 299, &c.

⁵ After I had completed this treatise, there appeared in the "*Acta Universitatis Lundensis*," Lund, 1871-'72, a work by *P. Olsson*—*Jakttagelser öfver skandinaviska Fiskar Föda*—in which I find very valuable information regarding the food of *Trutta salar* and *Trutta trutta* while in the ocean. I shall again refer to this work, as this information has enabled me to give fuller details in one place.

color from the secretions of the "*appendices*," these themselves being filled with the same matter. Nearer to the anus, this mucus became darker, and finally assumed a reddish-black color. In no part of the whole digestive organ did I find anything which might lead to the supposition that any solid food had been taken. Near the pylorus, I found in one of the specimens several tapeworms (*tania*) with their heads sticking in the appendices. In the tissues surrounding all these organs, but more especially in the pyloric cœca, I found a large number of entozoa.¹

I have continued these investigations during the months of September, October, November, and December, and invariably with the same result.

The digestive organs of *Trutta trutta* likewise showed the characters detailed above. In both species, males as well as females, in such as had already propagated their kind and likewise in such as still contained roe or milt, the character of the stomach and intestine was exactly the same as that of the first two specimens of *Trutta salar* examined by me; and I never found any food or anything which might be considered as remnants of food. Three times I thought I had found a fishbone, but a closer examination showed it to be particles of wood or bast which had become enveloped in mucus, and stuck to the side of the stomach or gut. The thick or corky cellulose had withstood the digestive power, which at any rate had been reduced to a minimum, and no new food had been taken in through which these indigestible particles could have been carried out. Up to the beginning of January, 1874, I thus examined stomachs of forty-four such spawn-salmon ("Laichsalme")—*Trutta salar* and *Trutta trutta*—and never found any food. I must here state expressly that these investigations were made during the spawning-season proper of both species.²

In the following, only *Trutta salar* is spoken of, as *Trutta trutta* ascends the Rhine for the purpose of spawning only till the beginning of January. From January on, salmon (*Trutta salar*) are but rarely caught in the neighborhood of Bonn, while on the Lower Rhine (near Wesel) many are caught about this season. In Wesel, I succeeded in obtaining

¹ Regarding these, as well as the entozoa which I found in those species of fish which I examined later—*Trutta fario* and *Alausa vulgaris*—see Gurlt's "Verzeichniss der Thiere, bei welchen Entozoen gefunden worden sind" in Wiegmann's "Archiv für Naturgeschichte," XI Jahrg., vol. i, 1845, p. 223.

² The spawning-season of the salmon extends, according to *Falencinnes*, (p. 179,) from the end of May till the end of February; according to *Sibold*, (p. 299,) from May till November. According to the information which I gathered from experienced fishermen and my personal observations, a spawn-salmon is scarcely ever seen in the Rhine before the end of August. Those which show themselves in the Rhine at an earlier date do not ascend the river for the purpose of spawning. As I have never seen a spawn-salmon after the 10th January, I feel justified in assuming that the spawning-season proper extends from the beginning of September till the beginning of January. This explains the fact that the season when the Dutch are not permitted to fish for salmon lasts from September 15 till November 15.—(From information communicated by Mr. *Lisner*, a fish-merchant of Wesel.)

and examining stomachs of several specimens.¹ All these salmon, and also those which I saw in March, May, and June, showed a very striking difference from those which had been caught during the spawning-season proper. The fishermen call them "*Wintersalme*"² (winter-salmon). They are highly esteemed on account of their excellent flavor, which far exceeds that of the spawning-salmon, (at least during the spawning-season proper,) and the character of their inner parts likewise differs very much from that of the latter.

This winter-salmon is found in the river nearly all the year round, as well as during the spawning-season proper,³ but is specially called "*Wintersalm*" by the fishermen during the winter-months, when its flesh is of the finest quality.

When I said before that the inner parts of these fish differ very much from those of the spawn-salmon, I referred to the sexual organs and the surroundings of the entrails. Of the former difference I shall speak later, and will confine myself here to the latter. The whole fish has a much better and fatter texture than the spawn-salmon, and its entrails are entirely overgrown with fat, so that the united appendages of the upper portion of the intestine (the *appendices pyloricæ*) resemble a lump of fat.⁴ When I commenced to examine the stomach, I obtained nearly the same result as in my examination of the spawn-salmon; for in by far the majority of cases no trace of food could be discovered. In one stomach, I found parts of the hard covering and of the wing of a beetle; and in another, the skin of an insect-larva, which could not be satisfactorily identified. In a third specimen, I found, in the back part of the intestinal canal, the scale of a fish, seemingly a cycloid scale. It was lying behind one of the numerous ring-shaped lids, which are found all through the lower portion of the intestinal canal, and had not yet been expelled with the other excrements.

Besides these, I examined twenty-three stomachs, but found no remnants of food. The three fish in whose digestive organs I found some

¹Through the kindness of Mr. *Ridder*, of Wesel. In Bonn, I obtained the material for my investigations chiefly through Mr. *Brenner*, but in part from Mr. *Schumacher*. I must also thank the following-named gentlemen for much valuable information concerning the food of the Salmon: Messrs *Lisner* and *Ridder*, in Wesel; *Brenner*, in Bonn; *Josten*, in Dinslaken; and *Remmings*, in Ruhrort.

²In this and the following I make a distinction between *Wintersalme* and *Laichsalme*, although they both belong to the same species, viz, *Trutta salar*. I shall later characterize this distinction more exactly; but I may state here that by *Laichsalme* I mean those fish which, during the spawning-season, ascend the rivers for the purpose of spawning, while I call *Wintersalme* those which, from October on, appear nearly all the year round, and which do *not* come directly for the purpose of spawning, as their sexual organs are entirely undeveloped from October to May, and only begin to develop from the month of May.

³Mr. *Ridder*, of Wesel, got the first *Wintersalm* on the 3d October, and Mr. *Brenner*, of Bonn, on the 6th October, 1873.

⁴There are such large quantities of fat, that it is extracted by boiling, and used for various purposes.—(According to information received from Mr. *Lisner*, of Wesel.)

remnants of food had been caught near Wesel. The food may therefore have been taken partly in the mouth of the Rhine and partly in the ocean.

I will here mention an interesting observation, which was communicated to me by the Messrs. *Ridder* and *Lindner*. The Dutch fishermen have occasionally found in the stomachs of those salmon which were caught near the mouth of the Rhine remnants of fish which they said came from the herring (*Clupea harengus*). But, according to the unanimous testimony of the fishermen, there never were found remnants of fish or any other food in the stomachs of salmon which had ascended higher up the Rhine. This observation agrees in every particular with those made by me.

These investigations therefore lead me to the following result: *Trutta salar* and *Trutta trutta*, while in the Rhine, do not take food at any season of the year, which explains the fact that all attempts to keep salmon and raise them artificially in fresh water have proved failures.¹ There are artificial hatching-establishments (*e. g.*, in Hüningen, near Strasburg, and in Arnheim) where the ripe salmon-eggs are artificially impregnated and hatched, and where the young salmon, called *Sälmlinge*, [in English samlets,] obtained in this manner, are kept for some time (perhaps one to three years); but, if these fish are to become full-grown salmon, they must be let loose so that they can reach the ocean, there to feed and grow. A friend of mine communicated to me the following: The institution near Arnheim, on the Yssel, has, during this spring, artificially raised 300,000 young salmon and placed them in the Yssel. These are to go to the ocean, return to the Yssel² during the following years, and then be caught as salmon. The young salmon are fed in the water of the Yssel, which is pumped into reservoirs from the river, and then led through the tanks in which the fish are kept. They are not supplied with any food, but find it in the water (infusoria, larvæ, &c.) If these young salmon are to be sent away, they are placed in special boxes, and fed on calves' brain and worms.

The following observation, communicated by *Sander* in the "Naturforscher,"³ is explained in the same manner: "A reliable fisherman kept young salmon for many years, and fed them—on what? Unfortunately, he did not inform me. He paid great attention to them, but found that

¹ *Günther* says on this point, (p. 9:) "The question whether any of the migratory species (of the genus *Salmo*) can be retained in fresh water, and finally accommodate themselves to a permanent sojourn therein, must be negatived for the present."

² It may be considered as an established fact that the salmon return to the river in which they were born and raised. In Brittany, a dozen young salmon were marked with copper rings on the tail. Of these, five were caught in the following year, three in the second, and three in the third.—(*Cornelius*, Zug- and Wanderthiere, Berlin, 1865, p. 202.) During the summer of 1873, 500 young salmon, twenty-one months old, 5 to 6 inches long, were marked and placed in the Rhine, in order to ascertain whether they will return to the same river.—(From a newspaper.)

³ *Der Naturforscher*, 15. Stück, 1781, p. 176.

not only did they not grow larger, remaining always the same size, but also that they did not increase at all in number."

Siebold has therefore come nearest the truth regarding the salmonoids found in the Rhine, (*Trutta salar* and *Trutta trutta*,) when he says that the salmon just before and after their spawning-season do not eat anything for weeks. I even go a little further, and maintain that these salmonoids do not eat at all as soon as they have entered the Rhine from the ocean.¹

The circumstance that, as I mentioned above, I found remnants of food in the stomachs of three winter-salmon is not against, but rather in favor, of my assertion. These three salmon were caught below Wesel, therefore comparatively near the mouth of the Rhine. The food whose few undigested remnants I found might therefore have been taken in the ocean, or when the fish had not yet lived in fresh water for any length of time,² and the desire for food had not yet become quite extinct. The best proof of it is the fact that nothing was found in the stomachs of those salmon which had been caught farther up the Rhine. This likewise explains, in a very simple manner, the above-mentioned observation of the fishermen, that the stomachs of those salmon which are caught in Holland near the mouth of the Rhine occasionally contain parts of fish.

The result of this whole investigation is therefore the astonishing fact, that fish which stay in the Rhine a long time, and move about a great deal and in a very vigorous manner,³ take no food at all.

Such a very astonishing fact might well awaken the belief among the common people that the salmon digests everything it eats in three minutes (!), although this is a physiological impossibility.⁴ I myself for a moment entertained the thought that the salmon might be able to digest food taken after it had been caught, as it is frequently kept alive in the fish-tanks for some time. But the fact that most salmon are killed by the fishermen immediately after they are caught by being

¹ It certainly does not follow directly from my investigations that they do not eat anything at all in fresh water; but it is very probable that the facts are the same in the Oder, Elbe, Weser, Vistula, and other rivers frequented by the salmon. (Of the English rivers, I shall speak below.)

² This would apply to those two specimens in whose stomachs I found remnants of insects, as no insects live in the ocean.

³ See, on this point, *Siebold*, op. cit., p. 297; *Valenciennes*, op. cit., pp. 194, 200, &c.

⁴ *James G. Bertram* (*The Harvest of the Sea*, London, 1865) says "that one gentleman who writes on this subject accounts for the emptiness of the stomach by asserting that the salmon vomits at the moment of being taken" (p. 192). Independently of the fact that the fishermen know nothing of this strange act of vomiting, the salmon could not well empty its intestines in this manner. But remnants of food are found neither in the intestines nor in the stomach. *Bertram*, whose book I unfortunately only got after I had finished my treatise, confesses that hundreds of fish had been examined, and that but rarely traces of food had been found. He likewise confesses that the salmon does not grow in fresh water, and still he asserts that it takes food when in fresh water. A recent publication will oblige me to refer once more to this point.

knocked on the head, and that their stomachs never contain remnants of food, militates against that supposition. All the fishermen whom I questioned assured me that they never had found food in the salmon even if cut open immediately after having been caught.

In view of this remarkable fact, two questions naturally arise: 1. How can the salmon live for a comparatively long time without food without (as is the case at least with the winter-salmon) growing visibly thinner? 2. How does it happen that the salmon does not eat any more after having entered fresh water? The first of these questions is less difficult to answer than the second. I shall now briefly examine the first.

It is well known that the change of matter (*Stoffwechsel*) and the heat of the animal body resulting from it reach their highest degree in birds and mammals, but that they are much less in amphibious animals and fishes, because the organs of respiration and of circulation are much less complete in those vertebrates than in the two higher classes. This also explains the well-known fact that amphibious animals and fishes can live without food for a much longer time than the higher vertebrates. This circumstance, however, does not yet sufficiently explain the fact that the salmon can live so long without food without growing visibly thinner, as the winter-salmon. One might feel tempted to think of the somewhat analogous winter-sleep of many animals, if this was not made impossible by the violent motions of the salmon. If the swimming and leaps of the salmon, like every motion of this kind, are nothing but a change from the molecular to the mass motion, and if this molecular motion can only be the result of a burning process, there must be some matter which makes such a burning process possible; and if this matter is not, as is usually the case, supplied by the taking of food, the body itself must furnish it; and this is actually the case with the salmon. As regards the winter-salmon, I have stated above that its stomach is surrounded by a very considerable mass of fat. This fat forms, so to speak, the reserve fund from which the expenses of this burning process are paid. This fund is large, and lasts long enough to make the winter-salmon during all the time of its sojourn in the Rhine (which is not as long as is generally supposed) a highly-esteemed fish.

The case is different with the spawn-salmon. When it ascends the Rhine, its eggs are already as large as pease, and the milt is almost ready for impregnating. Even while out in the ocean, the inner organs were chiefly engaged in developing the eggs and the milt. On entering the Rhine, it is well developed, but compared to the winter-salmon it has only a small reserve fund. This is considerably diminished by the very violent motions of the fish, and the remainder is so completely used up in fully forming the sexual organs that the quality of the flesh deteriorates considerably, and the fish becomes weak and miserable. It is, therefore, not astonishing to see these fish, after having finished spawn-

ing, utterly exhausted, "flottant à la surface de l'eau sans faire aucun mouvement; on peut les prendre alors facilement à la main."¹

As regards the second question, how does it come that the salmon does not eat anything in fresh water, there are two ways of explaining this fact. Either the fresh water (the Rhine) does not offer any suitable food, so that it cannot eat anything, or the salmon on entering the fresh water loses all desire for food, so that it does not want to eat anything. Regarding the first point, it is well known that the Rhine at any rate does not offer much food for fish. The salmon, especially, finds but little of its favorite food in the Rhine. *P. Olsson*² has made observations regarding the food of different species of fish on the coast of Scandinavia, and has, among the rest, also examined twelve specimens of *Trutta salar*. He says, regarding the contents of the stomach: "It is often empty, or contains a yellow mucus, (from the fresh-water crustaceans?) small fishes, (in seven specimens,) especially *Ammodytes* and *Gasterosteus aculeatus*, (in twelve specimens,) young fish, likewise crustaceans, viz, small *decapoda macroura* and *isopoda*, and *Mysis vulgaris*, according to Lilljeborg, (K. Vetensk. Ak. Förh., 1852,) and, in one case, a large coleopterous insect (*carabus*)³ was found." If we inquire into the place of sojourn of these animals, we find that the *Ammodytes* lives exclusively, and the above-mentioned crustaceans almost exclusively, in the sea. *Gasterosteus aculeatus* is frequently found in the region of the Rhine, "but prefers the small brooks flowing into the Rhine, Main, and Neckar," (*Siebold*, op. cit., p. 67,) and it would, therefore, be difficult for the salmon to get at it. The *carabus* must have been eaten in the neighborhood of the coast or the mouth of a river, as no insects are found in the ocean. As regards the mucus, *Olsson* would, on examining it microscopically, in all probability only have found torn epithelial cells, blood-atoms, &c. If, therefore, the absence of its favorite food would force the salmon to eat less while in the Rhine, it is very hard to believe that the salmon would not be able to find a substitute for its favorite food in the river. If it eats young fish while in the ocean, why should it not do the same while in the river, though, perhaps, the young of different species of fish? If in the ocean, or near the mouth of a river, it eats a *carabus*, why should it not hunt for insects while in the river? It seems to me that the want of suitable food is not the reason why it does not eat anything in the river. I am rather inclined to think that life in fresh water produces a certain morbid disgust with all food in the salmon; and not only in the spawning salmon, in which this peculiarity is not so striking, but also in the winter-salmon, which does not

¹*Valenciennes*, op. cit., p. 179. (Floating motionless at the surface of the water; they may then easily be caught with the hand.)

²*Olsson*, *Iakttagelser*, &c., p. 6.

³*Olsson* examined two specimens of *Trutta trutta*; in the one, he found nothing, and, in the other, fourteen *Clupea sprattus* and three *Ammodytes*.

ascend the Rhine for the express purpose of spawning.¹ With regard to this winter-salmon, which I have mentioned so often, I have made some observations, up to this date, (October, 1874,) which I will give in this place.²

Till quite recently, the opinion was prevalent, that the *Trutta salar* spawned every year. An anonymous writer in Loudon's Magazine³ was the first to show that this opinion is erroneous. This writer says: "Neither the salmon nor the trout spawns every year, for specimens of both kinds are frequently caught in January whose roe is smaller than mustard-seed, which, therefore, could not have spawned in that year; while, on the other hand, in the red fish, (spawn-fish,) which ascends the rivers in November and December, the spawn is almost ripe, and in March and April no trace of roe is found." This observation is correct. From September till May, specimens of *Trutta salar* appear in the Rhine whose sexual organs are entirely undeveloped. The fishermen call these "Wintersalme," (winter-salmon,) and esteem them very highly on account of their fat red flesh (Rhine salmon). It is absolutely certain that these fishes cannot have spawned in that one year, for they appear at the same time as the spawn-salmon, whose eggs have the size of pease.⁴ The question is only whether this barrenness is permanent or temporary.

Siebold, who was the first to show that permanently barren individuals occur in several species of salmonoids,⁴ is inclined likewise to consider these winter-salmon as permanently barren individuals;⁵ and I thought at first that he was right, from reasons which I will proceed to give.

Siebold shows that, in *Truttalacustris*, the barren ones are distinguished from the fruitful ones by some unimportant differences; the body of the barren ones is much more slender, and does not reach so large a weight as that of the fruitful ones; the mouth seems to be cleft deeper; the caudal fin does not so soon lose its emargination; no hook is formed on the lower jaw in old males; and, in their color, they differ much from the fruitful ones.

¹ *Siebold*, Die Süßwasserfische, &c., p. 509.

² I will not deny that, in exceptional cases, the salmon, while in the Rhine, feels a desire for taking food, for this is quite natural. Thus *von dem Borne*, in his interesting "Handbuch der Angelfischerei," Berneuchen, 1875, says that an Englishman, Mr. *Sachs*, near Schaffhausen, caught a salmon, weighing 16½ pounds, with an artificial *Squalius leuciscus*. According to *von dem Borne*, it seems that the salmon is more inclined to seek food in the English rivers than in the Rhine. It is true that he says, "While ascending the rivers, the salmon eats but little. *Buckland* has examined the entrails of hundreds of salmon, and always found them without food, and only containing cutozoa;" but afterward he mentions various bait (insects, fish, &c.) with which the salmon is caught in England.

³ *Loudon*, The Magazine of Natural History, vol. ii, 1834, p. 207, in an extract in *Wiegmann's* "Archiv für Naturgeschichte," 1835, vol. ii, p. 267.

⁴ From Mr. *Ridder*, in Wesel, I received the entrails of the first *Wintersalm* during this period (1874) on September 24.

⁵ *Siebold*, op. cit., pp. 276, 302, 321.

⁶ *Siebold*, op. cit., p. 277.

I have likewise found that the lower jaw of the older male individuals of the winter-salmon never shows such a striking hook as the fruitful male of the salmon (the hooked salmon). There is also a difference in the color of the winter-salmon and spawn-salmon. The winter-salmon has a grayish-blue back and silver-white sides, while the spawn-salmon has a darker, frequently reddish-gray, color. The former has on the sides only a few black spots, and the latter has on the sides and the gill-covers numerous red spots. The urogenital papilla is scarcely noticeable in the winter-salmon, while it is large, protruding, and swollen on the edges in the spawn-salmon. The winter-salmon, on the other hand, generally reaches a greater weight than the spawn-salmon, and its flesh is redder and fatter. With regard to size and weight, therefore, the case seems here to be just the opposite to what *Siebold* has found in *Trutta lacustris*.¹

All these facts, therefore, seem to be in favor of the supposition that the winter-salmon is the permanently barren variety of *Trutta salar*. But, in spite of this, I have arrived at the conviction that this barrenness is only temporary,² and that those fish which one autumn and winter appear as barren winter-salmon probably spawn as spawn-salmon during the next spawning-period.³ After I had continued my observa-

¹The opposite from the winter-salmon seems to be the case in the barren *Trutta lacustris*, also with regard to the quality of the flesh. *Siebold*, at least, says that, in the Lake of Constance, the thin and barren "Schwebforelle" is esteemed much less than the fruitful "Grundforelle," (p. 309.) The barren *Trutta fario*, (common trout,) on the other hand, has a better flesh than the fruitful one.

²*Günther* (op. cit., p. 8) says: *Siebold* "appears to have gone too far when he stated that this state of sterility extends over the whole period of existence of such individuals." In "Nya Bidrag till Kännedommen om Sveriges Salmonider," communicated in the "Kongl. Vetenskaps-Akademiens Förhandlingar," Stockholm, 1865, *Widegren* has shown in very young (one to three years' old) individuals of *Trutta trutta* and *Trutta salar* that this barrenness, which occurs in nearly one-half of all these fish, is only temporary. He mentions, as the chief difference between barren and fruitful fish, that in the barren ones the shorter middle ray of the caudal fin is not as much as, or, at most, not more than, half the length of the longest outer ray, while in the fruitful ones the shortest ray exceeds a little more than half the length of the longest one. This, in itself somewhat subtle distinguishing mark, (he gives, *e. g.*, the proportions of 19:40 mm. in the sterile against 20:38 mm. in the fertile, p. 290,) which is subject to exceptions (p. 280,) forms no criterion in the case of older individuals, as the caudal fin more and more loses its emargination as the fish grow old.—(See *Siebold*, p. 295.) *Widegren* then goes on to show that in the barren fish the sexual organs develop gradually; that the proportion between the longest and shortest ray of the caudal fin gradually becomes the same as in the fruitful ones; that the color changes, &c.

³*Widegren* thinks that several years may elapse before the barren ones become fruitful (p. 302). *William Brown*, on the other hand, ("Natural History of the Salmon by the Recent Experiments at Stormontfield," quoted from *Widegren*, p. 294,) says (p. 48) that of the young female fish which had been marked before going to the ocean, some returned in the autumn of the same year for the purpose of spawning, while others did not return till the autumn of the following year. *Von dem Borne* says (p. 339): "There are among the salmon some which spawn only every other year, just as there are among the young salmon some which only leave the fresh water after two years. (I must here remark that *von dem Borne* cites this fact from English sources, which were not accessible to me.) I, therefore, think that the same applies to those salmon whose home is the Rhine.

tions for more than a year, (from September, 1873, till October, 1874,) I became convinced that all the above-mentioned differences between the winter-salmon and the spawn-salmon disappear with the advancing season of the year and the progressing sexual development. From September till about May, the differences between the two are so striking that, without knowing the further development of the winter-salmon, they would forthwith be declared to be two different species. I am, therefore, not at all astonished that the spawn-salmon (*Salmo lamatus*) has been distinguished as a separate species from the winter-salmon (*Salmo salar*) when both were seen together, without knowing that the differences between the two were only temporary. From May onwards, the whole appearance of the winter-salmon changes, and gradually approaches that of the spawn-salmon. The spots become more numerous; besides the black ones, red ones make their appearance; the silver-white sides assume a dirty-white color, while the back changes from a slate blue to a dingy gray; the jaw of the male becomes elongated, and the hook is formed in the lower jaw; the cœca lose their fat; the flesh becomes paler and drier; the milt and the eggs become larger in proportion; and the edges of the urogenital papilla back of the anus swell and become more prominent. It is interesting to watch the growth of the ovaries. The ovary of the above-mentioned winter-salmon, caught near Wesel on the 22d September, weighed at that date 13 grams.¹ According to my observations of last winter, the weight of the ovaries increases very little up to April. The ovary of a winter-salmon, caught in April of this year, weighed 19 grams; of one caught in May, 22 grams; in June, 48; in July, 91; in August, 211; and the ripe ovary of a fish ready for spawning, (in November,) 800 to 1,000 grams.²

Two questions arise here: (1) Why does the winter-salmon ascend the Rhine long before it is able to spawn? and (2) How long does it remain in the river?

The first question is difficult to answer. In such cases, resort is had to an "obscure instinct." This would in this case be the desire for propagating, although this cannot as yet be realized. It is true that all salmons require a longer or shorter sojourn in fresh water for developing their sexual organs.³ It is possible that, in the winter-salmon, a sojourn in fresh water, even if it be only temporary, gives the first impetus toward the formation of the sexual organs; this is, in fact, highly probable. While in the sea, the fish has fattened so much that, if it continued to take plenty of food, the milt and eggs would not develop at all—a physiological fact which has long since been observed in other animals. This development becomes possible by the fish's abstaining from food while in the Rhine.

¹ 1 gram = 15.434 grains troy.

² In these figures, it must, of course, be taken into consideration that the fish from which the ovaries were taken were not absolutely equal in age, size, and weight; on an average, they weighed 9 kilograms, (1 kilogram = 2.205 pounds avoirdupois.)

³ See Siebold, *op. cit.*, p. 238.

In many cases, some outward cause may induce the fish to ascend the Rhine long before they are able to spawn. I will give the following observations on this point which I have made.

On the bodies of the winter-salmon I frequently found wounds caused by the teeth of other animals. These bites I found on different parts of the body; they were of different size, and most of them had healed over. The fishermen of the Rhine are well acquainted with this fact, and the Messrs. *Ridder* and *Lisner*, in Wesel, furnished me with the interesting information that a rich salmon-year (with regard to winter-salmon) might be expected if comparatively many fish appeared having such wounds. It is but natural to draw certain conclusions from these observations. Not only man but also other beings are eager for the fine flesh of the winter-salmon. The greatest enemy of the salmon are the seals (*Phoca vitulina* and *annellata*¹). These nimble robbers pursue the salmon,² which seeks a place of refuge in the Rhine. If its enemies increase in number and their attacks become more violent, the winter-salmon in consequence appears in the Rhine more frequently, and the above-mentioned observation would thereby be explained. Regarding the second question, "How long does the winter-salmon remain in the Rhine," I think I can assert on the strength of my observations that from September till May it only makes a temporary sojourn in the Rhine,³ and that it becomes permanent only from May.⁴

Of the temporarily barren salmon which occurs in the English rivers, *von dem Borne* says (p. 338) that it remains in the river nearly a whole year. This may be possible in the English rivers; but, as far as the Rhine is regarded, I must deny it emphatically, for the simple reason that the winter-salmon while in the Rhine eats next to nothing. The fishermen say that it gets into the Rhine only by "losing its way." It is a fact that near the mouth of the Rhine it is caught frequently all the year round; near Wesel quite frequently, but near Bonn only rarely, up to May. As the growth of the eggs—as I have remarked above—becomes considerable only from May, I believe that its sojourn in the Rhine becomes settled only from that time.

The results of the investigations which I have been able to make so far regarding the salmonoids occurring in the Rhine are briefly the following: In the Rhine, only two species are found, viz, *Trutta salar* and *Trutta trutta*; neither take any food while in the Rhine. Of *Trutta salar*, a

¹ See on this point *Bloch*, op. cit., p. 139.

² This probably takes place chiefly in winter, because the seal is at that season without any other food, and because the winter-salmon does not, like other fish, live deep in the water, but rather near the surface. Thus, *Mangold* (quoted after *Siebold*, p. 309) says that the barren *Trutta lacustris* lives near the surface, while the fruitful *Grundforelle* keeps near the bottom of the lake.

³ The great strength of its muscles enables it to travel long distances in a very short time. According to *Cornelius*, (p. 199,) it can swim twenty-three to thirty English miles; according to *von dem Borne*, (p. 338,) it swims about 1,500 feet in one minute.

⁴ *N. Loberg*, Norges Fiskerier, Christiania, 1864, p. 280, says of the Norwegian salmon that they stay in the rivers all summer.

fruitful variety (spawn-salmon) and a temporarily barren one (winter-salmon¹) exist. The former ascends the Rhine for the purpose of spawning from September till November; the latter appears sporadically, and for a brief season from September till May, and probably remains in the Rhine for a longer time, or permanently from May till the spawning-season. These results answer—at least as far as the grown salmon are concerned—the question, Is it injurious to catch “Rümpchen” because thereby valuable fish are deprived of their food. As these salmon do not eat anything while in the Rhine, the catching of the “Rümpchen” cannot possibly deprive them of any food. The case will be somewhat different with the young “Sälmlinge,” (salmon one to three years old, which have never yet made the journey to the sea.) Prof. *de La Valette St. George*, who is thoroughly acquainted with our native fishes, and occupies himself with artificial pisciculture, has informed me that he feeds his “Sälmlinge” (specimens of *Trutta trutta* and *Trutta lacustris* measuring on an average 8 inches in length) chiefly on “Rümpchen,” and that they devour them eagerly. As this in all probability will also be the case in the Rhine, and as the young *Trutta trutta* certainly does not differ from the *Trutta salar* with regard to the taking of food, the catching of “Rümpchen” will deprive these young salmon of a considerable amount of food.²

I shall secondly examine the question whether the catching of “Rümpchen” deprives the trout (*Trutta fario*) to any extent of their food.

II.

THE FOOD OF TRUTTA FARIO.

Next to the two above-mentioned species, the trout³ is with us the most common salmonoid; and is highly esteemed on account of the delicate flavor of its flesh. It prefers small, rapidly-flowing, clear waters, and is therefore chiefly caught in small rivers and mountain-streams—the Ahr, Sieg, Roer, Wupper, Wied, and Anbach near Neuwied, and the Kyll near Gerolstein. But as the “Rümpchen” are likewise caught in these very waters, it is of special importance to ascertain whether the catching of the “Rümpchen” deprives the trout of food.

The first material for my investigations I obtained November 25, 1873, from Mr. Brenner in Bonn.⁴ Among twenty-two fishes, I found four—

¹ This must be understood in this manner: that of those salmon which return to the sea from the Rhine after having done spawning, quite a number remain barren the next year, as probably the too rich food and the rapid accumulation of fat prevent the development of the sexual organs.

² I must, however, remark here that these young salmon go into the sea at a very early age—according to *Siebold* (p. 299) in their second year, when they are about 4 inches long; according to the recent observations of English naturalists, in their third year, when they are about 8 inches long—and that therefore the existence of the Rümpchen is no matter of life and death with them.

³ As to the character of this kind, see *Siebold*, op. cit., and *Falenciennes*, op. cit., p. 320.

⁴ To this gentleman I am also indebted for the material for all my later investigations; also those made on *Alausa vulgaris*.

teen females and eight males; in two of the females, the eggs were entirely undeveloped, and the same was the case with the milt in one male fish, while in the others the sexual organs were fully developed. The fins in these three fish were likewise much less developed, and the characteristic modification of the skin found in the trout during the spawning-season was wanting; in short, I recognized in these the barren variety of the trout. As Siebold¹ has proved with absolute certainty the existence of such barren varieties, and has accurately described their characteristic distinguishing marks, I will not enter further on this matter, but will only remark that since I have continually found specimens of barren trout. I will here add that there is no difference between barren and fruitful trout with regard to their food.

The section of the digestive organs showed immediately that their character was entirely different from those of *Trutta salar* and *Trutta trutta*. The œsophagus and stomach were not contracted, but in most cases considerably extended and showed symptoms of a—for the spawning-season—very considerable feeding activity. Nearly all the organs which play a part in digestion, from the œsophagus down to the anus, contained remnants of food. Among the twenty-two which I examined I only found one whose digestive organs contained no remnants of food whatever. Among the others there were several whose stomach contained no food-substance, but in the entrails I found the indigestible remnants of food.

I will now briefly state what I found in these twenty-one trout:²

1. Twenty-one wings of insects (mostly neuroptera).
2. Twenty-six parts of integuments, heads and wings of coleoptera and orthoptera, as well as crustaceans and myriopods.
3. Thirty-five tarsi and other portions of the legs of the same insects.
4. Twenty-six larvæ of *Phryganidæ* or their cases, composed of particles of quartz and plants.

What I looked for most eagerly—viz, remnants of fish—I did not find in any of these twenty-one trout. The stomach occasionally contained large connected parts of insects, and in some stomachs I found the tolerably well-preserved larvæ of *Sialis lutaria*. On one occasion, I found six cases of *Phryganidæ* in a fish, and several times three or four were packed closely together, so that they extended the stomach and could be seen from outside. In some cases, the larvæ of these cases were well-preserved. I found no lime in these cases, and in bringing them in contact with muriatic acid they did not effervesce. It was surprising to me that in three fishes I found large portions of the bast of a plant (perhaps

¹ Siebold, op. cit., p. 233.

² Any one occupied with similar observations will know that in most cases it is almost impossible to draw any conclusion, as to genus and species of the animals which have been devoured, from the half-digested and torn fragments which are found. Although in most cases the accurate definition of these animals is of no practical value, it is of great interest to the zoologist to get as near the truth as possible. I have, therefore, attempted a definition wherever it was possible.

Juncus or *Carex*) folded together, and measuring from one to four inches in length. It is not possible that the trout had taken this as food, and I explain its occurrence in the following manner: On these plants, some insect or larva had settled, the trout had eagerly rushed toward it,¹ and had seized the insect with the plant or portion of it. I was likewise surprised to find in the stomachs of some individuals ripe eggs of the size of pease, which, on closer examination, completely resembled the eggs of the trout. I thought at first that these eggs had got in accidentally while the fish was being dissected,² but I soon changed my opinion. These eggs occurred, as I found later, in other specimens, not only in the stomach but also in the entrails of trout, but when in the entrails always deprived of their contents by having been digested, the empty shells being folded together. This circumstance proves that this voracious fish devours the spawn of its own species.

Similar contents of stomach and entrails I found in ten other trout, which I examined on the 6th December. In the entrails of one I found besides, remnants of fish—vertebræ and bones enveloped in the reddish mucus of the entrails. It was, of course, impossible to ascertain to what species this fish belonged.

On the 14th December, I received fifteen, and on the 16th, eight trout-stomachs. In examining these, I was at once struck by the fact that the remnants of food had considerably diminished. I found a large quantity of partly-digested trout-eggs and a number of phryganid cases, but very few parts of other insects. The cause of this striking diminution of food was, no doubt, the change in the weather. Till the 13th of December we had had mild sunny weather, but from that date there had been considerable frosts. Two explanations of this diminution of food now became possible. The insects, larvæ, &c., had either sought a refuge from the severity of the weather in hidden nooks where they were safe from the persecutions of the trout, or the lower temperature had diminished the liveliness of the trout and their desire for food. The most probable explanation is that the two circumstances combined in diminishing the quantity of food-taken. On the 7th January, 1874, I examined the last thirteen trout. The result, on the whole, was the same as in the first instance. The weather had again become somewhat milder, and the remnants of food had consequently increased. In two of these trout, I at last found distinct remains of a fish. In one, I found scales, bones, and barbels; in the other, the tolerably well-preserved skeleton of a small fish. In this latter, the whole vertebral column, with portions of the bones and of the head, with three barbels, had been preserved; the total length of the skeleton was about four inches. The trout in which I found this fish was about ten inches long,

¹ It is well known that the trout, when rushing toward the bait, also devours the hook. *Valenciennes*, op. cit., p. 330.

² In dissecting the entrails, it occasionally happens that fresh scales of the same or other fish get in the œsophagus.

and the larger portion of the fish stuck in the lower half of the œsophagus,¹ as there was no room for it in the stomach. From the character of the skeleton, I feel justified in inferring that the fish was a *Cobitis barbatula*, which, like the trout, loves clear running water.

Quite recently, (10th June, 1874,) I succeeded, through the kindness of a friend, in getting six stomachs of trout which had been caught in the Kyll near Gerolstein. The examination of the stomach and entrails showed entirely different results from those of trout which had been caught during the spawning-season. In the first, I found four cases of *Phryganidæ*, which were shorter and thinner than those which I had obtained in winter; in the second, I found one hundred and thirty-six such cases, one insect, (half digested,) one dragon-fly's wing, and the remains of a fish; in the third, five hundred and eighty-five (!) cases, one insect, and the scale of a fish; in the fourth, one hundred and sixteen cases, one insect, and the remains of a fish; in the fifth, one hundred and eighty-six cases and the flower of a graminaceous plant; in the sixth, one hundred and fifteen cases, a small caterpillar, a number of fish-eggs, and the lower half of a small fish about four inches in length. The cases of the *Phryganidæ* were found in all the stomachs, and also in the entrails; in one, the intestinal canal as far as the anus was completely stuffed with these cases. I should expressly state that all these six fishes were well fed.

It follows from this that the trout takes much more food before than during the spawning-season, but that even during that season its chief food does not consist of small fish but of insects and their larvæ. I draw from this the further conclusion that the quality of the flesh of the trout does not deteriorate by this insect-diet, but that the delicacy of its flavor is heightened.

The results of these investigations therefore in general agree with the statements of other authors. Günther² says: "The trout is a very voracious fish, and its food consists, besides insects, their larvæ, and worms, particularly (?) of young fish." Valenciennes,³ Heckel⁴ and Kner make similar statements.

If from these investigations I now draw a conclusion as to whether the fishing for "Rümpchen" is injurious or not, I find that among the fifty-three trout which had been caught during the spawning-season there were three which had eaten fish, and among the six caught before the spawning-season there were four whose stomachs contained remains of fish. The fish, at any rate, formed but a very small portion of the food. If I now assume as highly probable that these fish belonged to

¹ "This part of the digestive organs lying immediately in front of the first curvature takes the part of a stomach, and digestion in it becomes far advanced."—Kner, "Ueber die Mägen und Blinddärme der Salmoniden," in the "Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften," vol. viii, 1852, p. 203.

² Günther, *Die Fische des Neckars*, Stuttgart, 1853, p. 116.

³ Valenciennes, *op. cit.*, p. 330.

⁴ Heckel and Kner, *op. cit.*, p. 252.

the genera *Cobitis*, *Phoxinus*, *Leuciscus*, or some other of the "Rümpchen" kind, the catching of these fish would in the worst case only deprive the trout of a comparatively small amount of food. And as the trout are flourishing, even if they feed almost exclusively on insects, it follows that they can live without any fish-food, and that no particular harm is done by the catching of the "Rümpchen." In conclusion, I will give the result of investigations which I have made regarding the food of the "Maifisch," (*Alausa vulgaris*), so as to enable us to pass a final judgment on the fishing of "Rümpchen."

III.

THE FOOD OF *ALAUSA VULGARIS* WHILE IN THE RHINE.

The three species spoken of above belong to the family of the Salmonoids, while the *Alausa vulgaris* is a representative of the Clupeoid family.¹ The "Maifisch" takes its German name from the month during which it ascends the Rhine for the purpose of spawning, and during which it is mostly caught. It is not so highly esteemed as an article of food as the salmon, but its flesh still forms a favorite and valuable food, so that the question whether by the catching of the "Rümpchen" it is deprived of food well deserves an answer based on scientific investigations. Till quite recently, the "Maifisch" (*Alausa vulgaris*) was identified with the "Finte" (*Alausa finta*)—even by *Heckel* and *Kner*. *Cuvier*² and other ichthyologists had tried to show certain differences between the two, but *Valenciennes*³ had showed these to be untenable, and therefore declared that both fish were one and the same species, viz, *Alausa vulgaris*. But since *Troschel*⁴ has examined these fish more thoroughly, and has shown the actual differences between them, it has become possible to distinguish them. The chief difference is in the gills; *Alausa vulgaris* has, on the first branchial arch, 99 to 118 long, slender, and thin lamellæ; on the second, 96 to 112; on the third, 74 to 88; and on the fourth, 56 to 65; while *Alausa finta* has, on the first and second arch, only 39 to 43 short and thick protuberances; on the third, 33 to 34; and on the fourth, 23 to 27.

The flesh of the *Alausa finta* has a bad odor, and is not nearly as fat and delicately-flavored as that of *Alausa vulgaris*,⁵ so that the fishermen

¹ As to the family and specific characters, see *Heckel* and *Kner*, p. 228; *Siebold*, p. 328; *Valenciennes*, vol. xx, 1847, p. 391.

² *Cuvier*, Règne animal, tome ii, 1829, p. 319.

³ *Valenciennes*, op. cit., p. 403.

⁴ *Troschel*, in *Wiegmann's* "Archiv für Naturgeschichte," 1852, vol. i, p. 228, and "Lehrbuch der Zoologie," 1859, p. 229; 7th ed., 1871, p. 268.

⁵ *Siebold*, op. cit., p. 334, erroneously doubts whether the difference in flavor between *Alausa vulgaris* and *Alausa finta* has anything to do with the specific differences of the fishes. Not only after the spawning, but also during the whole time of their sojourn in the Rhine, (therefore, also, at a time when they have not yet become worthless through spawning,) the *Alausa finta* has poor flesh, so that many fish-dealers do not keep it at all.

do not esteem it at all. As the *Alausa finta*, consequently, does not come within the scope of my observations,¹ I have confined myself to the examination of the food of *Alausa vulgaris*.

In the above-mentioned authors, I find no statement regarding the food of *Alausa vulgaris*. Only Günther (who, however, had not been able to examine any of those which occur in the Neckar, p. 121) says, (p. 124:) "The food of the 'Maifisch' consists chiefly of worms and insects. It is said, however, that it can also be caught with boiled pease." It will be seen from the following in how far he is right.

The first two stomachs of *Alausa vulgaris* I received on the 3d May; later I gradually got eighteen more, so that the total number of specimens which I examined was twenty. The result was, on the whole, the same in all. In most of them, I found that the stomach had some contents; only in a few I found little or nothing. The examination of the contents showed the following: Inside the stomach proper, which was strongly contracted, there was a cylindrical mass, pointed at the lower end, toward the pylorus; it seemed to consist of a stringy, white mucus, and showed the impression of the folds of the stomach. By a longitudinal section, the inside was laid open, and it became evident that the mucus only formed an outer covering, enveloping a reddish or gray grained substance. The microscopic examination of this substance showed a large number of remnants of diminutive animal organs and well-developed cell-like formations. As regards the former, I recognized tarsi, antennæ, &c., of microscopic entomostracans and other crustaceans. Occasionally, I found larger connected parts of these diminutive animals. It is possible that these tarsi, &c., belonged to insects; but I have never been able to find wings or parts of the skeleton, &c., of an insect. I must also state that I have not found remains of fish in any of the specimens which I examined.

Among the cell-like formations which I found in the stomach of *Alausa vulgaris*, there were (as shown by a microscopic examination) two varieties, a ball-shaped one and a tube-shaped one. In the ball-shaped ones, I recognized animal eggs (probably of *Ascaris adunca*, which is found in large quantities in the stomach of the "Maifisch"); the tube-shaped ones seemed to be encysted embryos of nematoids. But as I could not bring my investigations of this point to a final conclusion, and as its further discussion goes beyond the aim of this treatise, I confine myself to what has been said above.

CONCLUSION.

Nothing remains but to give a brief *résumé* of these investigations and their results, so as to definitely answer the question whether or not the catching of "Rümpchen" is injurious to other fishes.

¹ In examining the question as to whether the catching of the "Rümpchen" is injurious to other fish, only such fish can be spoken of which exceed the "Rümpchen" in quality; for one certainly would not think of sparing the "Rümpchen," e. g., for the pike.

Of the valuable fishes which, coming from the sea, ascend the Rhine and its tributaries, (*Trutta salar*, *Trutta trutta*, and *Alausa vulgaris*,) the two first-mentioned species do not eat anything, and the third only crustaceans and insects. The young salmon living in the Rhine seem to show a preference for the "Rümpchen" as an article of food; but they only spend that part of their life in fresh water when they are too small to hunt for "Rümpchen." The food of *Trutta fario* consists chiefly of insects and their larvæ, and only to a small extent of small fish which must be classed with the "Rümpchen." By the catching of the "Rümpchen," only a small portion therefore of the young salmon and the trout are to a limited extent deprived of food. Since, therefore, as *Troschel* has shown, no valuable young fish are destroyed by the fishing of "Rümpchen," since thereby the more valuable large fish are not deprived of any absolutely necessary food, and since, finally, the "Rümpchen" form a good and well-flavored article of food, thus amply making up for the damage which their being fished may do to the great fisheries, *I must declare the fishing of "Rümpchen" to be entirely harmless.*

