tape-worms, is full of a greenish-yellow viscous material which, when examined under the microscope, is found to consist of mucus with shed epithelial and other cells and with masses of crystals of carbonate of lime. In no case does the microscope reveal any food remains such as fish-scales, plates of Crustacea or bristles of worms or annelids. In the fish taken in the estuaries up to the month of August the gall-bladder is distended; in those taken later in the year it is empty. In all the fish from the upper waters the gall-bladder is empty and collapsed. According to the investigations of Hoek and of Gulland, the lining membrane of the stomach and intestine degenerates while the fish is in the river, but the correctness of these observations has been denied by F. B. Brown and J. Kingston Barton. Gillespie finds that the activity of the digestive processes is low in fish taken from the rivers, and that micro-organisms, which would be killed by the hydrochloric acid of the gastric juice were it actively secreted, flourish in the intestines of the fish from the upper waters. Those who believe that the salmon feeds in fresh water explain the fact that the stomach is always found empty by the supposition that the fish vomits any food when it is captured, and several descriptions of cases in which this has been observed might be quoted; but such observations must be accepted with caution, and the contracted state of the stomach, the absence of the hydrochloric acid of the gastric juice, and lastly the absence of any traces of digested food remains in the contents of the intestine, negative this explanation.

The question may be presented in another way. Is there any reason why the salmon should feed while in fresh water? The investigations carried on in the laboratory of the College of Physicians have definitely shown that the salmon leaves the sea with an enormous supply of nourishment stored in its muscles, and that during its sojourn in fresh water it gets its energy and builds up its rapidly growing ovaries and testes from this stored material. Briefly stated, these investigations show that the supply of albuminous material and fats stored in the muscles and used while the fish is in the river is amply sufficient for the greatest requirements of the fish. The amount of energy liberated from the fats and albuminous material is 570 times more than is required to raise the fish from the level of the estuary to that of the upper waters! These analyses further show that all the materials required for the construction of the ovaries and the testes are found in sufficient quantity in the muscles, with the exception of iron, which is, however, abundantly present in the blood.

It is a very common opinion that kelts feed voraciously while still in fresh water, and this has been used as an argument that they should be destroyed. It is not easy to bring forward such satisfactory evidence as has been adduced in the case of unspawned salmon, since it is illegal to kill kelts; but none of the 25 kelts procured by the Scottish Fishery Board, and examined in the College of Physicians\* laboratory, contained any food, and Mr Anderson, formerly of Dunkeld, informs Professor Paton that in the old days, when kelts were habitually killed when captured, he has opened a large number and never found any trace of food in the stomach. Some fishers declare that they have seen kelts devouring salmon fry, but it is not easy to make accurate observations in deep water. According to Dr Gulland's investigations, the mucous membrane of the stomach and intestine is completely regenerated while the gall-bladder contains bile, and the digestive activity of the alimentary canal is greater than in salmon before spawning. Kelts thus appear at least to be capable of feeding.

The rate of growth of the genitalia has been carefully studied by Miescher, Archer and Hoek. From January till about the end of May the growth of the ovaries is slow. In Hoek's series of observations, which are the most complete, they increased from ∙35 to •85% of the body weight. After this they enlarge more rapidly, and by the end of August are about 3% in salmon taken at the mouth of the Tweed, about 4% in the salmon from the mouth of the Rhine and about 8% in the salmon from the Basel fisheries. By November they have risen to 20% in the Tweed and in Holland, and to 23 % in the upper reaches of the Rhine. According to Archer’s observations, the development of the ovaries in grilse in the earlier months somewhat lags behind that in the salmon. The growth of the testes has been chiefly investigated by Archer and Tosh in the Tweed and by Miescher at Basel. From March to the middle of July in the Tweed these organs increase from about .19 to .35% of the weight of the fish. In July their rate of growth increases, and they reach their maximum development at the end of September, when they are about 6% of the body weight. In the Rhine in March they weigh about .1%, and they reach their maximum development of about 5% in October.

What leads to the migration of salmon from sea to river and river to sea? It is usually supposed that they come to the river to spawn; that it is the *nisus generations* that drives them from the sea, where their ova will not develop, to the fresh water where development is possible. But it is found that salmon are passing from sea to river at all seasons of the year, and with their genitalia in all stages of development—some fish, running in March with ovaries only I % of the body weight, other fish not running till October with ovaries 15 or 16% of the body weight. It is difficult, then, to accept the theory that the sexual act is the governing factor. That it is a secondary factor seems to be indicated by the great run of

fish in June, July and August, when the genitalia are most rapidly growing. There is one respect, however, in which all the fish leaving the sea for the river agree, and that is in the amount of stored material accumulated in their bodies. In the early running fish this material is largely confined to the muscles, but in the later coming fish it is more eqiîally distributed between muscles and genitalia. The amount of stored material may be measured by the amount of solids, and if we express the results of all the fish examined in terms of fish of uniform size—100 cm. in length— the following results are obtained :—

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Nov.@@1 | Feb. | Mar. | April. | May  and  June. | July  and  Aug. | Oct.  and  Nov. | Kelts. |
| Muscles  Ovaries | 2481  23 | 2214  24 | 2355  '24 | 2599  33 | 2210  47 | 2270  72 | 1750  545 | 946  9 |
| Total | 2504 | 2238 | 2379 | 2632 | 2257 | 2342 | 2295 | 955 |

It would thus appear that, when the salmon has in the sea accumulated a certain definite amount of nourishment, it ceases to feed, and returns to the river irrespective of the state of its genital organs. Nutrition, and not the *nisus generations,* appears to be the motive power. That the fish after spawning returns to the sea in search of food is fully recognized by all.

*Course of Migration.—*It is well known that while salmon run all the year through in greater or lesser numbers, the run of grilse takes place in the summer months, from May to August. But it is further possible to divide the salmon into classes—the so-called winter salmon of the Rhine,. large fish running from October to February, with unripe ovaries and testes; and the summer salmon, running for the most part from March to October, with genitalia more or less ripe. These summer fish are small in the early months, but increase in size as the autumn advances. The winter salmon, along with the early summer or spring fish, appear to pass directly to the upper reaches of the river, and to spawn there, while the larger late-coming fish appear to populate the lower waters. This seems to be indicated by the comparison of upper-water and estuary fish throughout the year. The period at which male and female fish enter the rivers also appears to be somewhat different. The observations of Tosh, Miescher and Hoek show that throughout the year the female fish exceed the males in number, and, secondly, that during the earlier months of the year female fish run in much larger numbers than do male fish. It is only in September that anything like an equality between the two sexes is established. But in Great Britain it is not until the end of August that the nets are removed, and one cannot but believe that the destruction of such a very large proportion of females as are captured during the early months of the season must have a most prejudicial effect upon the breeding stock.

*Rate of Migration.—*By a comparison of the first appearance of winter salmon and of grilse in the markets of Holland and of Basel— 500 m. up the river—Miescher gives some data for the determination of the average rate at which salmon ascend an unobstructed stream. It was found that winter salmon appeared at Basel about 54 days after their appearance in Holland, which would give a rate of passage of about 10 m. per diem. From a smaller number of observations on grilse, it appears that they travel at a somewhat slower rate. It is, however, doubtful how far these figures are of value in deciding the rate at which fish pass up the lower reaches of the river.

Great difficulties have been experienced in ascertaining the age and rate of growth of salmon. The practice has long ago been resorted to of “ marking ” salmon, the most satisfactory mark being a small oblong silver label, oxidized or blackened, bearing distinctive letters and numbers, to the dorsal fin. But of late the structure of the scales has been studied with the object of obtaining indications of the age, growth and spawning habit. H. W. Johnston in 1905 contributed an interesting paper on the subject. The scales bear concentric lines, which vary in number and relative distance according to the growth of the fish, and during the feeding periods these lines are added with more rapidity and a greater degree of separation than at other times. Johnston has endeavoured to ascertain their meaning in Tay salmon, and he has shown that the number of lines external to their last annual ring gives some clue to the time at which they left the sea; he is thus able to distinguish among ascending salmon such as are on their first return from such as have made the journey once or oftener before.

The group of Pacific salmon, or king salmon, commonly desig­nated as *Oncorhynchns,* contains the largest and commercially the most important of the Salmonidae. They arc anadromous species inhabiting the North Pacific and entering the rivers of America as well as of Asia. The best known and most valuable is the quinnat *(S. quinnat),* ascending the large rivers in spring and summer, spawning from July to December. They die after the breeding season is over, and never return to the sea. For the important Sal- monidae known as Trout, Ciiar, Whitefish, Smelt, GraylIng, &c., see the separate articles. The huchen *(S. hncho)* of the Danube is an elongate, somewhat pike-like form, growing to the same size

@@@1 Winter fish not due to spawn till following November.