XXV.—*On the Growth and Migrations of the Sea-Trout of the Solway* (*Salmo trutta*).
By Mr JOHN SHAW, *Drumlanrig*. *Communicated by* JAMES WILSON, Esq.,
 F.R.S.E.

(Read 27th March 1843.)

ALTHOUGH the sea-trout (*Salmo trutta*) cannot be considered either of so much importance to the community as an article of food, or so interesting in its habits and economy to the naturalist as the true salmon, nevertheless, it is universally allowed to rank next in value to that species. It holds a high place in the estimation of the public as an article of diet, and is, consequently, an object of great commercial value to our fisheries. Its history being still almost as involved and obscure as was that of the salmon some seasons back, I am induced to offer the following remarks with a view to its elucidation.

From the circumstance of the sea-trout fry, in its earlier stages, bearing such a marked resemblance to the young of the common river-trout (*Salmo fario*), enquirers, even of the closest habits of observation, have had much difficulty in assigning to it any other place among our British Salmonidæ than that of a mere variety of the last named species. However, by proceeding on the mode of artificial or mechanical impregnation, the exact species of the parent fishes being previously ascertained, there can remain no doubt as to the identity of the progeny, under whatever diversity of colour and markings they may shew themselves, in their progress to the adult state.

It being a question among naturalists whether the so-called herling (*Salmo albus* of Dr Fleming) is actually a distinct species, or only a certain progressive state of the young of the sea-trout, I have taken every opportunity of determining the question by marking the fins, &c., of a considerable number of these fishes for several years, according as the seasons and conditions of the river enabled me to obtain them; and many specimens, as the details of my experiments will shew, were taken and retaken, for several successive seasons, as common sea-trout, increasing in dimensions from year to year. But as I now know the herling to be only one of the links in the progressive chain, it will be better, instead of referring separately to that state of the fish, to narrate the details of the several experiments in the order in which the species advances in size, rather than that in which the experiments upon their several stages were conducted.

In consequence of experiencing much difficulty in capturing the parent sea-trouts in the act of depositing their spawn in the tributaries, I had recourse for many years to the plan of taking them from the cruive on the river, during the

summer months, when the real species to which they belonged was less difficult to determine. I then placed them in ponds, with a good supply of wholesome water, and spawned them artificially when the due season arrived. This method, however, I never considered as a very legitimate mode of procedure, from the circumstance of a possibility of error from an improper selection and combination of the parent fishes, and I therefore watched every opportunity of capturing them in the act of depositing their spawn in the natural bed of the streams or tributaries, each fish accompanied by a mate of its own selection. It was not, however, until the autumn of 1839 that I had the good fortune to capture the parent fishes under these circumstances, and this I effected by the aid of my fowling-piece.

On the 1st of November 1839, having discovered a pair of sea-trouts (See parent specimens A) engaged in depositing their spawn in the gravel of one of the small tributaries of the river Nith, and being unprovided at the moment with the necessary apparatus for their capture, I had recourse to shooting, as the only mode within my power of insuring instant possession of them. However, the vigilance exercised by both parents in protecting the ova from being devoured by multitudes of smaller fishes which surrounded them, rendered it exceedingly difficult to seize the precise moment at which both might be disabled by one discharge of the piece. This, however, was at length effected by shooting immediately across the heads of the pair as they lay parallel to each other, but more by the influence of concussion, than the actual effects of the shot, they being at the time in about six inches depth of water. Having taken them ashore, I proceeded to spawn them by pressing the ova from the body of the female into a little water by the side of the stream, and afterwards, by the same process, I caused the milt from the body of the male to mingle with it. I then removed the impregnated ova in a copper-wire gauze bag, in which some fine gravel had been placed, to a little stream connected with my experimental ponds. The temperature of the water was at this time 47°, but during the winter it ranged a few degrees lower. By the 40th day after impregnation, the embryo fish were visible to the naked eye, and on the 14th January 1840 (75 days after impregnation) the fish were excluded from the egg.

The specimen No. 1 exhibits the young as it existed the day on which it was hatched, with a single specimen of the ovum to shew the condition the day before hatching. The brood at this, the earliest period, exhibit no perceptible difference from the young of the salmon of a corresponding age, except that they are somewhat smaller in size, and of a paler blue upon the body, the vitelline bag being likewise of a lighter red.

The specimen No. 2 is the young sea-trout of two months old, taken from the ponds on 17th March 1840. It is about 1 inch in length, and has assumed those lateral markings which seem to characterize the earlier stages of all the

species of this family, but its progressive growth, the lapse of time considered, has been extremely small.

No. 3 shews the state of the young sea-trout when four months old, taken in May. It measures about 2 inches in length, and by its considerably enlarged size, and improved condition, exhibits the effects of an increase of food and temperature.

No. 4 is a specimen of young sea-trout 6 months old, taken in July. It measures $2\frac{1}{2}$ inches in length, and exhibits a corresponding progressive improvement in size and condition.

No. 5 is a specimen 9 months old, taken in October. It measures about 3 inches in length, and also exhibits an improved aspect.

No. 6 is the same species when 12 months old, taken in January 1841. It measures about $3\frac{1}{2}$ inches in length, and presents an example of the average size, and somewhat defective condition, of the brood during the winter months.

No. 7 is a specimen of young sea-trout 21 months old, taken in October 1841. It measures about 6 inches in length, and has now lost all the lateral bars or transverse markings which are so characteristic of the younger stages of the British Salmonidæ. It forms one of the most interesting specimens of the series exhibited. It bears a very marked resemblance to some of the varieties of the common river-trout, and it has also now attained that age (from 18 to 20 months) at which it appears that the whole of the males of the migratory species of our Salmonidæ are capable of procreation,—none of the females, however, of a corresponding age, in any of my broods, having ever been observed to mature their roes. But, from the experiments which I have repeatedly made with the milt from the young males of other broods of this age (18 months or upwards), I find them quite capable of reproducing their kind with the adult females.

No. 8 is a specimen of the young sea-trout upwards of 2 years old, taken in May. It measures about $7\frac{1}{2}$ inches in length, and has now, along with three-fourths of the brood, assumed the migratory dress. As the young of this species, in the migratory state, are not unfrequently mistaken by ordinary observers for that of the real salmon, it may be proper here to endeavour to give some general description of the colour and markings which they exhibit when first taken from the ponds. The whole brood, at the age of 2 years, average about 7 inches in length, and are of a dark brown on the back, passing gradually into a white silvery appearance on the sides and belly; the pectoral fins are white, with one-third part (the extremities) orange; the ventral fins are pure white; the anal fin is also white, with a faint marking of dusky on each side; the dorsal fin is of a lightish brown, inclining to black at the extreme points of the anterior rays, which are tipped with a very little white; the posterior portion of the rays of the same fin have a faint tint of orange, and the whole fin is very much spotted; the adi-

pose fin is dark brown, margined with red ; the caudal rays are of a light colour near the base, running into dark orange, terminated by a faintly marked double margin of black. The spots on the back and sides vary much in individuals of the same brood, but the specimens produced exhibit a pretty correct example of the general markings of the brood. The spots prevail principally along the back, with a few below the lateral line. Each spot is surrounded by a circle of a lighter colour than the general surface of the body, and this appears to be a prevailing character of the trout species, and one which the sea-trout fry exhibits even after having assumed the migratory dress, when every other feature of resemblance to the common trout has disappeared. The spots on the gill-covers are also more numerous than those of the salmon, generally amounting to 5 or 6.

From the ovum up to the migratory state, the natural economy of the sea-trout appears to bear a resemblance to that of the real salmon. However, from the latter stage to that of the herling (which, as I have said, is beyond all doubt the young of the sea-trout), there is certainly a singular departure from the uniform progress of that species. It appears from experiments very carefully conducted, that there is always a certain number of individuals of both sexes (probably about one-fourth of each brood) that never assume the silvery exterior, or migratory dress; and even if those which have assumed that appearance be detained in fresh water for a month or two, they will reassume the dusky coating; and by the beginning of the ensuing autumn, the females mature the roe sufficiently to reproduce their species with young males of corresponding age. As an evidence of this fact, I may here detail the particulars of an experiment made upon individuals in the condition alluded to. Having discovered, on the 25th of November last, that the whole of the females of the brood, as well those which had been silvery as those which had not, were exhibiting signs of being in the breeding state, I took six individuals (three males and three females, the latter having matured their roe for the first time at the age of $2\frac{1}{2}$ years, the former being *milters* for the second time), and commingling the milt and roe, I placed the impregnated ova in wire bags in a stream connected with the ponds, and in 76 days thereafter they were hatched, and the brood now exhibits as healthy a condition in every respect as those produced by adult parents from the sea.

From these facts, it may perhaps be inferred that the sea-trout bears, in some respects, a closer affinity to the common trout than it does to the real salmon; and that that portion of each brood which does not assume the migratory dress, but matures healthy roe and milt, and is capable of reproduction at the proper season without going to sea, forms one of the supposed varieties observable in all rivers to which migratory trout have access. It is then by no means improbable, that portions of each brood are permanent residents in fresh water, as they are never observed to migrate in a dusky state, along with the shoals of silvery fry,

at the usual season of migration. In support of such views, we have the authority of Dr M'CULLOCH, who states, that sea-trout are now permanent inhabitants of a fresh-water loch in the island of Lismore.

Having detailed the several particulars relating to my experiments on the ova of the sea-trout up to the migratory stage of the brood, it will now be necessary to recur to the results of experiments made on the fry while migrating to the sea.

On the 9th of May 1836, having observed the salmon fry descending towards the sea, I took the opportunity of capturing a number of them, by admitting them into the salmon cruive, and, on examination, I found about one-fifth of each shoal to be what I regarded as sea-trout; and conceiving this to be a favourable opportunity of ascertaining the fact by actual experiment, I proceeded to mark every individual of that species which entered the cruive in the course of the day. They amounted to about 90. A fresh, however, taking place in the river in the evening, prevented my following out the experiment any farther that season. In experimenting on migratory fishes at 25 miles distance from the sea, windings included, the chances of recapturing the individuals marked is comparatively small, and I therefore did not calculate upon retaking more than an individual or two out of the 90. My expectations were not agreeably disappointed by any better success than I had anticipated. However, on the 16th July, just 80 days afterwards, I recaptured a herling in the cruive, with the mark which I had put upon the young sea-trout of the previous May, viz., the whole of the adipose fin being taken off, and three-fourths of the posterior rays of the dorsal fin removed. It measured about 12 inches in length, and weighed 10 ounces. The average weight of the sea-trout fry, at the age at which they migrate to the sea, is about $3\frac{1}{2}$ ounces, so that the specimen referred to exhibited an increase of weight of $6\frac{1}{2}$ ounces in about 80 days' residence in salt water. It was my intention to have retained specimens of the several individuals on their return from the sea, as they were successively retaken, with the view of exhibiting more correctly the development and growth of the species in salt water. This single specimen, however, of that year having been injured in the cruive, was deemed unfit for the object in view, and was therefore set at liberty, in the hope of obtaining one in a more perfect state. In this, however, I was disappointed, no other having presented itself during the remainder of that season. But No. 9 is a specimen of the herling of the Nith, taken from the river in July, and is exhibited as an example of the next progressive stage ensuing that of the silvery condition of the smolt or fry (No. 8). It may also be considered as a correct representative both of the specimen alluded to, and of the general state of the species at that age. These herlings enter our rivers in most abundance in the months of July and August.

No. 10 is a specimen exhibiting the next state of advance beyond the her-

ling, and is actually one of the 90 individuals marked as fry in May 1836, though not captured on its first return. It was retaken on the 1st of August 1837,—fifteen months after being marked as a fry on its way to the sea. It weighed about two pounds and a half, and represents pretty correctly the average size of sea-trout on their second migration from the sea. These older fish usually make their appearance in our rivers in greatest abundance in the months of May and June. In consequence of the specimen now before you having been in fresh water for a considerable time, it has acquired a dusky exterior. To shew the better and brighter aspect of the species, I have placed beside it a specimen of corresponding size taken from the river in May.

In consequence of the herling having greatly abounded in the river Nith in the summer of 1834, I took the opportunity of marking a great number of them (524), by taking off the adipose fin, and returning them into the river. During the following summer (1835), I recaptured 68 of the above number as sea-trout, weighing on an average about $2\frac{1}{2}$ pounds. On these I put a second distinct mark, and again returned them to the river; and on the next ensuing summer (1836) I recaptured a portion of them, about 1 in 20, averaging a weight of 4 pounds. I now marked them distinctively for the third time, and once more returned them to the river, also for the third time. On the following summer (23d day of August 1837), I recaptured the individual now exhibited (No. 11) for the fourth time. It then weighed 6 pounds. This fish exhibits the nature of the several different marks put upon itself and the other individuals, as they were successively recaptured, from year to year, on their return to the river. These marks were as follows: 1st, The absence of the adipose fin (herlings in 1834); 2d, One-third part of the dorsal fin removed (sea-trout in 1835); 3d, One-half of the anal fin taken off (large sea-trout in 1836). Captured and killed in 1837.*

I also marked, in the summer of 1835, about 120 sea-trout, by putting copper-wire into the dorsal fin of one-half of that number, while I marked the other half by twisting a small portion of the copper-wire round the right maxillary bone. Of the latter group I recaptured five individuals the following summer, and found that they also had gained an average increase in weight of $1\frac{1}{2}$ pound. None were recaptured with the wire in the dorsal fin, which I attribute to the circumstance of that part being of too fragile a nature to retain the wire for a sufficient length of time; and therefore, though they no doubt returned, they could not be recognised.

From the numerous and long-continued experiments which I have thus been conducting for many years on this species of migratory trout, I have come to the

* Where only the cartilaginous portion of the fins is taken off, they frequently prove defective marks, as nature always makes an effort to heal and restore those important organs of locomotion, when injured. But when taken off close to where they articulate with the body, the parts are never restored. See, as examples, the dorsal and anal fins of No. 11.

conclusion that the small fry called *Orange Fins*, which are found journeying to the sea, with the true salmon fry, are the young of the sea-trout of the age of two years; that the same individuals, after 9 or 10 weeks' residence in the sea, ascend our rivers for the first time as herlings, weighing about 9 or 10 ounces, and on the approach of autumn pass into our smaller tributaries, for the purpose of continuing their kind; that having spawned, they soon again make their way to the sea, during their residence in which, they almost wholly acquire their increase of weight, viz. about $1\frac{1}{2}$ pound per annum; and that they return annually, with an accession of size each season, to the same river in which their parents gave them birth.*

* Among innumerable authentic and well-known instances of the migratory Salmonidæ returning to their own rivers, I may state, that, of the many hundreds of this species which I have marked, I am not aware that even one of them has ever found its way into any of the tributaries of the Solway, saving that of the river Nith.

I may here note, in reference to the change of colour in fishes in relation to the bed on which they rest, that if the head alone is placed upon a peculiar shade, whether light or dark, the whole body of the fish will immediately assume a corresponding shade, entirely independent of the colour of the ground on which the body itself may happen to rest.