On the growth of the salmon, from the egg to the adult / by R. Knox.

unity of the organisation in all that ever lived; the law of serial unity which makes the living and past organic worlds one, and not many.

Nevertheless, to man, species is everything in a practical sense; for, although specific character and structure explain but little in the philosophy of zoology, specialities are the first steps which lead to more important inquiries: without this step philosophic zoology, geology, palæontology, could not be said to exist: hence the intrinsic and enduring value of the labours of the immortal Cuvier.

R. Knox.

Meissen House, Upper Clapton,
June, 1855.

On the Growth of the Salmon, from the Egg to the Adult.

By R. Knox, M.D., F.R.S.E., &c.

All who have angled in such rivers as the Tweed, frequented by salmon, sea trout and river trout, must soon, if they observe at all, have become acquainted with the following facts or appearances:—

1. That river or common trout, whether large or small, may be readily enough distinguished from every other kind of fish caught in the river; occasionally, though rarely, the young trout may be confounded, when about the length of the little finger, with a small fish called the parr, to whose history I shall presently advert, but, in the fresh specimen, and with a good sight, the young trout may always be distinguished from the parr.

2. That these small fish, called parr, are to be found in the rivers frequented by salmon or salmon trout, from the sources to their embouchures, and in such rivers only. But the converse of this is doubted; first, by Mr. Young, of Invershin, who says that there are rivers frequented by parr, into which neither salmon nor salmon trout have ever penetrated; secondly, although I fished the Tyne, in Scotland, a great many times, and had it fished for me by skilful anglers, who knew the river well, I never could find a parr; thirdly, I was present at the fishing of a stream on the East coast of England (North Riding of Yorkshire), on the estate of Mr. Wharton, near Guisborough: the stream was fished with a net (which took everything), from a mill-dam insurmountable for salmon to the sea, yet no parrs were found: nothing, indeed, was taken but—1st, sea-trout of various sizes; 2nd, smolts covered with scales, on their way to the sea; and 3rdly,

a few common trout: on every hypothesis, save one, the absence of the parr in these and the adjoining streams is inexplicable: the fishing took place in May; the sea trout and smolts were descending to the sea: the net took everything to the minnow, yet no parrs were to be found: on one hypothesis alone is this explicable, namely, that the young of the sea trout, hatched from the ova deposited in November of the preceding year, had all become smolts, and were proceeding to the sea. If the age of these smolts had been two years or even one year, the young fish, in their generic or parr dress, must have been found in the streams and pools: nothing of the sort occurred: had the smolts, then and there found, being the females of one year, the males of the same age, but less in size, not as yet changed into smolts, must have been discovered in the net: in a fishing of some miles nothing of the kind appeared.

3. That these fish, called parr, are male and female; that in the female the roe remains always at its minimum; in the male, on the contrary, the milt enlarges remarkably during the autumn and winter months, and not infrequently is found enlarged at all times of the year.

4. That, in addition to river trout of various sizes, and of parr, which never exceed eight or nine inches in length, there appear suddenly as it were, in the streams, in May, thousands of a small fish (the smolt) covered with silvery scales, which fish is presumed to be, and has been proved to be, the young of the salmon and sea trout. It was first remarked by Mr. Hutchinson, of Carlisle, in 1782, and subsequently by all who observed what happened to the smolt when kept for some time and roughly handled, that the scales being rubbed off, the smolt assumes the appearance of a parr; but Mr. Hutchinson did not think that this proved the smolt and parr identical. What is the age of these fish—of the May smolts? The whole question of the protection of the salmon is wrapped up in this question. The question of its identity with the parr is a distinct question; the presence of the parr-markings to be discovered under the scales proves nothing specifically, since these are generic characters common to the whole natural family of the Salmonidæ at a certain period of their growth or development to trout and salmon of every kind.

5. It was asserted by Willoughby (1686), and the assertion has not been refuted, that with the developed milt of a male parr, 6 or 7 inches in length, the ova of a full-grown salmon may be fecundated. If we adopt the theory, that under every circumstance the parr is simply a young salmon or salmon trout, as the case may be, the astounding physiological fact first announced by Willoughby still

remains unexplained, and without a counterpart in zoology, namely, that the male salmon of five or six months age, according to the Invershin hypothesis, and of seventeen or eighteen months age, agreeable to the Drumlanrig experimenter, should already have arrived at the adult condition in respect of the ability of reproducing his kind; the female in the meantime continuing, as regards the ovaria, at the minimum of development; and, as if to add to the complexity of the enigma, we are now further asked by these experimenters to believe, that the female, in whom the ovaria do not alter, grows faster than the male by a whole year, the generative organs and the general growth of the body being in an inverse ratio to each other.

6. The May smolts, covered with scales, collect into flocks or groups, and descend the rivers to the ocean; parrs never do. In the smolt which descends to the ocean in May to seek a habitat still unknown, the ovaria and milt are uniformly at their minimum. His food in the ocean was unknown until I demonstrated it to be the eggs of the Echinodermata. The smolt which descends to the ocean in May, 5 or 6 ounces in weight, returns in July, August and September a grilse or salmon of as many pounds. If permitted, he returns to the ocean next spring; he again makes for the rivers a grown salmon in the autumn of the same year, varying from 12 to 20 lbs. weight. His subsequent history is not well known.

Lastly: Whilst in the fresh waters the grown salmon does not feed, but loses condition to a great extent: thus a return to the ocean is essential to his existence. Whilst a smolt he lived and throve on the common food of trout; he acquires the silvery scales in May, being then 7 or 8 inches in length; he seeks the ocean, impelled by an instinct seemingly as strong as that which induces the grown salmon to rush up the rivers at the approach of winter.

The observations just made are generally admitted to be facts: the more curious, indeed all of any moment, were known to Willoughby, Hutchinson and others; but they do not solve the difficulties connected with the subject, the first of which is—What is the age of the May smolt?

What is the age of the May Smolt?

The opinion which has prevailed, in Annandale, time out of mind, is, that as the parr is the young of the salmon, so the May smolt must be one or two years old; some thought more. The practical fishermen of the Tweed thought otherwise; they disbelieved the parr to be the young of the salmon, and thought that the May smolt was the

product of ova deposited under the gravel in October, November and December of the previous year. To bring the question of age to an issue there are obviously two ways: the first is to observe the progress of the ova surrounded by the natural influences, and undisturbed; the second is to watch the development of the ova placed in artificial circumstances. I naturally adopted the first, and for this simple reason, that the salmon being an animal *feræ naturæ*, or of the *wilde;* it would, at all times, be difficult to say how far an artificial locality might affect it. The result of my early observations have been stated briefly, and in much clearer terms by Sir John Richardson, in his admirable 'Fauna Boreali-Americana,' than by myself. I shall here quote from his work, premising that I had already carefully observed the development of the ova of the salmon deposited in the bed of the Whitadder, on the 2nd November, 1832; that on the 25th February I found the ova under the gravel seemingly unchanged; that on the 23rd March changes were visible, some of the young fry having burst their coverings, and were lying embedded in the gravel. On the 1st of April most of the fry had quitted their gravelly bed, and on the 19th May the river abounded with smolts (some 7 or 8 inches in length) of various sizes, all covered with scales. We now learned that smolts had been taken on the 5th May in the same streams, which I considered as the young of an earlier hatching, and as on a subsequent occasion I found ova unchanged on the 10th April, and on the 17th April fry lying embedded in the gravel, I inferred that the time of hatching varied according to circumstances easily understood. Twenty-two smolts were taken from the river, and examined with the greatest care; they were male and female, in tolerably equal numbers; the male could often be recognised from the female by the enlargement of the extremity of the lower jaw. It is right to observe, that for two or three years the parr had disappeared from the Whitadder. To return to the remarks made on this subject by Sir John Richardson, extracted from his admirable work on the American Fauna:—

"Dr. Knox, in the appendix to the very able paper from which the foregoing passages are abridged, remarks, that there are two circumstances which persons* of sound judgment and great experience with regard to the salmon question still think undecided, or at least demanding a more extended proof. The first is a series of experiments to determine the growth of the salmon fry from the state of the egg to its attaining the length of 6, 7, 8 or 9 inches, before which it is

* I alluded to Mr. R. Buist, of Perth.

seldom seen by the angler, and after which it ceases to be found in fresh-water rivers. Secondly, proof that the fish we call salmon fry (smolts), taken in salmon rivers by anglers during the months of April and May, do really proceed to the ocean, and return after a period to the rivers as grilse, salmon trout, and salmon. The facts ascertained by Dr. Knox, in conjunction with the previous observations of others who have attended to the subject, go towards the answer of the first question, whilst the experiments made in Sutherlandshire, on the Laxford and Divard may be considered as a reply to the second. Fry marked in April returned as grilse on the 25th June."

Soon after these observations had been made and submitted to the Royal Society of Edinburgh, others entered on the field, and the Duke of Buccleugh must have taken some interest in the matter, since he permitted one of his game-keepers, a Mr. Shaw, to experiment on the ova of the salmon, and on what he called the parr. The ideas of this person respecting the parr have no foundation whatever either in observation or experiment; the experiments he made led to what is called the two-years' theory of the May smolt. By confining the young of the salmon in ponds and boxes, and placing them under artificial circumstances, he contrived to retard the growth of the fry to the extent specified: thus he first misled himself, and then others.

When I first heard of the two years' theory of the age of the May smolt, my remark was this—"Wait a little, and another experimenter, proceeding on the same principles or want of principle, will prove to you that three years is the age; and after a little while another of the same class will show you that one year is the true period." The prediction was verified to the letter. Mr. Hannay, of Kircudbright,* showed by experiment that the smolt is a three years' old fish; Mr. Young, of Invershin, by the same method, proves one year to be the true age, and the experiment repeated at this moment by my esteemed friend Dr. Esdaile, of Perth, on ova reared in ponds adjoining the Tay, has brought to a sudden close, and for ever, the two-year' old theory, a delusion of the plainest character, but yet sufficient to mislead many naturalists. Scientific continental naturalists, finding persons engaging in these controversies who are not scientific men in any sense of the term, stand aloof.

Whilst I now write my friend Dr. Esdaile, to whom the public is already deeply indebted for services rendered humanity in India, and who I am proud to say was at one time my student, informs

* See this gentleman's letter, published by me in the work already quoted; the original is now before me.

me by letter, that a new theory of the age of the May smolt has been proposed, intended to include the history of the parr and all its difficulties: it is this; "the silvery May smolt fully developed as a smolt, and actually proceeding with or without the kelts, or spawned fish of last autumn, is a female of one year's growth; the males are there still in the form of parrs; their growth is slower; they remain in the waters another year, forming the autumn and winter parr, and descending next May with their sisters of one year's growth." I do not recollect a single observation directly in favour of this view, which still leaves all that is extraordinary in the history of the parr unexplained. The smolts which descend the rivers in May are of all sizes, from 3 inches or less to 7, 8 and 9 inches; the males supposed to be left are at least as large. These smolts are of both sexes, and such will be found to be the case with those leaving the ponds on the Tay. But if this be true, (which I doubt not), what becomes of the theory? The following are a few of the direct observations bearing on this question which I find in a little work I published lately,* but many more could be added to this had I leisure to examine my journals.

At my request, Mr. Harkness, of Lochmaben, fished the Æ, an Annandale river, for me in December, and caught with a bait (small red worms) twenty-four parr, which he transmitted to me at the time in Edinburgh. Of these parr fourteen were female and ten male. The largest parr measured 7 inches, the smallest 3 inches; the average was $5\frac{1}{2}$ inches. The female parr were as large as the May smolts. Why had they not left in the preceding May? In the females the ovaria were as usual at their minimum: in some of the males the milts were of considerable size, in others not developed: they had been feeding on insects. Now, if these parr were young salmon, why the development of the milt in the male? And if the females belonged to the class which was to descend next May, and the males only after another year, how comes it that no well-marked distinction can be established in respect of size? Of the hundreds of May smolts I have examined, I have never found the roe or milts altered in the slightest degree; they were uniformly at their minimum, nor could I ever discover any traces indicative of a fact which ought to have occurred if the winter male parr, with the milt developed, grew into a salmon, namely, appearances indicating that the milt had been developed the preceding winter.

* 'Fish and Fishings in the Lone Glens of Scotland. Routledge, London.'

On the 22nd July, 1833, six parr were caught with the artificial fly at Romaro bridge on the Lyne, a branch of the Tweed. They were of the usual size, averaging probably 5 inches: all were males, with the milts large, and 2¼ inches in length. Do we usually find salmon with the milts large in July? And if these parr become smolts next May, what in the meantime becomes of the enormously enlarged milts?

On the 3rd September, of thirteen parr caught in the Tweed, between the Bield and Polmudie, there were only two females, and such observations, if repeated and supported by extensive evidence, might lead to important results. In the mean time, it is remarked in my journal, that of these eleven males some were 8½ inches in length, others only 4 or 5 inches; in the larger the milts were enormously enlarged. Now, what became of these males, which in September were as large as the largest May smolts? Did they cease to grow until the arrival of May? What became of the milts? And if such a premature development of the male takes place without a cause and without an object, how comes it that no May smolt ever shows traces of these organs having been once developed?

In conclusion, it is to be regretted that experiments which might have formed valuable acquisitions to science have been so conducted as to be repudiated by most scientific men. Profoundly ignorant of the basis of all zoological science, the observers could not be trusted. Those being now conducted near Perth are in quite different hands, and will, no doubt, lead to important results. The question of a disproportion of males to females, as regards the autumn and winter parr, did not escape my notice, as may be seen by reference to page 93 of the work so often referred to in this brief notice; at page 95 will be found a minute account of the experiments on the Dee, proving the three-year old theory. With a little more confinement and restraint, the period of development of the smolt might perhaps have been extended to four years;* the two and three-year theories have now been disposed of by my friend Dr. Esdaile, but the one year view has still to be proved, and this can never be satisfactorily done by breeding in artificial waters.

R. Knox.

Miessen House, Upper Clapton,
June, 1855.

* Mr. Newman, editor of the 'Zoologist,' and a distinguished naturalist, informs me that you may keep tadpoles as tadpoles as long as you like, merely by restraining their development.