

6. C. GEGENBAUR. Bemerkungen über d. Milchdrüsen-papillen d. Saugetheire. *Jenaische Zeitschr.*, iii, 1873.
7. C. CREIGHTON. On the development of the mamma and the mammary function. *Journ. Anat. and Physiol.*, xi, 1877.
8. H. ALLEN. Mammary glands of bats. *Proc. Acad. Nat. Sci. Philad.*, 1880, p. 133.
9. G. REIN. Untersuchungen über die embryonale Entwicklungsgeschichte der Milchdrüse. II. *Arch. f. mik. Anat.*, xxi, 1882, pp. 678-694.
10. D. BARFURTH. Zur Entwicklung der Milchdrüse. Bonn, 1882. 1 pl.
11. A. KÖLLIKER. Grundriss der Entwicklungsgeschichte des Menschen und der höheren Thiere. 2te Aufl. Leipzig, 1884. (Milchdrüse, pp. 334-336.)
12. WILLIAM TURNER. An account of the great finner whale (*Balaenoptera Sabbaldii*) stranded at Longniddry. Part I: "Soft parts." *Trans. Roy Soc. Edinburgh*, xxvi, 1869-'72, pp. 197-251.

29.—THE EFFECTS OF AN ELEVATED TEMPERATURE ON FISHES.

By FRANCIS DAY.

In a stream in the Government gardens at Ootacamund, on the Neilgherry Hills, in Madras, in the middle of December, 1866, the average maximum was 72°, the average minimum 50°, the highest point noted 72°, and the lowest 42°, and here Indian carp thrive. In the lake in that station, 7,600 feet above the sea, between May 20 and June 12, 1866, I found the water at 6 a. m. 67½°, at midday 77°, at 4 p. m. 79°, and at 6 p. m. 73°. In the Coonoor Stream the water was from 3° to 6½° colder than in the Ooty Lake, while half way down to the low country, at 4 p. m., it stood at 74°, and 6 p. m. at 75°. In the Bowany River, in the low country, a much higher temperature prevailed, at 6 a. m. it being 79°, at 12 a. m. 92°, at 4 p. m. 86°, and at 6 p. m. 82°. But after the first burst of the monsoon the water may be roughly said to have decreased about 10° in the Ooty Lake, 1° or 2° in Coonoor River, rather more on a lower level, but from 10° to 13° in the Bowany River. All these localities being stocked with fish, it shows that they must become accustomed to a heat which rises to as much as 92° at midday in the low-country river.

In June, 1869, I took sixty-three observations in the Irrawaddi River, in British Burmah, the thermometer being immersed 1 foot below the surface, and the temperature recorded between 6 a. m. and 11 p. m. varied from 82° to 85°, while at the Een-gay-gyee Lake, on June 18, the water at 11 a. m. stood 90°. It is stated in *Nature* of February 12 that the secretary to the National Fish Culture Association at South Ken-

sington selected certain fishes for experimentalizing as to what temperatures they could survive in. All were first deposited in water registering 53°, which was gradually increased by the infusion of hot water through a tube, which caused the temperature to rise steadily. The rapidity of this rise is not given. We are told that none of the fish exhibited signs of failing vitality until the thermometer recorded 82°, when a perch became prostrated, and shortly afterwards its congeners followed its example in rapid succession in the following order: Roach, 82½°; salmon, 83°; minnow, 85°; gudgeon, 85½°; dace, 86°; tench, 88°; carp, 91°. Brandy is stated to have restored them all except the dace, which died. Whether further notes of these fishes have been kept, and if any more have succumbed, it would be interesting to know; but none of the temperatures appears to have reached what is normal for fish in India at certain seasons.

Dr. John Davy in 1853 made some very interesting observations on the above subject of temperature on ova and young fish, in each instance the experiment being carried on in a thin glass vessel of the capacity of about four ounces, nearly full of water, and this vessel was placed in a water bath of the temperature required. An ovum was two and a half hours in water at 70°, which rendered its circulation languid; kept two hours more, and increasing the heat of the water to 80°, no further apparent ill effects were seen. The vessel was now removed from the bath and allowed to cool gradually, and ten hours later a vigorous young fish was found to have burst its shell. An ovum and a young fish were kept in water between 68° and 72° for about eight hours, when the egg was found to be hatched and a tolerably active young fish was produced. Next day both were exposed to a temperature between 70° and 80°, rarely reaching 80°, and at the end of the day they were languid, or, if in motion, disposed to irregular movements. Removed from the water bath, the next day they were active, and subsequently showed no ill effects from their treatment. A young fish and an ovum were put into water raised to 82°, and after an hour to 85°, when the water was gradually cooled; but the circulation in the young fish was found to be languid, and the following day it was dead. The egg did not suffer materially for three days; subsequently a vigorous young fish was produced. An ovum kept in water for two hours at from 90° to 95° died, as did also one put for half an hour in water at 100°.

A young fish was kept three hours in water, commencing at 70° and gradually increased to 85°. The heart was then acting with tolerable vigor, and the following day the fish appeared to be nearly in its usual state, and five days subsequently it was tolerably active. A young fish kept in water at 84° was found to be dead, and to be sure that the result was not owing to a want of air in the water the experiment was repeated in the same water when cold, without injurious results. Another young fish was kept in water three hours and a half, rising from 78°

to 91°, without bad effects, while another two hours and a half in water between 88° and 90° died. One kept a few minutes in water at 92° seemed to be dying when removed, and appears to have died in about a quarter of an hour. Another was kept three hours in water gradually rising from 78° to 88°. At 85° the heart was acting, but no circulation was perceptible in the tail; at 88° it died. Dr. Davy has recorded many other experiments on this subject, as well as on the degree of temperature fatal to fishes.

In August, 1882, he placed a common trout of about a quarter of a pound weight into a good volume of water at 62°, which was pretty rapidly raised to 75° by additions of warm water, when it became very active and tried to leap out. In an hour the temperature was increased to 80°, and after a few more minutes to 85°, when it became convulsed, and, although transferred to cool water, died. When the water had sunk to 70°, smaller trout and a minnow were put in, and although the next morning the temperature had sunk to 67°, the trout was dead, but the minnow had not suffered.

A parr of the salmon was similarly treated, the water in half an hour being raised from 60° to 70°, and now it tried to escape. The water was raised to 80°, and it became torpid and convulsed; at 84° it seems to have died.

A char of about the same size had the water gradually raised to 80°, when it seems to have died. The trout tried to escape by leaping out of the water, while the char kept to the bottom, with its head downwards, as if seeking for a cooler locality. A small perch was put into water at 83°, falling in fifty minutes to 80°; after two hours it was found dead.

A minnow was put into water at 92°, and in less than two minutes it had turned on its side; but the water falling to 90°, it recovered, resuming its natural mode of swimming. A gold carp was put into water at 96°, but at once became restless. After a few minutes the temperature had fallen to 94°, and it remained motionless; now transferred to water at 70°, it rapidly revived. After about an hour it was placed in water at 93°, which at first it bore with, then became languid; but as the water cooled it revived, and at 88° it resumed its natural position.

A common carp was placed in water at 60°, raised in five minutes to 78°, and in twelve more to 80°; after another half hour the heat was suddenly increased to 85°, but it became languid, so it was allowed to cool to 80°, when it seemed to revive, so the heat was increased to 95°, and as it appeared as if dead, it was lifted into cool water, where it slowly recovered its powers. Other similar experiments on the loach and the eel were made.

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