

XI. REGENERATION OF THE ANAL FIN OF XIPHOPHORUS HELLERI

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In a previous publication ('23),* the writer has shown that
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the anal fin of the male *Xiphophorus helleri* undergoes a postnatal development. The anal fin of the female and that of the young fish in the indifferent stage are identical in structure but, of course, differ in size. With sex-differentiation the anal fin of the fish in the indifferent stage is transformed into an intromittent organ or gonopod of the male animal. In this metamorphosis the third ray increases greatly in diameter and together with the fourth and fifth grow to twice the length of the rest of the rays of the anal fin. In the fully formed gonopod these rays are provided with tooth-like projections and hooks which serve a purpose in copulation. The first, second, sixth, seventh, eighth, ninth, and tenth rays remain rudimentary.

*Sex-differentiation in *Xiphophorus helleri*, Biol. Bulletin, Vol. XLV, No.

During the progress of the work mentioned above it becomes necessary to determine the power of regeneration of parts in both sexes of *Xiphophorus helleri*. The anal fin was selected for study. Not less than half a dozen of sexually mature males and the same number of females were selected and isolated in separate aquaria. The anal fin of both sexes was amputated as close as possible to the body and allowed to regenerate. Weekly examinations were made to ascertain the progress of the experiment. It was found that every female so operated upon, regenerated a complete anal fin within ten months. Already during the first week after operation proliferation of tissues from the stump of the fin was clearly perceptible. In some cases the fin was completely developed at the end of five weeks. In the case of the male, however, the amputated fin showed no signs of regeneration after a period of seven months.

The newly regenerated anal fins of the females were again removed and allowed to develop, which took approximately the same amount of time as before. This operation was repeated three times with results identical in every case.

Discussion. It is known that in general the power of regeneration varies indirectly with the height of the animal in the evolutionary scale. That is to say, the lower the organism, the higher the power of regeneration. A fresh-water Hydra or a flat worm (*Planaria*) may be cut up into pieces, and each of them will regenerate the entire organism. In the higher invertebrates the power of regeneration is limited to the appendages. In the vertebrates the power is still more limited. The appendages in the tadpole can be regenerated but not the legs of the adult frog. In the higher vertebrates the power of regeneration is confined to skin appendages (hair, nail, etc.) and the healing of wounds. It is clear that the power of regeneration of parts depends on the degree of differentiation of tissue. In the lower organisms the cells undifferentiated and plastic, and, at least theoretically, each cell is capable of producing the entire organism. In the higher types the body cells become modified to perform a definite function, and consequently lose their plasticity or power of regeneration. In the present case of *Xiphophorus helleri* we have a specimen that has lost the power of regeneration with the exception of the female. From this it would logically follow that the female is the less differentiated and thus the more plastic of the two sexes, and perhaps it may be said that the male is a dedifferentiated female. Interesting parallels supporting this idea have been found in the work on *Xiphophorus helleri* cited

above. In the case of sex differentiation it was observed that the female gonad is a linear descendant of the indifferent gonad. The primordial germ cell of the indifferent gonad enlarges and forms oocytes. In the male, however, the primordial germ cells take no part in sex cord formation; thus the testis is in a sense a new formation or dedifferentiation. In the case of sex-reversal it was found that the male gonad dedifferentiated from the remains of the degenerated ovary. It is interesting if not significant to note that in *Xiphophorus helleri* as well as in other animals in which sex-reversal has been observed and reported, the change is from the female sex to the male and not the contrary. The latter fact has been a subject of experimentation and argument for the last few years and it may be suggested at this occasion that the change of sex from female to male and not the reverse is probably a function of the power of regeneration.