REVIEWS

ÉTUDE EXPÉRIMENTALE DU DÉTERMINISME DE LA RÉGÉNÉRATION DES NAGEOIRES CHEZ LES POISSONS TÉLÉOSTÉENS

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Annales de l'Institut Océanographique (Monaco), nouvelle serie, tome 28, fascicule 1, 61 pp., 25 figs., 19 tables. Paris, Masson et Cie., 1953.

The removal of one or a combination of fins is the tool most commonly used by fishery biologists to mark a group of fish for later recognition--not as individuals, it is true, but as a year class or a group which was stocked or subjected to some other treatment simultaneously. Thus it is not surprising that a fair amount of experimental work and even more observational effort have gone into assessing the subsequent fate of fin-clipped fish--their rate of growth, survival, and so on.

The results of such work in the last 15 years or so are by no means clear-cut. Ricker stressed the cumulative effects of small disadvantages which may, over more than one season of competition and predation, work to the serious detriment of a group of fin-clipped fish.[1] Shetter, observing his animals for shorter periods of time, found that fin-clipping by and large neither impaired the growth nor made experimental fish more vulnerable to predation than his controls.[2] Further, there have been numerous unpublished instances in which fishery biologists, dealing with variations in behavior and growth, as between marked and unmarked fish, would look upon the only apparent difference --clipped fins-- as the cause of such variation, availing themselves of the often useful but always suspect "post hoc, ergo propter hoc" (subsequent to this, therefore caused by this) manner of reasoning.

A series of experiments dealing with the effects of controlled environmental variables on fin regeneration is therefore of utmost importance. These experiments have been performed by Buser-Lahaye, and the results to be discussed here are clear-cut and interesting. They promise to be of considerable help to the field-worker and they substantially increase our knowledge of fish physiology.

Here fins were removed singly or in combination from a number of fresh-water fishes (*Ameiurus nebulosus*, *Cyprinus carpio*, *Gobio gobio*, *Phoxinus phoxinus*, *Xiphophorus hellerii*, *Lebistes reticulatus*, and *Gambusia holbrooki*) as well as from marine teleosts (*Julis vulgaris*, *Mugil capito*, *Mugil auratus*, *Gobius capito*, *Heliastes chromis*, *Serranus cabrilla*, and *Scorpaena scrofa*). Most of the detailed work was done on *Gambusia*, *Ameiurus*, and *Mugil*. The fins were removed with a very sharp instrument a few millimeters from the base so as to avoid scarring the body. Measurements were taken at regular daily or weekly intervals, on small fishes under the microscope and on the large ones with calipers.

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[1] Ricker, W. E. 1949. Effects of the removal of fins upon growth and survival of spinyrayed fishes. Jour. Wildl. Mgt. 13 (1): 29-40.

[2] Shetter, D. S. 1951. The effect of fin removal on fingerling lake trout (*Cristivomer namaycush*). Trans. Am. Fish. Soc. 80 (1950): 260-277.

1952. The mortality and growth of marked and unmarked lake trout fingerlings in presence of predators. Trans. Am. Fish. Soc. 81 (1951): 17-34.

The rate of regeneration, expressed in percentage, was obtained by taking the ratio of regenerated fin length to its total length before amputation; thus the speed of restoration could be plotted against time. All experiments were made in aquaria, some in flowing water and some in standing water. The following conditions were studied:

(1) Temperature. This ranged generally between 17° and 30° C., though a few experiments were done with waters as low as 10° C.

(2) Light. Only white light was used; the effect of varying periods of illumination on fin regeneration was tested.

(3) The relative importance of temperature and light was investigated.

(4) Internal factors. The roles of the thyroid and pituitary glands were given special attention.

EXPERIMENTAL FINDINGS

It was found that regeneration, when it occurs, is preceded at all times by the formation of scar tissue, most noticeably in cases of retarded regeneration. Spiny and soft rays differ as to speed and ease of regeneration. This was especially apparent on bullheads, where a section of pectoral or dorsal fins would affect both types of fin rays. Whether this retardation was due to the more irregular section of the thicker bony element or to other causes was not ascertained.

The removal of caudal fins of Gambusia at various levels revealed that regeneration proceeds faster if less, and more slowly if more, of the fin is cut off.

A few other observations preceding the experiments proper are of interest:

(1) Young fish regenerate fins faster than adults.

(2) There is no difference in speed of regeneration (in Gambusia, at least) between the sexes. It should be mentioned, though, that one might well suspend judgment on this point until some further tests have been made.

(3) Different fins are regenerated at different rates (figure 1).

(4) The general state or condition of the fish--as would be expected--affects the speed of regeneration.

TEMPERATURE

The effects of temperature were the most spectacular. There exists, apparently, a threshold below which no regeneration takes place (figure 2). Above that

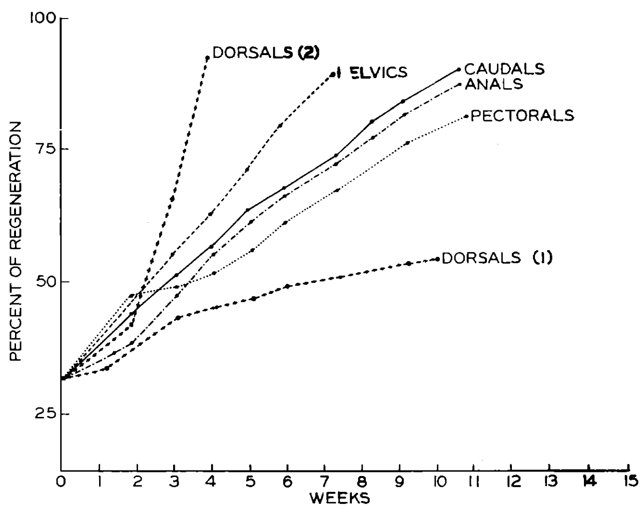

FIGURE 1.--Mugil capito: mean speed of regeneration of different fins.

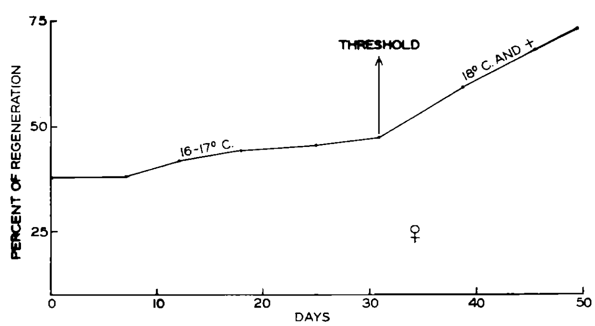

FIGURE 2.--Temperature threshold of the fin regeneration of Gambusia females in fresh water.

(Figures 1 and 2 have been adapted from Buser-Lahaye's figures 6 and 9.)

temperature, 17° C. in the experiment in which Gambusia were observed, the rate of regeneration increases in proportion to the increase of temperature (figure 3).

Black bullheads, for instance, do not begin to regenerate a fin before 3 weeks after amputation at 20° C. At 25° C., visible regeneration starts after 12 to 15 days; at 30° C., a week suffices to start new growth.

Fish acclimated to winter conditions will begin to regenerate amputated fins when the temperature increases and will stop regeneration when the temperature decreases.

LIGHT

At temperatures that were just below the threshold, continued illumination produced regeneration; but at temperatures that were around 10° C., even continued illumination did not give rise to fin regeneration on Gambusia. Complete darkness at elevated temperatures resulted in a slight increase of the rate of regeneration, but an increase in light intensity at constant temperature also seemed to increase the speed of fin regeneration (figure 4). Illumination of constant intensity and varying duration did not produce decisive results.

INTERNAL FACTORS

The thyroid gland of experimental fish responded to temperature increases by increasing activity and to decreases in temperature by regression, but varying periods of illumination did not affect the secretory state of the thyroid. It was therefore attempted to inhibit and stimulate thyroid action by biochemical means and observe the results, if any, on fin regeneration.

Pregneninolone, a highly active testosterone derivative, slowed regeneration, apparently by changing the pituitary influence on the thyroid gland; and thyroxine injections at subthreshold temperatures speeded up regeneration. Histological observations accompanied and corroborated these regeneration tests.

The thyroid, for anatomical reasons, could not be removed; but operative removal of the pituitary gland was successfully accomplished in Gobius capito and Ameiurus nebulosus.

Animals without pituitary glands did not regenerate their clipped fins and were characterized by a marked retrogression of thyroid activity and development. Thus a pituitary - thyroid mechanism of fin

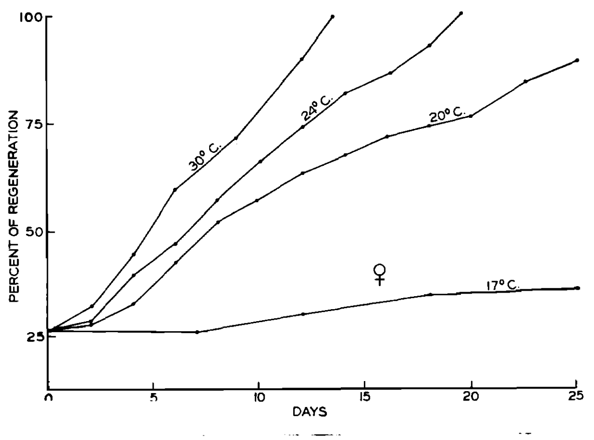

FIGURE 3.--Speed of fin regeneration at different temperatures. Gambusia females in fresh water.

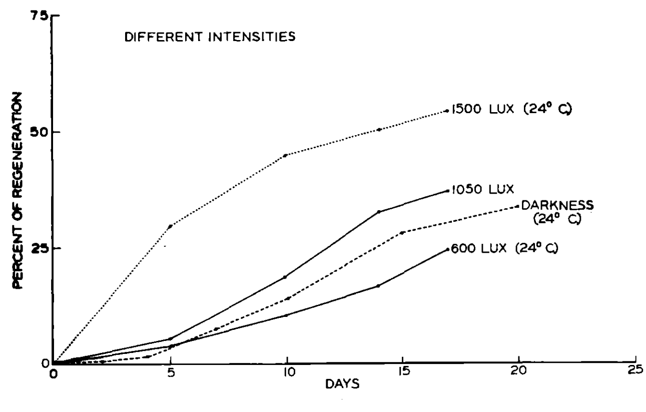

FIGURE 4.--Mean speed of regeneration of caudal fins on Gambusia females held at different light intensities.

(Figures 3 and 4 have been adapted from Buser-Lahaye's figures 10 and 13.)

regeneration and perhaps of growth phenomena in general (including scale regeneration) is to be postulated, though--as this reviewer must point out--the crucial experiments, in which animals without a pituitary gland would be given injections of thyrotrophic hormones, have not yet been performed.

In summary, the following conclusions may be stated:

(1) The experiments point to temperature and light as most important factors in fin regeneration.

(2) The regulation of regeneration, as well as perhaps other growth phenomena, proceeds through endocrine channels, with the thyroid and the pituitary as important intermediaries.

Some additional experiments suggest themselves. These studies would test the quality of light as well as the quantity and thus would compare fish at various levels of physiological activity to a greater extent than has been done in the present experiments. Also, a comparison of the mechanisms of fin and scale regeneration, observed simultaneously, would certainly be of interest. Last, but not least, similar work should be extended to trout and other decidedly cold-water species. Some of these experiments are now planned at the Department of Fisheries, University of Michigan.

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ANALYSES BIBLIOGRAPHIQUES, 1940-1950

Annales de la Station Centrale d'Hydrobiologie Appliquée
(Ministère de l'Agriculture: Direction Générale des Eaux et Forêts)
Fascicule hors série, pp. 7-175, Paris, 1953

This bibliography of French publications in hydrobiology, 1940-50, prepared by a group of collaborators working under the general supervision of Paul Vivier, forms the principal part of a special, unnumbered issue of the Annales. (Included in this same issue are three reports on original work--work on triclads, bacteria, and Hydracarina.) The contents of this volume were assembled originally for publication as a number of the Internationale Revue; but when plans for reestablishment of that journal failed, it was decided to publish the material in the Annales.

The appearance of this bibliography will be welcomed by the many American workers who have experienced difficulty in covering French literature in their field. In France, as in America, papers on hydrobiological subjects seem to be badly scattered among a large number of publication outlets--many little known and sparsely distributed outside the country of publication.

The 1,059 titles listed are accompanied by abstracts. Some of the abstracts are extremely brief, but others are comprehensive. In several instances one abstract covers a series of related articles.

The major subject headings (translated) and the numbers of papers listed are as follows:

I. Biocoenosis of fresh water - 21
II. Lakes - 21
III. Subterranean waters - 85
IV. Brackish waters - 31
V. Botanical hydrobiology - 14
VI. Fresh-water algae - 132
VII. Protista - 74
VIII. Rotifers - 6
IX. Turbellarians - 16
X. Hirudinea - 1
XI. Fresh-water mollusks - 22
XII. Crustaceans - 42
XIII. Acarina - 14
XIV. Aquatic insects - 314
XV. Fresh-water fish - 228
XVI. Applied hydrobiology - 38