# RACIAL STUDIES IN FISHES

## II. EXPERIMENTAL INVESTIGATIONS WITH *LEBISTES RETICULATUS* (PETERS) REGAN

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(With One Graph.)

### I. *Introduction.*

The purpose of the experiments about to be discussed was to contribute information on the rather obscure question whether, or to what extent, quantitative racial characters are hereditary.

The tropical-American Cyprinodont *Lebistes reticulatus* (Peters) Regan[1] was employed in the experiments. I have previously used this little aquarium-fish in experimental investigations, namely for the purpose of demonstrating the importance of environment on the numbers of organs (dorsal rays).

*Lebistes reticulatus* is, like so many of its relatives, *viviparous*, and under favourable conditions the female brings into the world, at intervals of about 4 weeks, a considerable number of young. The young possess at birth the full number of vertebrae, dorsal rays, etc., which is therefore recognisable immediately after birth.

The experiments fall into two groups, of which the first helps to elucidate the importance of *external factors* (temperature) upon the number of dorsal rays. The second is concerned with the question whether hereditary differences, i.e. differences dependent upon *internal factors*, may be proved to exist in different individuals. Before I proceed to discuss the experiments, I may draw attention to the fact that the

[1] C. Tate Regan, "A revision of the Cyprinodont Fishes of the Subfamily Poeciliinae," *Proc. Zool. Soc. London* 1913, Vol. II. pp. 977—1018, 1913.

number of dorsal fin rays in *Lebistes reticulatus* varies from 5 to 8. By far the most usual number is 7.

A more detailed account appears in Vol. XIV, Nos. 1 and 5, of the *Comptes-Rendus des Travaux du Laboratoire de Carlsberg*, Copenhagen.

II. *Importance of External Factors.*

The principle was to vary the temperature for the same pair of parents from one period of pregnancy to the other, and then determine the number of dorsal rays in the various broods of offspring. In the beginning I had no means of maintaining a constant temperature in the aquaria, and was therefore compelled to limit myself to stating that the animals in the experiments were kept at a "low," "medium" and "high" temperature, in which "medium" temperature was ca. 6° above "low" and ca. 3° below "high." "Low" temperature was generally equivalent to ca. 19° Centigrade, varying between ca. 17° and ca. 23°.

In the experiments 5 different pairs of *Lebistes reticulatus* were used. The results of these investigations can be seen from Tables I—V, each of which shows the number of rays in several broods from the

TABLES I—V. *Number of dorsal rays in offspring of the same pairs of parents at different temperatures.*

TABLE I. ♂ 7 × ♀ 7.

| No. of rays | High temperature Born 12 March | Medium temperature Born 13 April | Low temperature Born 1 June | Low temperature Born 25 July | High temperature Born 25 Sept. |
|---|---|---|---|---|---|
| 8 | 9 | — | — | 1 | 4 |
| 7 | 6 | 20 | 25 | 33 | 16 |
| 6 | — | — | 13 | 4 | — |
| n | 15 | 20 | 38 | 38 | 20 |
| a | **7·600** | **7·000** | **6·658** | **6·921** | **7·200** |
| $\sigma$ | ±0·532 | — | ±0·493 | ±0·390 | ±0·414 |
| P. E. A. | ±0·093 | — | ±0·054 | ±0·043 | ±0·062 |
| Fl. | ±0·465 | — | ±0·270 | ±0·215 | ±0·310 |

TABLE II. ♂ 8 × ♀ 8.

| No. of rays | Medium temperature Born 12 April | Low temperature Born 29 May |
|---|---|---|
| 8 | 15 | — |
| 7 | 29 | 27 |
| 6 | — | 5 |
| n | 44 | 32 |
| a | **7·341** | **6·844** |
| $\sigma$ | ±0·483 | ±0·399 |
| P. E. A. | ±0·049 | ±0·048 |
| Fl. | ±0·245 | ±0·240 |

TABLE III. ♂8 × ♀7.

| No. of rays | Medium temperature Born 23 May | Low temperature Born 14 July |
|---|---|---|
| 8 | 8 | — |
| 7 | 49 | 31 |
| 6 | — | 6 |
| n | 57 | 37 |
| a | **7·140** | **6·838** |
| $\sigma$ | ±0·351 | ±0·399 |
| P. E. A. | ±0·031 | ±0·044 |
| Fl. | ±0·155 | ±0·220 |

TABLE IV. ♂6 × ♀6

| No. of rays | Medium temperature Born 1 April | Medium temperature Born 27 May | Low temperature Born 13 July |
|---|---|---|---|
| 8 | 1 | 1 | — |
| 7 | 11 | 31 | 15 |
| 6 | 3 | 6 | 21 |
| n | 15 | 38 | 36 |
| a | **6·867** | **6·868** | **6·417** |
| $\sigma$ | ±0·565 | ±0·439 | ±0·505 |
| P. E. A. | ±0·098 | ±0·048 | ±0·057 |
| Fl. | ±0·490 | ±0·240 | ±0·285 |

TABLE V. ♂6 × ♀6.

| No. of rays | Medium temperature Born 7 May | Low temperature Born 19 June | Low temperature Born 14—15 August |
|---|---|---|---|
| 8 | — | — | — |
| 7 | 11 | 17 | 35 |
| 6 | — | 11 | 18 |
| 5 | — | 2 | — |
| n | 11 | 30 | 53 |
| a | **7·000** | **6·500** | **6·660** |
| $\sigma$ | — | ±0·636 | ±0·487 |
| P. E. A. | — | ±0·078 | ±0·045 |
| Fl. | — | ±0·390 | ±0·255 |

same pair of parents. The date of birth of the young is noted in each case, as also whether developed at low, medium, or high temperature.

It is distinctly evident from the tables that the different broods do exhibit a difference in the number of dorsal fin rays, and it is further seen that the average *number of rays was greater where the young had been developed at a high temperature than where their development took place at a low temperature.*

In all my later experiments this result has been confirmed. I will content myself with discussing a single one of the later experiments, which, technically speaking, had the advantage over the preceding ones in that the temperature in the aquaria could be kept constant, there

being a fluctuation of only one-tenth of a degree (± 0·1). The two parents had respectively 7 and 5 rays in the dorsal fin. The experiment took place partly at 25°, partly at 18°. The three first broods were produced at 25°, following which the parents were maintained at 18°, from the day the third brood was born until the birth of the fourth brood. After this the temperature was raised again to 25°, at which degree the development of the last broods of young took place. The result of the experiment is given in Table VI.

TABLE VI.

*Number of dorsal rays in offspring of the same pair of parents at different temperatures.*

| | No. of Specimens | | | | | |
|---|---|---|---|---|---|---|
| No. of rays in offspring | 25° Brood 1 Born 15/5 1918 | 25° Brood 2 Born 10/6 1918 | 25° Brood 3 Born 6/7 1918 | 18° Brood 4 Born 21/9 1918 | 25° Brood 5, 6, 7 Born 25/10, 21/11, 24/12 1918 | 25° Brood 1, 2, 3, 5, 6, 7 |
| 7 | 8 | 13 | 29 | 6 | 51 | 101 |
| 6 | 1 | 2 | 3 | 13 | 4 | 10 |
| 5 | — | — | — | 1 | — | — |
| n | 9 | 15 | 32 | 20 | 55 | 111 |
| a | **6·889** | **6·867** | **6·906** | **6·250** | **6·927** | **6·910** |
| $\sigma$ | ±0·333 | ±0·352 | ±0·296 | ±0·550 | ±0·262 | ±0·288 |
| P.E.A. | ±0·075 | ±0·061 | ±0·035 | ±0·083 | ±0·024 | ±0·018 |
| Fl. | ±0·375 | ±0·306 | ±0·177 | ±0·415 | ±0·129 | ±0·092 |

Thus we see, that whilst the broods developed at 25° had an average of 6·91 rays, the average number of rays fell to 6·25 at 18°. The difference between the averages was thus 0·660 and the probable error of this difference ± 0·085.

As all experiments in this connection have given a similar result, it may be taken as proved that the number of rays in the dorsal fin of the offspring *is affected to a considerable degree by the temperature* to which the mother is subjected whilst in a state of pregnancy. Remarkable besides is the great difference in the duration of pregnancy at the different temperatures; which at 25° lasted ca. 1 month, at 18° more than 3 months.

III. *Importance of Internal Factors.*

The object of the experiments about to be discussed was to investigate whether hereditary differences in the number of dorsal fin rays could be proved to exist. The principle of the experiments was to maintain *different* pairs of parents in the *same* environment, and see whether the offspring were different as regards the number of rays.

The specimens employed in the experiments were selected from two races with which since 1915 selection experiments had been undertaken, partly towards a high, partly towards a low number of dorsal rays. The parents had, respectively, both 8 and both 6 rays in the dorsal fin. In each case the specimens were kept at a constant temperature, viz. 25°. In addition, in order to secure uniform environment, the specimens whose offspring should be compared were placed in the same aquarium, separated only by a trelliswork of thin glass tubes. In other words they lived in quite the same body of water, maintained at a constant temperature. The aquarium contained no plants, but a continuous stream of atmospheric air bubbled through the water.

The experiment falls into two series, A and B. In series A there were employed partly ♂ 269 and ♀ 270 (each with 6 rays), partly ♂ 267 and ♀ 268 (each with 8 rays). For series B there were employed partly ♂ 274 and ♀ 273 (each with 6 rays), partly ♂ 276 and ♀ 275 (each with 8 rays). All the experimental fish in series A were kept in the same aquarium which stood at the side of the one in which all the fishes belonging to series B were placed.

From the appended Table VII and from the graph on p. 152 one remarks that there was in both series a very great difference in the

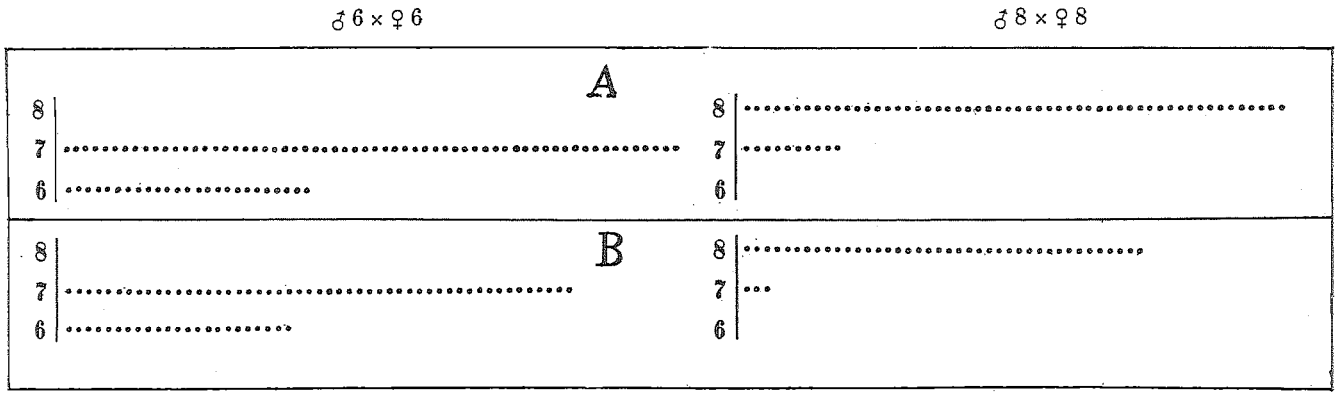
TABLE VII.

*Number of dorsal rays in offspring of four different pairs of parents at a constant temperature of* 25° C.

| | Series A | | Series B | |
|---|---|---|---|---|
| | ♂ 269 × ♀ 270 both 6 rays | ♂ 267 × ♀ 268 both 8 rays | ♂ 274 × ♀ 273 both 6 rays | ♂ 276 × ♀ 275 both 8 rays |
| No. of rays in offspring | Brood 1, 2, 3, 4 Born 23/9, 17/10, 9/11, 4/12 1918 | Brood 1, 2, 3, 4 Born 27/9, 23/10, 19/11, 17/12 1918 | Brood 1, 2, 3, 4 Born 29/9, 24/10, 21/11, 18/12 1918 | Brood 1, 2, 3 Born 29/9, 26/10, 26/11 1918 |
| 8 | — | 54 | — | 40 |
| 7 | 62 | 10 | 51 | 3 |
| 6 | 25 | — | 23 | — |
| n | 87 | 64 | 74 | 43 |
| a | **6·713** | **7·844** | **6·689** | **7·930** |
| σ | ±0·455 | ±0·366 | ±0·466 | ±0·258 |
| P. E. A. | ±0·033 | ±0·031 | ±0·037 | ±0·027 |
| Fl. | ±0·165 | ±0·154 | ±0·183 | ±0·133 |

average number of rays in the offspring of fishes with 6 and with 8 rays, namely in the first series **1·131** (Probable error of difference = 0·045) and in the second **1·241** (P.E. Diff. = 0·045).

This difference cannot be due to difference in environment because the fishes swam in the same aquarium, indeed in the very same water




## EXPLANATION OF THE GRAPH.

Number of rays in the dorsal fin in offspring of 4 pairs of parents all kept at 25°. Graphical representation of the experiment given in Table VII.

The figures give the number of rays; each dot represents one individual member of the offspring. The two upper graphs refer to Series A; the two lower ones to Series B of the experiment. The two graphs on the left represent offspring of parents having 6 rays in the dorsal fin, the two on the right represent parents with 8 rays.

It is to be seen that in each series the offspring is different in spite of the environment being identical.

at a constant temperature and with regular ventilation. The conditions with regard to uniformity were in my opinion the most favourable possible and I cannot but conclude from the present experiment, that the *difference proved to exist in the offspring of parents with respectively* 6 *and* 8 *rays is of hereditary (genotypical) nature.*

IV. *Concluding Remarks.*

The investigations here treated fall into two groups: (1) Experiments in which the *same mother* was exposed to *different environments* in different periods of pregnancy and (2) Experiments in which *different mothers* were exposed to the *same environment*, have thus succeeded in elucidating these rather complicated questions.

It has been shown that the number of organs may be very susceptible to environment, but that this fact cannot—under suitable experimental conditions—disguise the fact, which we specially wanted to demonstrate, viz. that there are or may be differences of hereditary nature between the various individuals.

This proof is of considerable interest for our view upon the nature of "races" in fishes, and supports in a high degree the opinion expressed by me at a previous occasion[1]: "My view then, with regard to the nature of 'races' in fishes, as characterised by our population analyses, is briefly this. A fish 'race' is largely a statistical conception. It implies a mixing of different genotypes, and the average values characterising the 'race' are primarily dependent upon the quantitative proportion between these; only secondarily on the environment."

[1] Johs. Schmidt, "Racial Studies in Fishes. I. Statistical Investigations with *Zoarces viviparus*, L.," *Journal of Genetics*, Vol. VII. p. 117, 1918.