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Rigor mortis of fish.

By

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Part II.

Rigor Mortis of Fish

One of the objections raised against cold storage fish is that, since this flesh food is most highly prized when very fresh, it is unsuited to keeping for long times. While it may be that this is merely a habit in regard to food, yet it is possible that those changes for which we deliberately wait in the case of the flesh of mammals, are not desirable in the case of fish. We 'hang' our meats to allow the changes of *rigor mortis* and its passing to occur, but for fish we use no such preparation.

It has, therefore, seemed advisable to investigate the nature of the death stiffening of fish, and in particular, to learn something of the times which are necessary for it to reach its maximum and to pass.

A study of the literature gives little information in regard to fish in this connection. Many conditions are, however, noted as affecting, for other animals, the time intervals for the maximum of stiffening and final relaxation; such, for example, as the temperature at which the animal is kept after death; the size of the animal; its species; the condition of the muscle just before death, as to nutrition, fatigue, oxygen supply and so on.

The paper by Panton and Dempsey (1) and the following sections deal with some of these conditions as influencing the rigor of fish.

Influence of Size

For these tests, the apparatus described by Panton and Dempsey (1), was used. Several sets of apparatus were set up side by side in the laboratory, so that a series of fish could be examined under the same conditions of temperature. The fish were brought to the laboratory as soon as possible after they were caught in the river just below. In some cases they were still quivering when they were taken from the fish basket and in no case did they show any suggestion of stiffness. They were put very quickly into the apparatus, fish of different size being deliberately chosen. In the case of the small forms, they were fitted in whole between the supports, but in the case of the large fish, the tail parts were cut off, approximately the same length as the fish used by Panton and Dempsey (1), i.e. about 60 cm., these were wedged into the apparatus and the other parts of the fish were examined chemically as described in another paper (Benson (2)).

Two series of tests were made with haddock, as is shown by the table and in the charts, on which are indicated the weights necessary to pull the freely suspended tail through the given arc of the apparatus, and plotted against the times, when these weights were needed.

From these charts it is evident that the time intervals for maximum stiffening and relaxation are directly related to the size of the fish. This agrees with results obtained by investigators, who have studied other animals: We find Nagel (3) gives different curves of rigidity and time for strong summer and thin winter frogs, and he explains the different results obtained by Bonhoeffer (4) and by Walker and Schlapfer (5) as due to the size of their animals. Whether these different curves for the fish are the results of differences in fatigue of the fish, the smaller being the more exhausted, is not now possible to know as the fish were all taken from a trawl. It is generally recognized that fatigue causes a very early appearance of rigor, so that we find Lichtwitz (6) saying "Dasz die Totenstarre wirklich durch Bildung von Säure (Milchsäure) herbeigeführt wird, sehen wir an der dem Jäger bekannten Erscheinung dasz geherztes Wild, das bei der starken körperlichen Anstrengungen, mehr Milchsäure gebildet als verbrannt hat, nach dem Tode fast sofort in Totenstarre verfallt, die bei dem in gröszerer körperlicher Ruhe Gestorbenen erst allmahlich durch die postmortale Milchsäureanhäufung entsteht". (p. 118)

These tests were made in a bright, sunshiny laboratory of the St. Andrews Biological Station and the differences of temperature were therefore, considerably greater than were desirable, but the effects of the temperatures were similar to those noted by Panton and Dempsey. The temperatures of the room are shown on the Charts.

Thus Fish 4 and Fish 6, which were almost the same size, reached the same maximum amount of rigidity but in different times, on account of differences of temperature.

Fish 5 seemed to soften after about 2½ hours, for no reason which I could notice. This was a much shorter time than was expected from its size, as suggested by the results obtained on August 30th. The rest of the fish still felt very firm and after this apparent softening, the stiffening again increased to go to its maximum at the fifth hour and to an amount of stiffness, greater than that expected by the fish studied on August 30th. This is perhaps, an example of the "Stufen" of which Nagel (3) speaks on p. 298 of his article.

Variations for Different Species

It has so far only been possible to make two experiments comparing the rigor curves of Haddock with those of Hake and Cod. The results are given in the tables and the charts and, for the cod, seem to support the idea expressed by fishermen, that the cod "soon gets hard".

The very different time relations shown for the hake and cod as compared with haddock suggest differences of colloidal condition of the muscle which are entirely in agreement with results noted in regard to suitability or unsuitability for freezing as shown by histological study (Jackson(7)),and peculiarities in regard to muscle juice. (Benson (2) and (8)).

This difference in colloidal condition is indicated, too, by the very different extent of the rigidity of the different species of fish. The cod became very hard, the haddock also, very firm but the hake was, in comparison, fairly soft even at what was apparently its maximum of stiffening. While the haddock of 2.1 kilos required, at maximum rigidity, a weight of 700 gms. to pull the tail part through the arc, the hake of almost the same size, required at the most only 226 gms. to move the same length of tail through the same distance.

The cod seems to have shown the greatest rigidity for this size of fish but there is not enough data to draw conclusions on this point.

J.W.

Further experiments of this kind should be made and other forms of fish tested, but the results agree with those of Nagel (3) and Bonhoeffer (4) who found very different time intervals for rigor mortis for toads and frogs. These two experiments seem to indicate:-

(1) that the muscle of different species of fish is of different colloidal nature, and

(2) that it requires different times for fish of different species to reach the height of rigidity and the subsequent softening.

Conclusion.

There are therefore indications:-

(1) that the rate at which rigor mortis appears and disappears is hastened by increasing the temperature in which the fish is kept.

(2) that the rate is slower the larger the fish of the species, in the case of the haddock, at least.

(3) that the rate is different for fish of different species, and

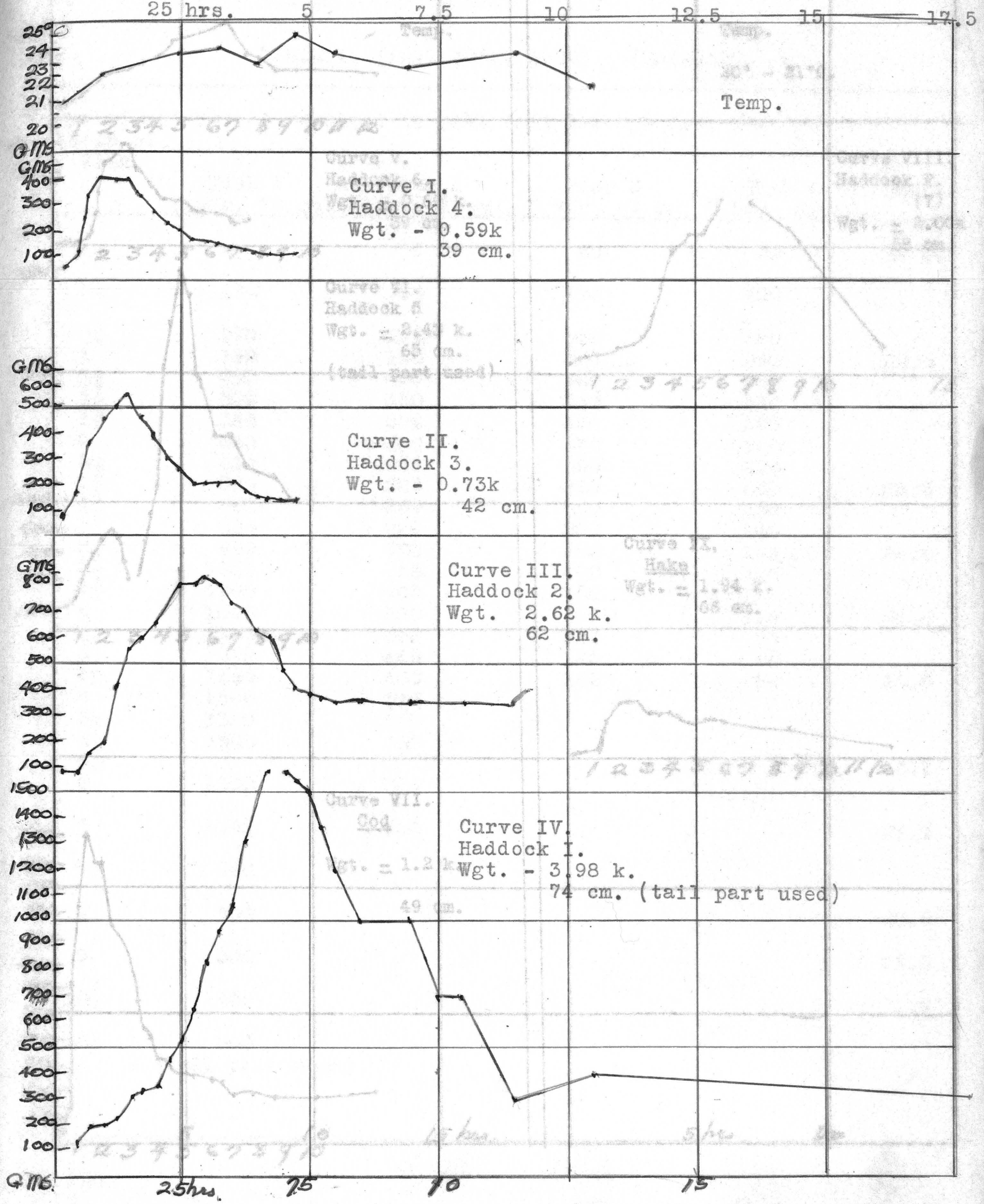
(4) that the amount of the rigidity is proportional to the size of the fish.

It is thus evidently difficult to decide in what condition of stiffness the fish are best for food. We are, however, in the habit of keeping fish as cold as possible until we are ready to use them, and we speak of preferring fine, big fish. These are both conditions which lengthen the time for rigidity. When added to this, we consider that we expect fish to be firm to be at their best, it seems likely that it is rigid fish which we prefer.

This would suggest another reason for freezing fish for cold storage in as fresh a state as possible, but as to the rate at which the changes of rigor may proceed in frozen fish, we have no information.

I am glad of this opportunity to again express my thanks to Dr. Huntsman for his great kindness in so graciously providing facilities for work and for his many, and valuable suggestions.

August 30th 1922



Sept. 2nd. 1922 Aug. 25th. 1922

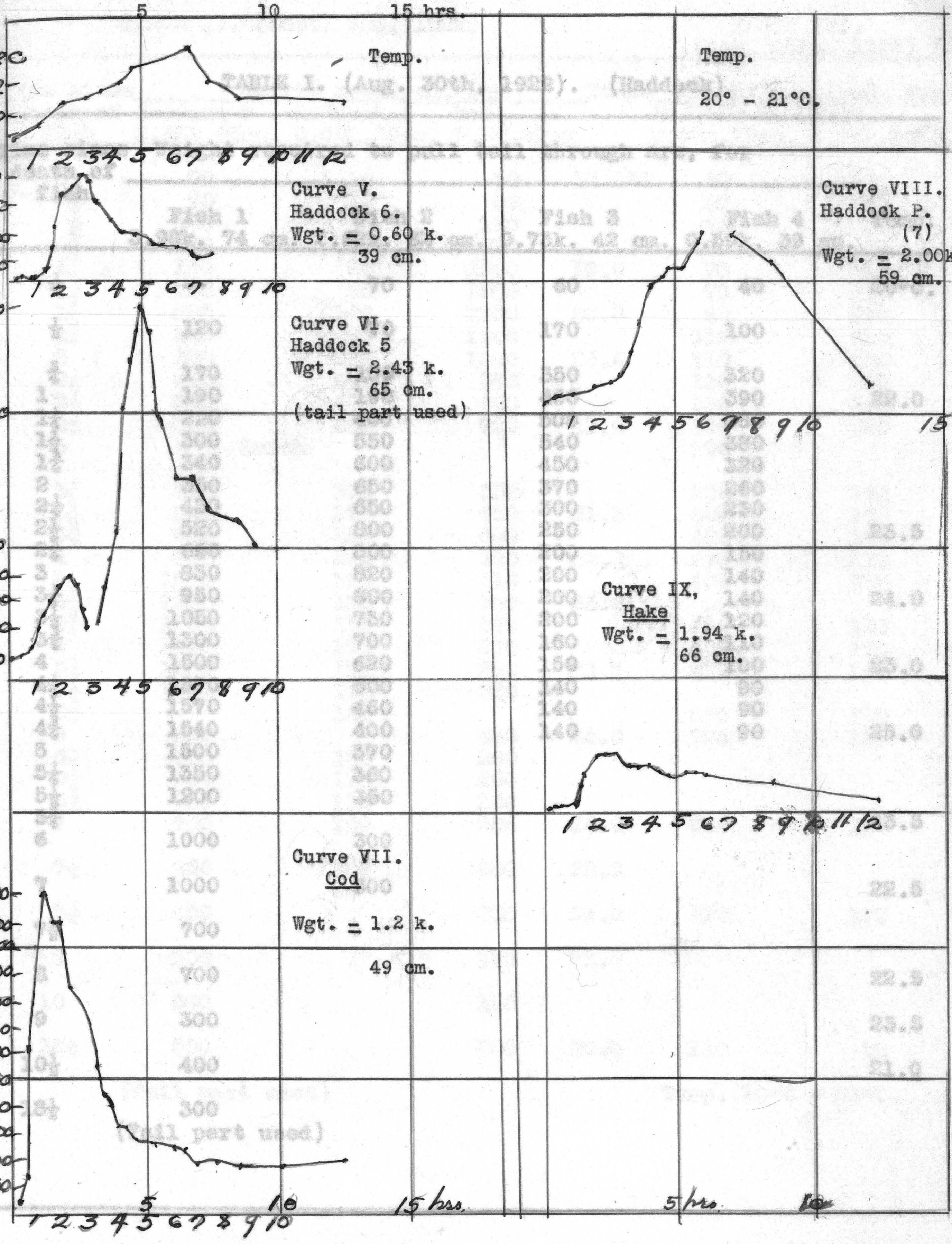


TABLE I. (Aug. 30th, 1922). (Haddock)

Time since death of fish	Weight required to pull tail through arc, for Fish 1 3.98k. 74 cm.	Fish 2 2.62k. 62 cm.	Fish 3 0.73k. 42 cm.	Fish 4 0.59k. 39 cm.	Temp.
¼	--	70	60	40	20°C.
½	120	70	170	100	
¾	170	150	350	320	
1	190	190	450	390	22.0
1¼	220	400	500	380	
1½	300	550	540	380	
1¾	340	600	450	320	
2	350	650	370	260	
2¼	430	650	300	230	
2½	520	800	250	200	23.5
2¾	650	800	200	150	
3	830	820	200	140	
3¼	950	800	200	140	24.0
3½	1050	730	200	120	
3¾	1300	700	160	110	
4	1500	620	150	100	23.0
4¼	1570	600	140	90	
4½	1570	460	140	90	
4¾	1540	400	140	90	25.0
5	1500	370			
5¼	1350	360			
5½	1200	350			
5¾					23.5
6	1000	300			
7	1000	300			22.5
7½	700				
8	700				22.5
9	300				23.5
10½	400				21.0
18½	300 (Tail part used)				

TABLE II. (Sept. 2nd, 1922) | TABLE III. (Aug. 25th. 1922)

Time since death of fish	Weight required, for Haddock 5 2.43k.65cm.	Haddock 6 0.60k.39cm.	Cod 1.2k.49cm.	Temp.	Weight required, for Haddock 7 2.00k.79cm.	Hake 1.94k.66cm.
0	90	10	30	18.3°C	50	20
¼	90	10	50		60	20
½	100	10	120		70	20
¾	150	10	600		70	30
1	190	20	1000	19.0	70	50
1¼	240	50	1200		75	110
1½	290	140	1100	20.0	90	170
1¾	350	240	1100		110	220
2	370	320	1000	20.4	110	220
2¼	370	350	850		130	220
2½	350	400	800		130	220
2¾	200	400	750	21.0	150	226
3	lunch				190	
3¼	200	300	550		250	180
3½	340	270	450	21.3	350	170
3¾	450	220	400		390	180
4	600	200	320	22.0	470	170
4¼	1000	190	310		490	170
4½	1200	180	300	23.0		
4¾	1300	170	270		550	150
5	1400	170	270		550	160
5¼	1300	150	280	23.5	580	160
5½	1000	140	260			
5¾		130			650	150
6	850		260	24.0	700	150
6¼	750	130	260			
6½	750	120	260			
6¾	750	110	240			
7	700	100	200	24.0	680	130
7½	650	100	200	22.0		
8½	650		200	21.0	570	110
9	500		170	21.0		
10	500		160			
12½	500		200	20.5	110	50

(Tail part used) | Temp. 20°C - 21°C.

BIBLIOGRAPHY

(1) W. Baumann. "Untersuchungen über die Muskelstarre." Archiv. f. die. ges. Physiol., vol. 167, p. 117, 1917.

(2) J.R. Panton and E. Dempsey. "The Influence of Temperature on the Rigor Mortis of Fish." (Unpublished results) and Report to Biological Board of Canada, 1921.

(3) C,C. Benson. Report to Biological Board of Canada, 1922.

(4) W.A. Nagel. "Experimentelle Untersuchungen über die Todtenstarre bei Kaltblütern." Archiv. f. die ges. Physiol., vol. 58. p. 279. 1894.

(5) K. Bonfoeffer. "Ueber einige physiologische Eigenschaften dunn und dichfaseriger Muskeln bei Amphibien." Arch. f. die ges. Physiol., 601, 47, p. 125, 1890.

(6) E. Walker and Schlapfer, reported by L. Hermann. "Kleinere Beiträge zur Lehre von der Muskelstarre." Archiv. f. die ges. Physiol., vol. 55, p. 481, 1894.

(7) L. Lichtwitz. "Klinisce Chemie." Springer. Berlin. 1918.

(8) F.S. Jackson. "The Freezing of Fish." Contributions to Canadian Biology, vol. 1, new series, p. 297, 1923.

(9) C.C. Benson. Report to Biological Board of Canada, 1920.