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Comparison of the Beats in Three and Four Chambered Hearts.

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A careful observation of the beating hearts of the cat and turtle shows a marked dissimilarity in the manner of contraction. The cat heart appears to remain relatively constant in length, but expands and contracts laterally with each beat, while the turtle heart may be seen to contract uniformly in all directions, as a ball of muscle.

In our attempt to examine this phenomenon in a quantitative way, we used the method outlined by Takeuchi[1] who used cinematographs to examine volume changes of the heart during anoxemia. In our experiments a 16 mm Filmo motion picture camera was used to photograph the beating hearts, exposed *in situ,* at speeds of either 8 or 16 pictures a second. Light was obtained from Eastman photoflood lamps.

After the pictures had been taken, each frame was studied under the binocular microscope, using an ocular micrometer which gave a value of one ocular unit equal to ½ mm. By means of this, measurements were made of the greatest width and length of the ventricular picture on successive frames for 5 or 6 beats. The amount of change could be plotted graphically against time (in exposures) to form curves similar to the kymograph cardiogram. From these curves the actual dimensions of the hearts during the cycle could be determined for any point on the cycle. Differences between systolic and diastolic sizes along the 2 axes studied were then translated into percentages of the maximum dimensions.

From the above data it may be seen that the ratio between the contraction of the width and length in the heart of the turtle is much nearer 1.0 than is the ratio of the cat's heart. In most cases the turtle ventricle contracts longitudinally even more than it contracts transversely, thus giving ratios of less than 1.0, in distinct contrast to the condition in the cat. Pictures made of the heart beat in the undivided ventricle of the fish and the double ventricle of the bird show results which agree with the ratios of the turtle and cat respectively. Although no definite statements can yet be made, varia-

* Contribution from the Zoological Laboratory of the University of Illinois, No. 522.

1 Takeuchi, K., *J. Physiol.*, 1925, **60**, 209.

TABLE I.

Animal	No. of observations	% contraction in width	% contraction in length	Width/Length Ratio
Turtle	1	22.4	25.2	0.888
	2	24.7	29.3	0.843
	3	12.3	10.3	1.194*
	4	30.8	30.0	1.025
	5	30.7	37.5	0.818
	6	21.1	20.0	1.055
	7	20.1	20.3	0.990
	8	10.7	12.5	0.856
	9	16.15	20.7	0.780
	10	15.3	19.6	0.780
Catfish	1	23.8	18.9	1.26
Cat	1	7.1	1.8	3.95
	2	6.6	1.5	4.30
	3	7.0	1.7	4.11
	4	5.0	1.56	3.12
	5	11.96	4.41	2.72
	6	13.33	4.05	3.30
Chicken	1	7.8	3.5	2.23

*Isolated heart.

tions of the ratio in different experiments may be correlated with the rate of beat and intraventricular pressure.

These figures indicate that the contraction in the single ventricles of the turtle and fish is the result of the nearly equal participation of both longitudinal and transverse muscle fibers, while contraction in the double ventricles of the cat and bird is largely the result of the transverse muscles, the longitudinal contraction being relatively small.

For a possible explanation of this difference one might consider the intraventricular septum as a buttress against any movement in the direction in which it lies, but affording no resistance to movements in the lateral direction. On the other hand, since the septum is absent in the hearts of the turtle and fish, there is nothing to prevent the muscle from contracting more or less equally in all directions and giving the contracting ventricle a ball-like appearance. These differences between the length and the width in the 3- and 4-chambered hearts may also be related to the structural arrangement of the inner and outer muscle layers.