ON THE ABILITY OF CERTAIN MARINE INVERTEBRATES TO LIVE IN DILUTED SEA WATER.

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There are many reasons for believing that animal life originated in the ocean and has gradually spread through the ages into freshwater and land habitats (15, 21). In the past annelid worms invaded the soil, probably by a rather indirect route which led them first into freshwater and gradually out into the land (23). At the present time many animals in various parts of the earth show varying degrees of ability to live in diluted sea water (1, 3, 10, 11, 12, 21). Marine invertebrates which have been studied have an osmotic pressure in their blood which is approximately equal to that in sea water, but the mineral salts are somewhat less and the pressure is maintained by other substances, largely organic, which are present (1, 8, 9). The skins of various animals differ greatly in ability to control the exchange of chemicals between the body fluids and the surrounding medium. Adolph (1) studied the exchanges of substances through the skins of annelids and found that there was little resistance to them.

The writer felt that it would be of interest to determine the ability of representative marine annelids to live in diluted sea water, and during August 1927 made some observations in the Marine Biological Laboratory at Woods Hole. Thanks are due to Drs. J. A. Dawson and R. Bennitt who made suggestions and helped in the identification of several species. Mr. A. M. Hilton and his staff of collectors also made special efforts to secure materials.

Animals were brought in fresh from the field and placed as soon as possible in clean glass finger bowls containing 250 cc. of water. Tubicolous worms were removed from their tubes, except in the case of Hydroides, which was studied both in and out of tubes, and of Cystenides, which was left in its own tubes.

The water in all bowls was changed each morning, and oftener when it showed indications of becoming stagnant or when a worm bled. Dilutions were made with fresh water from the taps in the Marine Biological Laboratory. Sea water came from the same source. Page (13) has made a careful analysis of this water for mineral constituents.

The results of the observations are given in Table I. *Nereis virens*, *Laonice viridis*, and *Limulus polyphemus* showed a considerable degree of toleration for sea water diluted to one fourth its normal salinity. *Arabella opalina*, *Glycera dibranchiata*, and *Lepidonotus squamatus* lived for many days in one half sea water and one half fresh. Most of the worms tested lived several days in three fourths sea water. *Nereis* in higher concentrations of sea water climbed out of the dishes at intervals and was found in varying degrees of desiccation, hence some individuals probably died sooner than some of those in more dilute solutions. Every *Laonice* studied lived throughout the period of observation and was active at the end. The Hydroides in tubes did not live as long as those which were removed. This was probably due to the fouling of the water by small organisms in and on the mollusc shells to which the tubes of these worms were attached. The *Limuli* used were small individuals, less than 10 cm. long. All that were tested in solutions as low as one fourth sea water survived to the end of the observations. One individual lived 26 hours in a solution of one eighth sea water, and another lived two hours in fresh water.

Nereids have been observed in various localities to be noteworthy for their ability to endure considerable dilution of sea water (3, 7, 11, 13). In India there is a species of *Limulus* which lives in brackish water (3). Vaughn (24) found that several species of corals survived a reduction of twenty per cent. in the salinity of the sea water and he interpreted this as indicating that the ocean has been in the past less salty than now. The observations described in this paper show that many worms have similar toleration. The writer cannot see that general features of bodily structure and habitat are especially correlated with ability to survive in diluted sea water. Apparently delicate branchiate worms, like *Chætopterus*, *Diopatra*, and *Laonice*,

endure fresh water about as well as apparently tougher worms, such as *Phascolosoma* and *Lumbricillus*. The only oligochæte observed, *Lumbricillus agilis*, was not as hardy as many polychætes when placed in diluted sea water. In low salt concentrations all the animals studied showed a tendency to swell and became turgid and extended. *Laonice* perhaps showed this least; *Lepidonotus* and *Lumbricillus* perhaps most; *Amphitrite* frequently bled and died soon. The individual *Nereis* which lived and was active for twenty-one days in a medium containing only one fourth sea water became very active and soon began to shrink to its normal size when replaced in undiluted sea water.

TABLE I.

TIME IN HOURS WHICH ANIMALS LIVED IN SEA WATER AND VARIOUS DILUTIONS OF IT.

A indicates that an animal was apparently in good condition when the observations were discontinued.

Name of Animal.	No. Observed.	Sea Water.				
		1	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$
Amphitrite ornata (Leidy)	12	65	115	7	2	
Arabella opalina (Verrill)	5		302*A*	302*A*	.7	
Arenicola marina (L.)	2				2	
Chætopterus pergamentaceus Cuvier	10	403*A*	403*A*	4	1	
Cirratulus grandis Verrill	4	475*A*	475*A*	8	3	
Clymanella torquata (Leidy)	13	487*A*	487*A*	38	.3	
Cystenides gouldii Verrill	3		35	256*A*	4	
Diopatra cuprea (Bosc)	17	280*A*	478*A*	30	.2	
Glycera dibranchiata Ehlers	9	498*A*	498*A*	498*A*	.7	.4
Harmothoe imbricata (L.)	7	228*A*	228*A*	4	.5	
Hydroides hexagonus Bosc	12	260*A*	260*A*	105	.5	
Laonice viridis (Verrill)	8	230*A*	230*A*	230*A*	230*A*	
Lepidonotus squamatus (L.)	13	474*A*	474*A*	379*A*	.3	
Limulus polyphemus (L.)	13	191*A*	191*A*	192*A*	192*A*	40
Lumbricillus agilis Moore	5	8	100	130	.3	
Maldane urceolata (Leidy)	1			8		
Nephthys bucera Ehlers	2	356	115			
Nereis virens Sars	13	236+	259*A*	500*A*	500*A*	3
Phascoloscoma gouldii (Pourtales)	4	252*A*	298	.3	.2	
Pista palmata (Verrill)	5	303*A*		35	26	

SUMMARY.

The ability of *Limulus*, *Phascolosoma*, and eighteen marine annelids to survive in various dilutions of sea water was studied. Most of the animals lived for a week or two in a mixture of three

fourths sea water and one fourth fresh; several species lived in one half sea water. *Limulus*, *Laonice*, and *Nereis* lived and were active for periods of two to three weeks in one fourth sea water, but died in weaker solutions.

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