STUDIES ON THE CIRRAL MOVEMENTS OF THE BARNACLE, BALANUS BALANOIDES

By WILLIAM H. COLE, *Rutgers University*

As a part of a larger study on chemical stimulation in animals the work in 1931 at Mount Desert Island consisted of observations on (1) unstimulated animals, and (2) on animals stimulated by the normal aliphatic acids. For collecting the data on unstimulated animals, I am indebted to Miss Ruth Feng.

(1) For a period of six weeks 120 individuals were continuously immersed in running sea water. The rate of cirral movement of individuals was recorded on alternate days under experimental conditions held as constant as posible (illumination, water supply, vibrational insulation, rate of water flow 250 ± 25 cc. per minute, temperature 17.2 ± 0.2° C.). Complete records of 61 animals were obtained with at least 50 readings on each, and with equal chronological distribution. The number of observations in this group totaled 5,316. The mean rate with its probable error was calculated for each individual. Frequency plots for individuals and for the group as a whole indicated the absence of gross inaccuracies, and the probability of a constant experimental error. The mean rates varied from 94 to 125 beats per minute with a prominent non-skewed mode at 107.7. The highest probable error for all observations on any one individual was only 1.03% of the mean, and the lowest was 0.2%. The majority of individual probable errors of the means expressed as percentages of the means lay between 0.3 and 0.6%. Such small errors are seldom encountered in an unselected population of animals over an equally long period of time. Daily variations of the rate remained constant throughout the period, indicating that there was no harmful effect of continuous immersion on this typical inter-tidal species as far as its cirral rate is concerned. Comparisons between statistically uniform selected data from 50 individuals further showed that animals with slow rates are as regular as, and no less variable than, those with fast rates. It was found that increased variation was correlated with the use of stored tank sea water. Whenever water that had been stored for six or more hours was used the rates of movement regularly decreased in some animals and closure occurred in others. As soon as freshly pumped sea water was used the rate quickly returned to normal and all irregularity disappeared. That such changes were not due to the corresponding small changes in aeration, pH, carbon dioxide and oxygen content was proved by appropriate experiments. It was tentatively concluded that minute changes in the chemical constitution of the sea water were responsible for the effects. Due to the increase in temperature of the stored water from a mean of 15 ± 5° C., to 22 ± 5° C., it is supposed that the rapid decomposition of the micro-fauna might release organic compounds highly stimulating or toxic to the barnacle.

All of the observations support the conclusion that under the proper

condtions, changes in the cirral rhythm are reliable criteria of stimulation.

(2) The other part of the work had to do with the relation between closure of the valves and concentration of fatty acid. From four to nine different concentrations of each of the following acids made up in sea water were used at the same pH as sea water: formic, acetic, proprionic, butyric, valeric, caproic, heptylic, caprylic, involving 158 different tests on one lot of 137 animals. Throughout the tests all other experimental conditions were held as constant as posible, as described under (1) above. The apparatus was so arranged that the sea water flowing over the animals could be shut off and replaced by the experimental acid solution at the same rate of flow and temperature. The number of regularly active animals was recorded at one minute intervals until no further change in the number occurred. The animals were then thoroughly rinsed by excess sea water, and allowed a thirty-minute "rest" period. Reproducible results indicated the complete absence of any adaptive or harmful effects. The data have not yet been analyzed, but as a rough approximation, it may be said that as concentration increases the effectiveness of the acids for closure also increases; and that as the length of the carbon chain in the molecule increases the stimulating efficiency increases. The relations between these factors are by no means simple, and considerable study of the data will be necessary before an intelligent interpretation can be proposed.