THE RELATION OF WATER UPTAKE AND OXYGEN CONSUMPTION OF BODY TISSUES TO THE MOULTING CYCLE IN

BALANUS BALANOIDES (L.)

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It is now well known that there are many complex biochemical changes associated with crustacean moulting cycles. The present investigation is concerned with water uptake and oxygen consumption. Travis (1954) has given a detailed account of the changes in water content during the moulting cycle of Panulirus argus (Latreille). She found that the water content of an intermoult animal is 71%; this value rises on the day preceding ecdysis to 75%, to 81% fifteen minutes before ecdysis and reaches a peak value of 82% the day following the loss of the old exoskeleton. From this point the water content gradually falls, to reach the late intermoult value only after the new exoskeleton is fully calcified. In agreement with what is known of other Decapods (Drach, 1939) water absorption is probably complete six to twelve hours after ecdysis. There appears also, much evidence for a rise in oxygen consumption prior to, or at, ecdysis (Scudamore, 1947; Frost, Saloum & Kleinholz, 1951; Bliss, 1953; Roberts, 1957). Scheer & Scheer (1954) have shown that in Neopolitan Palaemon serratus (Pennant), indicated by them as Leander serratus, this change in oxygen consumption is not just a maximum at ecdysis; from a value of 14.5 units in the intermoult (C1-C2) stage, $QO_2$ rises to 18.5 units at the D1 stage when active resorption is taking place, but this is followed by a fall to 13.2 units at the D2 stage which immediately precedes ecdysis: when the new integument has been fully formed (D3) and absorption of water is complete there is a further rise to 17.6 units, after which the oxygen uptake returns to its normal intermoult value. How far these changes are typical of other crustaceans is unknown; these authors point out that the pattern they observed may be restricted to this particular race of P. serratus since as regards its hormonal behaviour it differs in some respects from the same species elsewhere.

Although a well defined annual cycle in many biochemical constituents has recently been demonstrated in two boreo-arctic cirripedes, Balanus balanoides (L.) and B. balanus (L.) (cf. Barnes, Barnes & Finlayson, 1963a) no metabolic changes associated with the moulting cycle of cirripedes has been reported. Costlow & Bookhout (1958) failed to find any correlation between oxygen uptake and the stage of the moulting cycle in B. amphitrite var. denticulata Broch and sug-
gested that this may be due to the relative simplicity of the shed exoskeleton and underlying tissues, or to the masking effect of a persistent respiration of the shell-forming tissues; the latter according to them (Costlow & Bookhout, 1953, 1956, 1957) are not affected by the moulting cycle. *B. amphitrite* Darwin is a warm water species and the experimental temperature used by Costlow & Bookhout could be relatively high; further, the animals used were small. Both these conditions lead to a high moulting frequency — two to three days from moult to moult. It should be easier to detect any metabolic changes associated with the moulting cycle in a species with a much longer moulting cycle and when the oxygen consumption is measured on whole bodies isolated from the shells.

THE MATERIAL AND METHODS

*B. balanoides* (L.) growing on live mussels were used. The mussels were first split and then cleaned of their tissues and, selecting several replicate sets covering a wide size range of animals, a single barnacle was isolated on each mollusc valve. The material was then enclosed in a cage and transferred to a raft for two weeks to allow complete removal of mussel tissue which otherwise would subsequently have fouled the water in the small experimental vessels. Each animal on its mussel shell was then maintained isolated from its fellows in the compartments of a multi-compartment plastic container. Sea water, changed several times each day, was put in the compartments and all the containers gently agitated on a mechanical shaker. Food, in the form of a mixed culture of diatoms was added once or twice daily. A record was kept of the moulting of each individual animal, the time of the moult being assigned to the mid-point of the time when it was first seen and that of the previous inspection. A large number of animals were maintained in this way so that the experiments could be completed in a limited time (15 days); this is necessary in order to avoid errors due to changes in the body composition with season, changes which markedly affect the oxygen consumption. The experiments were run during the early summer when the moulting frequency (10-12 per 100 animals per day) is reasonably high and relatively constant, and when the development of the gonads has only just begun.

After several days animals at different and known stages of their moulting cycle, were available for experiments. A set of animals at the same stage and of variable size was then used to determine the oxygen uptake and water content. Oxygen uptake was determined on the whole bodies carefully dissected from the valves; in this way an approach to a 'basal' or resting value is obtained. For each stage in the moulting cycle a size series of animals was used since oxygen uptake is markedly weight dependent. The method has already been described in detail and the rationale and validity of the results obtained critically examined (Barnes & Barnes, 1959; Barnes, Barnes & Finlayson, 1963a). The oxygen uptake was measured at 10°C (a value near the mean, 12°C, at which the animals were maintained throughout) by standard differential manometry. The wet weights