

Similar experiments have recently been carried out on the behaviour of several species of prawns which confirm that there is a close parallel between mechanisms at work in prawns and crabs and those in fish. In both groups there are several mechanisms that detect displacement of the body; these are present in the same animal and are presumably used simultaneously. In *Palaemon serratus* (Pennant) and *Palaemon elegans* Rathke visual, inertial and tactile stimuli elicit compensatory movements of the eyestalks and to a varying extent of the organs responsible for controlling the direction of movement, that is, the antennae, pleopods and telson. The statocyst has been shown to be essential to enable these animals to respond to rotation in the absence of visual and tactile stimuli. *Pandalus montagu* Leach, which has no statocyst and which does not respond to inertial stimulation, possesses an additional sense which enables it to respond to water movement when it is rotated; this sense normally augments the response to visual and tactile stimuli.

It is interesting to note that of the four possible mechanisms available to give information about the animal's displacement relative to its environment, no particular crustacean so far studied appears to use more than three to control its direction of movement. *Palinurus vulgaris*, although possessing statocysts, resembles *Pandalus montagu* in giving no response to inertial stimuli, but shows compensatory behaviour when stimulated by water currents, while the other prawns and brachyuran crabs<sup>5</sup> give compensatory eyestalk responses to visual, tactile and inertial stimuli but not to water movements.

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### The Teleostean Swim-bladder

THE enigmatic secretion of gas into the teleostean swim-bladder has been attributed to the acidification of the blood bathing the gas gland epithelium<sup>1</sup>. The resultant local changes of  $pH$ ,  $pCO_2$  and  $pO_2$  are thought to be sequestered from the rest of the circulation by counter-current exchange in the rete mirabile. This has been the only credible explanation; but its acceptance has rested upon its credibility. Even though the isolated gas gland epithelium actively converts glucose to lactic acid<sup>2</sup>, there has been no evidence, either *in vivo* or *in vitro*, for an oriented hydrogen-ion extrusion into the solution bathing the serosal surface of the epithelium, the surface normally bathed by blood.

The following experiments indicate that the isolated surviving gas gland epithelium of the pollack (*Polachius virens*, L.) selectively extrudes hydrogen ion into the solution bathing its serosal surface. The gas gland epithelium was dissected free of its serosal coat and exposed to oxygenated saline within 15 min. after removal of the fish from water. The epithelium

was mounted as a flat 1-cm.<sup>2</sup> membrane between simplified chambers<sup>3</sup> that permitted measurement of the trans-membrane potential and membrane conductance. The membrane separated two identical solutions having a volume of 5 ml. and the following composition: sodium chloride 200, potassium chloride 10, calcium chloride 5, magnesium chloride 2, glucose 25 and yohimbine 0.002 mM/l. The solutions were gassed with 100 per cent oxygen and experiments were conducted at an ambient temperature,  $22^\circ \pm 1.6^\circ C.$ , which was probably supraoptimal. The bathing solutions were removed at 2-hr. intervals and the initial  $pH$  recorded after 15 min. of gassing with air passed through a soda-lime column. Using a glass and calomel electrode pair stable and linear within  $pH$  0.05, the solutions were titrated to  $pH$  7.0 with 12 mM sodium hydroxide.

The gas gland epithelia from five fish were observed for two successive 2-hr. periods. The rate of extrusion of hydrogen ions into the bathing solutions, mean and standard deviation of 10 observations, expressed as  $\mu\text{equiv. cm.}^{-2} \text{ hr.}^{-1}$  was  $0.53 \pm 0.3$  into the serosal and  $0.08 \pm 0.07$  into the luminal solution. The corresponding  $pH$  of these solutions was  $4.8 \pm 0.2$  and  $6.2 \pm 0.8$ , respectively. The wet weight was  $67 \pm 37$  mgm. Neither the amounts of hydrogen ion extruded nor the resultant hydrogen ion concentrations suggest that these observations were the result of a casual autolytic phenomenon. In my experience the rate of production of lactate by the frog gastric mucosa is  $0.08 \mu\text{equiv./105 mgm. wet weight/hr.}$  It should be noted that the acidification of the solutions bathing the gas gland epithelium does not result from hydrogen ion transport from one solution to the other, as is the case for the gastric mucosa with an equivalent alkalization of the serosal solution during acidification of the luminal solution<sup>4</sup>. While no attempt was made to identify the metabolic acid generated by the gas gland epithelium, the titration curves suggest that extrusion of hydrogen ions was associated with a weak electrolyte the  $pK$  of which was considerably higher than that of lactic acid. In all experiments there was no significant trans-epithelial potential difference. It was less than 1 mV. The d.c. conductance was  $7.2 \text{ mmhos. cm.}^{-2}$ .

The rate of secretion of hydrogen ions by two gastric mucosae of the pollack was also determined for comparison. When the serosal surface of these mucosae was bathed by a somewhat different solution containing sodium bicarbonate 30, sodium hydrogen phosphate 1 and histamine 0.1 mM/l., and both solutions gassed by 95 per cent oxygen and 5 per cent carbon dioxide, the mean rate of hydrogen ion secretion was  $1.5 \mu\text{equiv. cm.}^{-2} \text{ hr.}^{-1}$ , the  $pH$  of the luminal solution 4.2, wet weight 155 mgm. and conductance  $7.8 \text{ mmhos. cm.}^{-2}$ . As expected, there was a significant gastric trans-mucosal potential of 10–20 mV.

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