On the Function of the Rectal Gland in the Spiny Dogfish (Squalus acanthias)

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The conspicuous rectal or digitiform gland of the dogfish and of other Elasmobranchs has been observed by thousands of students, but its function seems unknown. Surgical catheterization of the duct of the gland resulted in fluid for analysis and data on rate of flow. Analysis showed the secretion to be a watery colorless fluid, nearly neutral, isosmotic with plasma, containing relatively little urea, potassium, magnesium, calcium, bicarbonate, and sulphate, but containing sodium chloride concentrated to about twice the plasma level. Observed flows ranged from 0-1.9 ml/kg/hr for single hour periods. In two fish of nine studied, sustained flows of 1.3 ml/kg/hr for twelve hours, and 0.77 ml/kg/hr for forty-eight hours occurred. Composition and rate of flow indicate that the rectal gland can eliminate from the blood significant amounts of sodium chloride, and presumably this is its function. Data from one fish showed that the combined rectal gland and urine output of sodium and water is approximately that of sea water.

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Further Data On the Secretion of the Rectal Gland in the Dogfish, Squalus acanthias

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Exploratory experiments were performed on parameters which define the secretion of the rectal gland (cf. Science, 131: 670-1, 1960 for previous data). The following injected agents provoke an increased secretion: NaCl, 10ml of 4, 6, 8% solution; urea, 10 ml equivalent osmotically to 4, 6, 8% NaCl; sucrose, 10 ml equivalent to 4, 8% NaCl; urea-saline equivalent to dogfish blood, 20 ml.; distilled water, 20, 35 ml. One ml NaCl or 2 ml water gave no response. There is always a delay of about 1/2 - 1 1/2 hours after injection before response. Repeated injections of the same dose of NaCl into the same fish gave highly reproducible responses. With NaCl the response gave maximum values when measured over full hours, of 1.6-1.8 ml/kg/hr, from baselines of 0-0.3 ml/kg/hr.

Response to the above agents was not equal. Sodium chloride was peculiarly effective. Sucrose equivalent to NaCl osmotically always resulted in a weaker response: maximum 1.0 ml/kg/hr for 10 ml equivalent to 10 ml, 4% NaCl; 1.4 ml/kg/hr for 20 ml equivalent osmotically to 20 ml,

8% NaCl, *vs* 1.7 ml/kg/hr for 10 ml, 4, 8% NaCl. Response to urea was about half that of to sucrose. With urea-saline or distilled water, the highest rate was 1.4 ml/kg/hr for 35 ml injected solution. The chloride content of the secretion does not vary sufficiently to contradict these results based on rate of flow.

The secretion mechanism seems to respond to NaCl, osmotic load, and volume, but NaCl seems to exert an individual effect separate from osmotic load or volume.

Atropine (2-16 mg/3.5-6 kg fish) blocks the response to NaCl. Epinephrine and pilocarpine in various doses was not stimulatory. Eserin, and eserin followed by acetylcholine gave variable responses. Eserin plus acetycholine did frequently give maximal or near maximal responses. Acetylcholine alone, as would be expected was ineffected although marked vaso-motor changes were noted.

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Secretion by the Rectal Gland of the Dogfish, Squalus acanthias

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The rectal gland seems concerned solely with sodium chloride excretion. Dogfish were studied by continuous collection of rectal gland fluid (RGF) and urine up to 142 hours. The composition varied between individual fish and for a single fish. The commonest value was 490-9 mM/L with a range of 440-540. Secretion rates varied from 0-4.4 ml/kg/hr, but over long periods averaged 0.45, range; 0.11-0.81. Secretion was irregularily oscillatory and not at a constant rate. With or without visible secretion, plasma chloride fell across the gland: v/a, 95-68%. Combining total RGF and urine, and assuming these fluids approximate the net influx of portions of the external sea water, it appears that a slightly dilute solution of sodium chloride enters but that magnesium is largely excluded. When the rectal gland is made inoperative surgically, plasma and urine chloride rose, stabilized as sub-lethal levels, and the urine effected a net loss of chloride. In short term runs of 24 hours, dilute sea water did not change rectal gland flow or blood chloride.

Secretion by the gland can be stimulated by: NaCl = sucrose> urea> antipyrine. Also by volume changes: water, added whole blood. Secretion is not blocked by the local application of Metycaine and not induced or changed by the standard cholinergic and adrenergic agents and their blockers, or by mammalian Pitressin and L-8 vasopressin. It is suggested that the gland is activated by a blood-borne hormone.