How ancient is the trait that increased levels of plasma ammonia serve as a signal for hyperventilation? A case study in an elasmobranch, the spiny dogfish (*Squalus acanthias*)

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In mammals, elevated levels of plasma ammonia cause stimulation of respiration. Since mammals eliminate excess nitrogen waste as urea through the kidneys and not through respiratory processes, this was considered to be an evolutionary relic from ancestors that use ventilation to eliminate nitrogen waste as NH_3. Recently, it has been proven that in teleost fish e.g. trout, hyperventilation does occur when plasma ammonia increases, allowing these fish to eliminate ammonia through the gills. Broad ranges of fish – from shark to trout – hyperventilate after a meal as part of the specific dynamic action. In shark this happens without a change in arterial Po_2 or Pco_2, the classical regulatory mechanisms for ventilation, but concomitant increases of P_{NH3} and $[NH_4^+]$ have been observed. Since sharks try to retain as much nitrogen as possible to support the synthesis of their main osmolyte urea, why would they let the levels of plasma ammonia increase unless it serves as a signal?

This hypothesis has been tested by measuring ventilation rates after injecting spiny dogfish (*Squalus acanthias*) with ammonia as either NH_4HCO_3 versus $NaHCO_3$ or $(NH_4)_2SO_4$ versus Na_2SO_4 (to control pH and HCO_3 levels respectively), or injecting controls with NaCl. Additionally, responses to high environmental water ammonia exposure (by NH_4HCO_3) were recorded. We confirmed that increased levels of plasma ammonia induced hyperventilation in spiny dogfish. High environmental ammonia had no immediate effect and only induced hyperventilation once plasma ammonia levels started to rise. The results clearly indicate that these ancient fish already used ammonia as a signal for hyperventilation after a meal, supporting the extra oxygen consumption needed for the specific dynamic action without the need for a drop in blood Po_2.