Effect of Environmental Changes on the Lipid Composition and (Na\textsuperscript{+} + K\textsuperscript{+})-Dependent Adenosine Triphosphatase in the Gills of the Eel, Anguilla anguilla

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The common eel migrates from fresh water to sea water during its natural history; freshwater eels can be readily adapted to sea water in the aquarium and vice versa. Adaptation of freshwater eels to sea water is accompanied by a 3–5-fold increase in the specific activity of (Na\textsuperscript{+} + K\textsuperscript{+})-dependent ATPase (adenosine triphosphatase) in the gills, largely owing to an increased amount of the enzyme in the chloride cells that contain the sodium pump (Utida et al., 1971; Sargent & Thomson, 1974).

The temperature dependence of (Na\textsuperscript{+} + K\textsuperscript{+})-dependent ATPase, and the fatty-acid composition of lipids, were measured in the gills of a natural population of silvered, freshwater eels migrating down river towards the sea. These fish had been subjected to environmental temperatures decreasing from 17°C to 10°C during the four months (August–October) before capture. The (Na\textsuperscript{+} + K\textsuperscript{+})-dependent ATPase in gill microsomal fractions yielded an Arrhenius plot with a single temperature discontinuity at 20°C. The major polyunsaturated fatty acid in the total lipid of the gills was C\textsubscript{20:4} w6, and the ratio (total w3 acids)/(total w6 acids) was 0.6. The ratio (saturated + monounsaturated acids)/(total polyunsaturated acids) was 1.1. The eels were then fully adapted to sea water in the aquarium for two months at 13.5°C, without feeding. The amount of (Na\textsuperscript{+} + K\textsuperscript{+})-dependent ATPase in the gills increased threefold during this time, but neither the position of the discontinuity in the Arrhenius plot, nor the fatty acid composition of the gill lipid, changed.

Similar studies were carried out on a natural population of eels caught in a seawater environment. The fish had been subjected to increasing environmental temperatures from 4°C to 14°C for the four months (March–June) before capture. The (Na\textsuperscript{+} + K\textsuperscript{+})-dependent ATPase in gills yielded an Arrhenius plot with a single discontinuity at approx. 10°C. The predominant polyunsaturated fatty acids in gill lipid were C\textsubscript{32:6} w3 and C\textsubscript{32:6} w3, and the ratio (total w3 acids)/(total w6 acids) was 2.3. The ratio (saturated + monounsaturated acids)/(total polyunsaturated acids) was 1.1. These fish were maintained in the seawater aquarium at 13.5°C for several months without feeding. The position of the single discontinuity in the Arrhenius plot of the enzyme increased to 20°C, and the fatty acids in the gill lipids were now more saturated, as indicated by ratio (total w3 acids)/(total w6 acids) of 1.6; the ratio (saturated + monounsaturated acids)/(total polyunsaturated acids) was 1.6.

The gill lipids in these experiments consisted predominantly of phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine, phosphatidylinositol, sphingomyelin and cardiolipin. The relative proportions of these lipids were the same in freshwater and seawater eels.

It is concluded that the position of the temperature discontinuity in the Arrhenius plot of (Na\textsuperscript{+} + K\textsuperscript{+})-dependent ATPase can be correlated with the extent of unsaturation of tissue lipids during adaptation in the natural environment. Changes in the lipid unsaturation and the Arrhenius-plot discontinuity of (Na\textsuperscript{+} + K\textsuperscript{+})-dependent ATPase appear to result from changes in temperature and not from changes in salinity during the migration of fish from fresh water to sea water.


1975