Natural-born divers and the molecular traces of evolution

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An aquatic lifestyle imposes serious demands for the organism, and this is true even for the tiniest molecules that form our body. When the ancestors of present marine mammals initiated their return to the oceans, their physiology had to adapt radically to the new medium. Dr. Michael Berenbrink and his colleagues at Liverpool University have been studying how myoglobin, the molecule responsible for delivering oxygen to the muscles during locomotion, has been modified in seals and whales to help them cope with the needs of a life at sea.

The researchers have found evidence indicating that the net positive charge of this protein is increased in marine mammals compared with terrestrial relatives, and they have speculated that this may help improving the solubility of the molecule. This is important as divers may contain 10 times more myoglobin in their muscles than terrestrial animals. The team has also found a conspicuous increase of the amino acid histidine in the myoglobin of strong divers, which may allow the animal to deal better with the accumulation of lactic acid that is frequent during long dives (the same build up is the cause of the cramps we sometimes get during strenuous exercise).

In order to confirm that this was indeed the result of evolutionary pressure, they went on to study the molecular sequence of myoglobin in small aquatic mammals such as beavers, muskrats and water shrews, which only dive for considerably shorter periods of time, to see if they could also find evidence for the same trend. Indeed, the net charge of the myoglobin molecule in aquatic rodents was twice as high compared to their strictly terrestrial relatives, and the trend was also verified for some semi-aquatic species of insectivores. Graduate student Scott Mirceta will be presenting these latest results at the Society of Experimental Biology Annual Meeting in Glasgow on Monday 29th June 2009.

The net electric charge of any protein is directly related to the charge of its individual amino acids, and therefore it can be predicted if the amino acid sequence is known. Dr. Berenbrink's team have determined large parts of the myoglobin sequence for four different species of insectivores, and combined it with the analysis of already published sequences from other species to reach their conclusions. They were careful to select species with close terrestrial relatives that could be used as a natural control group during the sequence comparison, so that differences at the molecular level could be safely assumed to be the product of their habitat preference. "This work will contribute to our understanding of protein solubility in general", explains Dr.Berenbrink. "It will also allow the analysis of natural selection on protein structure/function in multiple parallel cases in which a high muscle myogobin content evolved, such as in divers but also in burrowing animals that normally experience hypoxia".

Source: Society for Experimental Biology