© 2023. Published by The Company of Biologists Ltd | Journal of Experimental Biology (2023) 226, jeb246618. doi:10.1242/jeb.246618

INSIDE JEB

European eels swim super efficiently to complete Sargasso Sea odyssey

A European eel (*Anguilla anguilla*) swimming in a flow tunnel. Photo credit: Florian Sulzer.

Carried on currents across the Atlantic Ocean from their Sargasso Sea spawning grounds, tiny European glass eels (*Anguilla anguilla*) eventually make their way up rivers to the heart of the continent where they mature and grow. Yet the return journey is far more enigmatic. Until recently, scientists had only tracked the adult eels as far as the Azores, but now the complete odyssey has been logged. Researchers also recorded the animals diving down hundreds of metres (600–1000 m) into chilly waters by day before returning to warmer waters near the surface (200 m) at night. But what effect might repeatedly plumbing the depths have on the rate at which these animals use their precious energy? Jan-Dag Pohlmann from Thünen Institute of Fisheries Ecology, Germany, explains that in 2009, scientists discovered that eels swimming at 100 atm pressure – encountered on the deepest dives – use significantly less energy, so he and colleagues from his institute and the University of Innsbruck, Austria, decided to find out how swimming at depth and in cool water might affect the eel's metabolism.

Constantin Lindemann (now at Alfred Wegener Institute, Germany) purchased nine eels from fishers on the Ems and Rhine rivers, Germany, as the animals prepared to embark on their extraordinary journey. Once the eels were settled in the lab, Lindemann and the Thünen technical support staff simulated their return to the sea by gradually increasing the salinity of the water, and then set three of the eels swimming in individual flow tunnels at ∼0.5 m s^{-1} while they recorded the amount of oxygen the eels consumed as they swam initially at 1 atm pressure in warm water (19°C) for ∼8 days. Then, the team ramped up the pressure to 8 atm for several more days at the same temperature, before cooling the water to 16°C and remeasuring the eels' oxygen consumption at the two pressures. Finally, the researchers lowered the temperature again to 13°C, allowing the eels to continue their lab-based endurance swim at the two pressures. Commenting on the challenges of this experimental regime, Pohlmann says, 'It is very stressful to run any experiment over such extended periods of time'.

After repeating the ∼1.5 month experiment twice more with an additional 6 eels swimming distances ranging from 1464 to 2195 km, it was clear that even at the relatively modest pressures they could produce in the lab, swimming at higher pressures gave the eels in warmer water a metabolic boost by reducing their oxygen consumption. At 20°C, the eels' oxygen consumption dropped by an impressive 13.7% at 8 atm pressure. Their efficiency also improved by over 50% as the water temperature dropped, from 30.2 mg O_2 kg^{-1} h^{-1} at 20°C to 15 mg O_2 kg^{-1} h^{-1} at 12°C.

What does this all mean for European eels as they set off on their extraordinary homeward odysseys? '[We] provide clear evidence that lower temperatures and increasing pressure at higher temperatures result in lower energy requirements for long-term swimming', says Pohlmann, adding that the animals seem to be even more efficient swimmers than thought previously and probably benefit significantly by descending down as far as 1000 m each day. Swimming at depth when in subtropical waters could give them a much-needed metabolic boost as they near their deep blue spawning grounds.

10.1242/jeb.246618

Pohlmann, J.-D., Pelster, B., Wysujack K. K., Marohn, L., Freese, M., Lindemann, C. and Hanel, R. (2023). Temperature and pressure dependency of oxygen consumption during long-term sustained swimming of European eels. *J. Exp. Biol.* **226**, jeb246095. doi:10.1242/jeb.246095

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