Evolutionary leap from fins to legs was surprisingly simple

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New research reveals that the limbs of the earliest four-legged vertebrates, dating back more than 360 million years ago, were no more structurally diverse than the fins of their aquatic ancestors.

The new finding overturns long-held views that the origin of vertebrates with legs (known as tetrapods) triggered an increase in the anatomical diversity of their skeletons.

The research was carried out by Dr Marcello Ruta from the School of Life Sciences at the University of Lincoln and Professor Matthew Wills from the Milner Centre for Evolution at the University of Bath in the UK. The authors found that fish and early tetrapods developed similar levels of anatomical diversity within their fins and limbs, despite the fact that their skeletons were constructed in very different ways.

Published in the leading scientific journal *Palaeontology*, the findings challenge some long-standing assumptions about evolution. It is generally expected that when organisms evolve new features – or 'key innovations' – that enable them to exploit new environments, the rate of evolution and diversification will speed up. This is believed to have happened with the evolution of birds from dinosaurs and, most iconically of all, in the transition from finned aquatic fish to limbed tetrapods.

The evolution of limbs was thought to have opened up a whole new realm of possibilities for tetrapods, so the scientists set out to examine just how substantial the evolutionary transition from fish to tetrapods

really was by analysing a variety of different fin and limb skeletons from the fossil record.

Dr Marcello Ruta said: "Our work investigated how quickly the first legged vertebrates blossomed out to explore new skeletal constructions, with surprising results. We might expect that early tetrapods evolved limbs that were more complex and diverse than the fins of their aquatic predecessors. However, although radically different from limbs, the fins of the distant fish-like forerunners of tetrapods display a remarkable array of subtly varying traits. This variation may point to a previously unsuspected range of biomechanical functions in their fins, despite the fact that those ancestors lived exclusively in water."

Professor Matthew Wills explained: "It has usually been assumed that when organisms evolve novel attributes that enable them to colonise fundamentally new environments – as in the move from water to land – this should trigger rapid evolutionary diversification and be accompanied by an increase in structural variety. Our work challenges this received wisdom, and shows that, at least in the case of the evolution of early tetrapods, key innovations did not quickly lead to greater anatomical variety. For the first time, legs had evolved to fulfill new functions. Not only must they be able to support the weight of the body on land, but they also needed to enable the animal to walk. Perhaps these dual requirements limited the number of ways in which these first legs could function and evolve, thereby constraining their range of variability."

Dr Ruta concluded: "This study has profound implications for the analyses of biological systems, past and present, especially when we deal with major diversification events. Perhaps early tetrapods did something different from other organisms, and this makes this finding even more fascinating and challenging. Or perhaps we are forced to recast our notions of evolutionary success and concede that, in some cases, key innovations enable changes that have nonetheless taken many millions of

years to play out."

More information: Marcello Ruta et al. Comparable disparity in the appendicular skeleton across the fish-tetrapod transition, and the morphological gap between fish and tetrapod postcrania, *Palaeontology* (2016). DOI: 10.1111/pala.12227

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