Fish scales

The mighty pirarucu

Defeating piranha requires strong armour

FISH SCALES have to be tough, to provide protection, flexible, to permit movement and light, to preserve buoyancy. These conflicting requirements have driven the evolution of scales that can endure considerable punishment without impinging on mobility. But work just published in *Matter*, by Robert Ritchie and Marc Meyers of the University of California's campuses at Berkeley and San Diego respectively, suggests that one fish, the pirarucu, has taken things to extremes. The reason is that pirarucu share their habitat with piranha.

Pirarucu can be 4.5 metres long and may weigh 200kg. That makes them one of the world's largest freshwater fish. The places they call home are often lakes cut off from river channels in the Amazon basin. Just the sort of habitat favoured by piranha.

Given their penchant for stripping the flesh from anything they encounter, piranha might be expected to kill pirarucu on sight—but this rarely happens. That led Dr Meyers to wonder if living alongside such voracious predators has resulted in pirarucu evolving particularly tough scales. To ▸▸

Scales, however, are no protection from people

look into this, he collected some pirarucu scales and brought them back to California. He and Dr Ritchie then measured the scales' toughness by squeezing them between metal plates. They concentrated on examples that already had cracks in them. They monitored changes in these cracks under increasing pressure, using optical and electron microscopes, and found that the cracks barely grew until the force used exceed 500 newtons. This is more than enough to resist the bite of a piranha. In fact, it turns out that pirarucu scales are among the toughest natural materials in the world. Which left the researchers wondering how this toughness is achieved.

On closer examination, they found that each scale has two layers. The surface layer is highly mineralised. Below that is a layer made of fibres of collagen, an elastic protein common in vertebrate skin, organised at random. The mineral layer, they observed, was capable of resisting the sort of damage a piranha bite would inflict. But if and when it did fracture, the effect of the randomly organised collagen layer was to stop the crack propagating.

This arrangement differs from other tough fish scales which have been studied. Any collagen in these is organised in an orderly manner and will not stop cracks propagating—so they rely on being more heavily mineralised than those of pirarucu. That makes fish which sport them less manoeuvrable through the water.

Whether insights from pirarucu scales will percolate into materials science remains to be seen. But they might. Armies and police forces are always on the lookout for better armour. Just possibly, an Amazonian fish could provide them with it. ■