Why do woodpeckers never get a headache?

The woodpecker is a small bird originating from the Picidae family. Members of the Picidae family are found all around the world mostly living in the forest or woodlands but some of them are found in treeless areas like the desert. We all know the most characteristic feature of the woodpecker, drilling into a tree. They use their beaks to find percusion cavities and areas of disease in which insects may hide. Not only do they use their beaks for gathering food they also bore into a tree chiseling away bit by bit to create their nesting hole. Furthermore the woodpeckers vigorous pounding and drilling in the tree is a ritual of sexual display to attract mates. The drilling of the woodpecker happens with great speed each blow hits the tree with a speed of 6-7 m/s. During the day they strike their beaks 12000 times against the tree with rates up to 20 times a second [1,6]. So why do the woodpecker never get a headache or suffer from head injuries?

We know that a professional boxer can withstand a hard hit when he is expecting it, but is vulnerable from an unexpected blow to the head. A head on strike on the horizontal plane is less likely to result in the loss of consciousness than a strike from the side, therefore adding rotational energy. To prevent the rotational force the woodpecker works like a carpenter, first two preliminary light taps to the target before delivering the full strike. When delivering the full strike the head of the woodpecker undergoes a tremendous amount of deceleration force up to 1200 g in 0.5 - 1.0 ms. Right before this strike hits the woodpecker closes his eye to prevent wood chips from damaging his eyes and to prevent them from popping out of the sockets [2,5].

The woodpecker has more physical advantages in his body to prevent head injuries. The hyoid is muscle that surrounds the skull of the woodpecker starting in the mouth running over the back of the head to the right nostril. This muscle is in fact the tongue of the woodpecker used as a sling. When striking forward the hyoid is also shot forward, therefore pulled tight against the skull protecting the brain from damage [1,3]. By appling pre tentinon with a force of 25 N the natural frequency in the head of the woodpecker is higher, thus resulting in a reduction of resonance in the brain [4]. The beak orientation of the woodpecker also helps to reduce the strain on the brain. Three possible orientations are upper and lower are the same length, upper longer or lower beak longer. The peak strains are the highest if the upper and lower beak are the same length. Minimal impact force occured when the lower beak is longer than the upper beak. Peak strain in the anterior-brain is 0.04 compared to the 0.69 when the upper and lower beak are the same length [3]. Due to the narrow subdural space there is also little cerebrospinal fluid present in the head of the woodpecker. Therefore reducing the transmission of shock waves through the brain [3,5]. The structure of the woodpeckers bone is different than most other birds. Woodpecker have a more spongy like bone structure observed in the cranial bone. It consists of a plate- like structure compared to a more rod-like structure with the other birds [3].

By obtaining twenty-eight specimens throughout the skull of the woodpecker it is possible to test the strength in different locations of the skull. The specimens are test with a trapezoidal load ranging from 50 uN to 1250 uN. The coefficient of variation throughout the measured specimens ranged from 16% to 40%. Therefore the standard deviation is large in the skull of the woodpecker, presumably owing to the large difference in micro-structure of the

woodpeckers skull [4]. To further investigate the structure of the skull at a macro-equivalent modulus a new experiment was executed. To calculate the property of spongy and compact bones the homogenization theory was used. This experiment resulted in a higher outcome of the maximum forces endured by the bone.

What is the actual benefit of knowing all the systems and structures that help the woodpecker protect it self again head injury. Researchers at the University of California used all the information mentioned to create a bio-inspired shock absorbing system that exceeded the traditional ways of shock absorption. The experiment concludes a 60 mm smoothbore air-gun, the projectile is made with the insides of the woodpeckers skull. The beak or the outside of the projectile (enclosure I) is made from steel with a diameter of 60 mm and a thickness of 3 mm. The skull bone with cerebrospinal fluid (enclosure II) is made from aluminium and has a diameter of 50 mm. The hyoid or the viscoelastic layer is made out of rubber and surrounds enclosure II. The spongy bone inside enclosure II is filled with close-packed microglass. Inside the close-packed microglass lives the brain (micromachined devices). The bio-inspired shell is compared with a shell made of hard resin (3M Scotchcast) [7].

The micromachined devices tested were silicon-controlled rectifiers (SCRs), diodes, optocouplers, and capacitors which are known for their sensitivity to mechanical stress. BIRD-I using the hard resin shock-absorbing system with micromachined devices embedded in the resin was exposed to a force of 20000 g to 60000 g resulting in physical damage of 26.4% at 60000 g. BIRD-II consisting of the bio-inspired shock-absorbing system with the micromachined devices embedded in the close-packed microglass only 0.7% had physical damage when exposed to 60000 g [7]. The tolerance of de endured force is greatly increased by is woodpecker inspired shock-absorption system, resulting in a decreased failure rate of the micromachined devices.

All the mentioned characteristics help to ensure that no brain damage will be inflicted on the woodpecker during the drilling in a tree.

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