Evolution in reverse: insects recover lost 'wings'

May 5 2011, by Marlowe Hood

Two cicadas sit on a leaf at a forest preserve in Willow Springs, Illinois. The extravagant headgear of small cicada-like bugs called treehoppers are in fact wing-like appendages that grew back 200 million years after evolution had supposedly cast them aside, according to a study published Thursday in Nature.

The extravagant headgear of small bugs called treehoppers are in fact wing-like appendages that grew back 200 million years after evolution had supposedly cast them aside, according to a study published Thursday in *Nature*.

That's probably shocking news if you are an entomologist, and challenges some very basic ideas about what makes an insect an insect, the researchers said.

The thorax of all insects is by definition divided into three segments, each with a pair of legs.

In most orders, there are also two pairs of wings, one on the middle segment of the thorax and another at the rear.

Other orders such as flies and mosquitoes have only one set of wings, at the rear, and a few -- most ants, for example -- have no wings at all.

But no insects today have functional flappers in the first segment next to the head.

Their forebear, however, did.

"Primitive insects 350 million years ago had wings on all of their body segments," said Benjamin Prud'homme, a researcher at the Development Biology Institute of Marseille-Luminy in France and lead author of the study.

"We don't know if they were all for flight, but we do know -- from fossil records -- that these wing-like structures were present on each and every body segment."

Over the next 100 million years, he explained, wings on the first segment of the thorax and the abdomen dropped away entirely.

But then, some 50 million years ago, something strange happened to the cicada-like treehoppers: they once again sprouted wing-like structures from the top of the first segment of the thorax.

Some of these wildly divergent extrusions resemble thorns, others look like antlers, and still others like aggressive ants or animal droppings, creating one of Nature's most exotic menageries.

Experts had long assumed that these so-called "helmets" were armour-like expansions of the insects' exoskeletons.

But by carefully observing the treehopper's development into adulthood, Prud'homme and colleagues showed that this headgear began as a pair of buds -- attached at the sides, and articulated like wings -- that fused together as they grew.

Evolution is usually described as linear, but these modified wings suggested the process had come full circle.

"This is the only known example of a modern insect that has grown a third pair of wings," Prud'homme said by phone. "It is a modification of the basic body plan of insects."

Just how this happened remains a mystery. For 200 million years, certain genes prevented wing-like structures from emerging on this part of any insect's anatomy.

The researchers speculated that these genes had lost their inhibiting capacity, but experiments on other insect species demonstrated that their repressive powers remain intact.

However it happened, the evolutionary process found a way to put the renewed appendages to use, the researchers speculate.

"This extra pair of wings was not needed for flight, but nor did it prevent it," Prud'homme said. "So it became raw material for evolution to play with."

Many of the helmets appear to serve as camouflage, helping the insects to avoid predators.

The study shows "how development abilities can be lost or silenced over millions of years, only to be redeployed to contribute to the evolution of a complex and beautiful appendage," commented Armin Moczek, a professor at Indiana University, also writing in Nature.

More information: Body plan innovation in treehoppers through the evolution of an extra wing-like appendage, *Nature* 473, 83–86 (05 May 2011) doi:10.1038/nature09977 www.nature.com/nature/journal/ … ull/nature09977.html

Abstract
Body plans, which characterize the anatomical organization of animal groups of high taxonomic rank1, often evolve by the reduction or loss of appendages (limbs in vertebrates and legs and wings in insects, for example). In contrast, the addition of new features is extremely rare and is thought to be heavily constrained, although the nature of the constraints remains elusive2, 3, 4. Here we show that the treehopper (Membracidae) 'helmet' is actually an appendage, a wing serial homologue on the first thoracic segment. This innovation in the insect body plan is an unprecedented situation in 250 Myr of insect evolution. We provide evidence suggesting that the helmet arose by escaping the ancestral repression of wing formation imparted by a member of the Hox gene family, which sculpts the number and pattern of appendages along the body axis5, 6, 7, 8. Moreover, we propose that the exceptional morphological diversification of the helmet was possible because, in contrast to the wings, it escaped the stringent functional requirements imposed by flight. This example illustrates how complex morphological structures can arise by the expression of ancestral developmental potentials and fuel the morphological diversification of an evolutionary lineage.