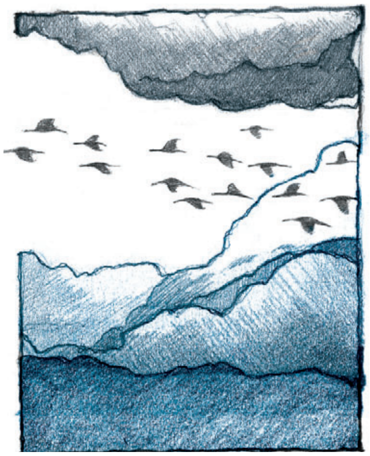
Keeping track of the literature isn't easy, so Outside JEB is a monthly feature that reports the most exciting developments in experimental biology. Short articles that have been selected and written by a team of active research scientists highlight the papers that JEB readers can't afford to miss.

Outside JEB

ENVIRONMENTAL CHANGE



CLIMATE CHANGE A PLUS FOR ALBATROSS

Despite the flurry of front-page headlines reporting the all-encompassing reach of environmental change, the bulk of climate change studies have centred on terrestrial ecosystems, considering factors such as temperature and rainfall. However, other environmental elements may have been overlooked. In the marine environment, wind is a considerable component of the ecosystem that has been influenced by climate change. In the Southern Ocean, westerly winds have shifted poleward and increased in strength as a result of increased atmospheric pressure. Pelagic seabirds like the albatross are nomadic predators, counting on the winds in this region to reduce the cost of flight between their breeding and foraging sites. Curious about the impact of climate change on these charismatic animals, Henri Weimerskirch and others at the CNRS in France sought to determine the influence of Southern Ocean winds on the foraging ecology of the wandering albatross (*Diomedea exulans*), one of the most far-ranging pelagic seabirds. Ultimately, they hoped to understand what consequences this might have on life-history traits like breeding success and body condition.

The CNRS team combined over 40 years of records on breeding success and tracking data on the duration of foraging trips with measurements of foraging success and body mass of wandering albatross on Crozet Island, located in the windiest area of the Southern Ocean. Though it is known that wind boosts flight in this nomad, the results of this research come as quite a surprise given the usually negative impact of changing climate. The team discovered that for the wandering albatross, climate change has actually been a benefit!

Weimerskirch and his colleagues revealed that breeding success in this species has increased over the past 40 years. The risk of breeding failure is highest during egg incubation, a duty shared by both males and females in these birds. However, higher wind speeds mean shorter foraging trips, and shorter foraging trips mean shorter incubation shifts and a higher chance of breeding success for the albatross. In addition, the researchers realized that the body mass of incubating birds of both sexes has increased by 1 kg over the past 20 years, a hefty 10–12% of their bulk. They suggest that this enhanced physique may boost flight performance in gustier zones, perhaps even reflecting that the mass gain is an adaptive response to the blustery surroundings.

It isn't often that climate change proves advantageous to the affected critters and these findings are also relevant for conservation, as the range of this species has shifted poleward in concert with the winds. This has reduced their overlap with tuna long-line fisheries, which are known to increase albatross mortality. However, this upbeat scenario may not last forever. Even breezier conditions forecast for 2080 could prove detrimental for albatross flight performance and if winds shift even further toward the poles, the island of Crozet may cease to be a refuge for this central-place forager.

10.1242/jeb.064154

Weimerskirch, H., Louzao, M., de Grissac, S. and Delord, K. (2012). Changes in wind pattern alter albatross distribution and life-history traits. *Science* **335**, 211-214.

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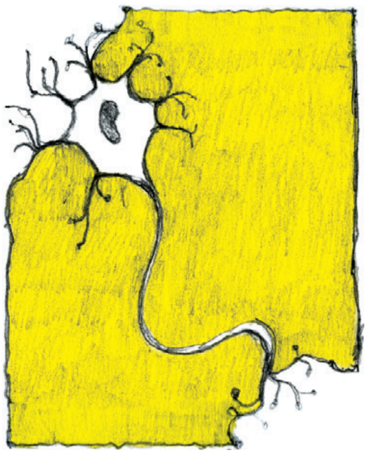
COOPERATIVE BEHAVIOUR



THE NOT-SO-PLAIN DUET OF THE PLAIN-TAILED WREN

Among the beautiful, colourful birds inhabiting the Andean mountains of Ecuador, plain-tailed wrens seem rather underwhelming; little drab-looking birds hopping around bamboo thickets looking for the insects that will be their next meal. However, despite their dull appearance, plain-tailed wrens' songs are anything but plain. Like a stereo recording, you can hear the song coming from two places at once, as it is a perfectly coordinated duet where the male and female rapidly alternate syllables of the tune. The syllables don't overlap, as each of the singers leaves gaps where their partner interjects with remarkable precision.

A team of scientists from the US and Ecuador, led by Eric Fortune at Johns Hopkins University, investigated how plain-tailed wrens are able to coordinate their amazing duet. From over 150 h of audio recordings, the scientists were able to extract and analyse over 1000 songs from plain-tailed wrens. They discovered that while most of the time pairs of wrens sang together, sometimes both males and females sang by themselves, each singing their part of the song, leaving gaps where their counterpart would normally interject. Because the duration of these gaps was larger and more variable during solo singing than during duets, the authors conclude that wrens do not just follow a fixed pattern when producing their song, but instead rely on auditory cues from their partner to determine the length of the gaps between syllables. Interestingly, the songs of solo males were more variable and infrequent than those of females, who were frequently recorded singing by themselves. Moreover, sometimes males made mistakes during a duet, failing to sing their part of the song. On these occasions, the female would continue singing her part, leaving larger gaps between her syllables until the male joined in again. These observations suggest that female plain-tailed wrens may be the leading duetting partner.

Fortune and his team also examined how the brain of the wrens encoded the song. They captured six birds and recorded the responses of individual neurons in the part of the brain responsible for learning and production of songs (the high vocal centre). The scientists played back the birds' own duets as well as individual syllables from the male and female singers. The reaction of both the males and females was strongest to the duet, and was larger than the reactions to either the male or female solos or even the sum of the two responses together. However, both males and females exhibited a more pronounced response to the female syllables alone than to the male song. These results demonstrate that the complete song is encoded in both male and female wren brains and, again, suggests that females take the leading role.

The findings from this study might reveal the mechanisms of cooperative behaviour that occurs among other animals. Each partner needs to know the part they play, but they also need to be able to receive cues from their partner in order to know when and how to play their own part. Moreover, they both need to be more tuned in to the leader's cues for the operation to succeed. It takes two to tango, after all.

10.1242/jeb.064170

Fortune, E., Rodríguez, C., Li, D., Ball, G. and Coleman, M. (2011). Neural mechanisms for the coordination of duet singing in wrens. *Science* **334**, 666-670.

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BIOMECHANICS

WHY DON'T WOODPECKERS GET HEADACHES?

Head injuries sustained in car crashes and sports collisions commonly cause serious brain injury or death, but woodpeckers repeatedly bash their heads against trees without so much as a headache. This interesting observation became the focus of a study published in *PLoS ONE*, in which Lizhen Wang, of Beihang University, and colleagues set out to investigate exactly how woodpeckers protect their brain from impact injury.

There are a number of suggestions as to how woodpeckers resist the high impacts associated with their characteristic rapid pecking, but Wang and colleagues wanted to find out the extent to which all of these factors really play a role. To this end they analysed the movements and detailed anatomical features of great spotted woodpeckers (*Dendrocopos major*), which could hold the key to their unique shock absorption system.

First, the team used high-speed video cameras to record the 3D movements of woodpeckers pecking at a sensor that recorded their pecking force. What they observed were pecking speeds of over $7\,\mathrm{m\,s^{-1}}$ and high decelerations on impact. Next, they used micro-CT scanning and microscopy to examine the bone and structures in the skull, and mechanically tested specimens of bone to obtain the exact mechanical properties of the tissue. Putting these data together, the team developed a finite element model of the woodpecker's head that simulated the impacts experienced by the bird by reproducing the recorded pecking motions. They then modified various anatomical features, such as beak length, to examine the effects these had on how the force is transferred at impact.

Analysing the results, the researchers saw that the woodpecker's shock absorption arrangement consists of a number of features. From the micro-CT scan, they observed an uneven distribution of 'spongy' bone, primarily at the forehead, which they think plays a role in shock absorption. Also, they suggest that the bird's hyoid apparatus (a cartilage and bone structure that in woodpeckers reaches up to the top of the head and into the nasal cavity) may act as a 'safety belt' for the head, absorbing shocks and bearing high stresses. Finally, from the 3D model, the researchers found that the outer tissue layer of the upper beak is longer than that on the bottom but, conversely, the bone structure is longer on the bottom than on the top. They think that these unequal lengths allow impact to be distributed away from the brain, *via* the lower beak.

Although some of these adaptations are only useful if you are a woodpecker, scientists are keen to develop new woodpecker-inspired safety devices to keep us safe from impacts. Knowledge of the material properties and distribution of the shock-absorbing spongy bone can be incorporated into the design of new safety helmets. It could well be that nature has revealed a potentially life-saving mechanism to prevent head impact injury.

10.1242/jeb.064147

Wang, L., Cheung, J.T.-M., Pu, F., Li, D., Zhang, M. and Fan, Y. (2011). Why do woodpeckers resist head impact injury: a biomechanical investigation. *PLoS ONE* **6**: e26490. doi: 10.1371/journal.pone.0026490.

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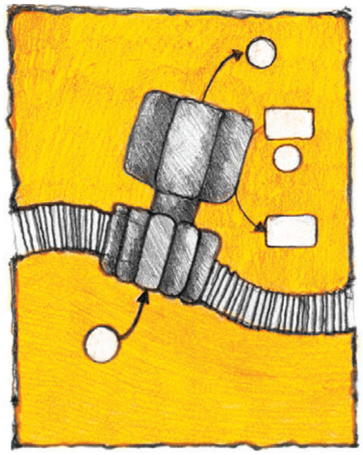
MYOTOXIN ANTIDOTE



POTENTIAL ANTIDOTE TO SNAKE VENOM MYOTOXIN

Snakebites are frequently hazardous accidents that require immediate medical treatment to neutralize the venom's toxic effects. A feared complication of South American pit viper bites is extended myonecrosis, i.e. large destruction of muscle tissues, which may lead to amputation of the bitten limb and permanent disability. Although the currently available antisera can neutralize the hemotoxic effects of the venom, their success in preventing myotoxic effects is limited. Understanding how the muscle-damaging toxins of the venom act may therefore help to improve current therapies to prevent extended tissue damage. In a recent study published in *PLoS ONE*, Brazilian scientists led by Márcia Gallacci and Marcos Fontes have analyzed a pit viper myotoxin. They identified the region on the surface of the venomous protein that interacts with an inhibitor to inactivate the protein's damaging effects, a finding that has important implications for the toxins' mode of action.

One of the most damaging components of pit viper venoms are catalytically inactive versions of phospholipase A_2 (Lys49-PLA_2), and it seems that they have a crucial role in myonecrosis. They bind and destabilize the muscle cell membranes, resulting in a collapse of the ionic gradients that are required to transmit electric signals from the nerves to the muscle, which prevents the muscle from responding to nerve signals and results in muscle degeneration. Some compounds, however, appear to be able to prevent membrane destabilization caused by this toxin. One of them is rosmarinic acid, a polyphenolic compound from plants, which inhibits the myotoxic effect by an unknown mechanism.

To provide more insight into myotoxin neutralization by rosmarinic acid, the Brazilian team analyzed the structure and function of PrTX-I, a Lys49-PLA_2-type toxin from the venom of the South American Piraja's lancehead (*Bothrops pirajai*). First, they characterized the myotoxic effects of PrTX-I on phrenic diaphragm muscles from mice by incubating them in organ-bath chambers and then adding either PrTX-I from the pit viper venom or rosmarinic acid, or both substances. Next they recorded the muscle's ability to twitch in response to an electric stimulus before preparing histological sections to evaluate the resulting muscle damage.

In the PrTX-I-treated muscles the team observed a dramatic decrease of twitch amplitude (suggesting the loss of neuromuscular signal transmission) and significant muscle damage as indicated by lesions and a loss of myofibrils. However, simultaneous treatment with PrTX-I and rosmarinic acid prevented the loss of nerve signal transmission and muscle damage, while rosmarinic acid alone had no effect. Thus, they demonstrated that rosmarinic acid can efficiently protect the muscle cells from the toxic effects of PrTX-1. Finally, the scientists crystallized the PrTX-I toxin in the presence of rosmarinic acid, hoping that they would be able to visualize the binding site on the toxin's surface that rosmarinic acid contacts to inhibit the toxin. Indeed, they showed that rosmarinic acid binds to PrTX-I at the entrance of a hydrophobic channel. This finding was unexpected, because the binding site was at a different location from the region that was previously suggested to mediate myotoxicity.

By analysing the structural basis of the neutralizing effect of rosmarinic acid on PrTX-I, Gallacci, Fontes and their colleagues provide new insight into the mode of action of a myotoxin from pit viper venom. They propose a model in which rosmarinic acid impedes the interaction of PrTX-I with muscle cell membranes by blocking a hydrophobic channel that could bind the fatty acid tails of membrane phospholipids. Their discovery may lead to the development of more Lys49-PLA_2 myotoxin inhibitors that can be used to improve serum therapy for venomous snakebites.

10.1242/jeb.064162

Dos Santos, J. I., Cardoso, F. F., Soares, A. M., Dal Pai Silva, M., Gallacci, M. and Fontes, M. R. (2011). Structural and functional studies of a bothropic myotoxin complexed to rosmarinic scid: new insights into Lys49-PLA_2 inhibition. *PLoS ONE* **6**, e28521.

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