© 2015. Published by The Company of Biologists Ltd | The Journal of Experimental Biology (2015) 218, 1618-1620

Birds get crash-course in collisions

It's an all too familiar scene: you're driving along a smooth stretch of road, not an obstacle in sight, when, suddenly, a group of birds/frogs/lizards/furry animals materializes in your path. You try honking, flashing your lights, but to no avail. Finally, just when it seems like impact is inevitable, the critters scatter in all directions, leaving you with a clear road, but a fast-pumping heart. Although these road–wildlife interactions often end innocuously, animal–vehicle collisions are all too common in our busy world. But why do some individuals mis-time their escapes? Do animals adjust their response according to the speed of the approaching threat? Scientists from the US Department of Agriculture teamed up with researchers from Indiana State and Purdue University in Illinois, USA, to face these questions head on.

Travis DeVault and his colleagues suspected that animals make decisions about when to escape based on one of three types of behavioural rules: the distance between themselves and the threat (e.g. always escape when threat is 10 m away), the time between themselves and contact (e.g. always escape when a threat is 1.5 s away) or a dynamic integration of both distance and time. To figure out which of these rules applies when assessing vehicles approaching at different speeds, DeVault and his team had to be creative. They edited real video recordings of a car approaching head on to simulate eight driving speeds ranging from 60 to 360 km h^{-1}. This range encompasses everything from average city driving to airplane take-off and landing speeds. Next, they played these edited videos back to groups of captive brown-headed cowbirds (*Molothrus ater*) and filmed their reactions. From observations and recordings of escape speeds in wild individuals, the team estimated that cowbirds need at least 0.8 s to clear the path of an oncoming vehicle to avoid a collision. Knowing this, they were able to assess whether the alert and flight initiation times and distances used by the birds enabled a successful escape at each simulated speed.

The researchers found that cowbirds use a fixed escape-distance rule when deciding when to flee. This strategy worked quite well when faced with vehicles moving at low speeds. When simulated approaches were less than 120 km h^{-1}, most birds got out of the way in time. Unfortunately, the failure to adjust flight initiation distance according to the context was bad news for birds when speeds increased: with less time to impact once their distance threshold was passed, most individuals could not avoid a collision when speeds exceeded 120 km h^{-1}.

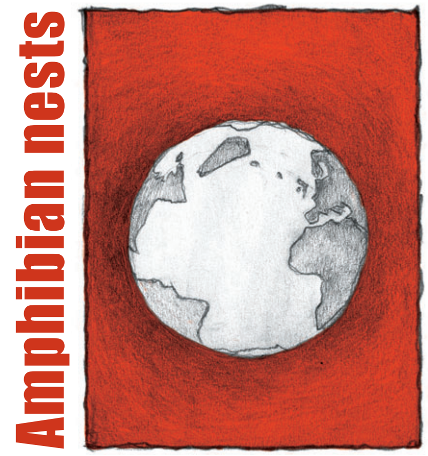
Escape strategies based on distance rather than time are probably quite effective against natural threats like hawks, foxes and wolves, which approach at slower and more predictable speeds. However, the fast-paced world of planes, trains and automobiles may be too overwhelming for most wildlife to process. More research is needed to find viable solutions for preventing these road–wildlife interactions. Until then, be sure to buckle-up, keep your eyes on the road and SLOW DOWN!

10.1242/jeb.112219

DeVault, T. L., Blackwell, B. F., Seamans, T. W., Lima, S. L. and Fernández-Juricic, E. (2015). Speed kills: ineffective avian escape responses to oncoming vehicles. *Proc. R. Soc. Lond. B* **282**, 20142188.

Sandra A. Binning
University of Neuchâtel
sandra.binning@unine.ch

Bubbles create cosy environment for developing embryos



Although the majority of amphibians lay their eggs in water, some species choose to breed in a more terrestrial environment. For these land-loving species, their eggs have to contend with more extreme fluctuations in environmental conditions than their aquatic-based friends, and the eggs run the risk of dehydrating. To help alleviate this problem, some frogs make bubble nests to lay their eggs in. However, as both terrestrial and aquatic breeding frogs produce bubble nests, their exact function had remained a mystery. It was long assumed that the bubbles helped protect developing eggs from predators, reduced egg dehydration and improved the oxygen supply to the developing embryos. However, a recent study by Méndez-Narváez and colleagues, at the Universidad de los Andes, Colombia, has identified an additional function behind these bubble nests, and the special properties they possess. The secret of the bubble nest's success, it seems, is how they insulate the developing embryos from extreme fluctuations in ambient temperatures.

The study, published in *Physiological and Biochemical Zoology*, examined sympatric leptodactylid frogs that habitually build bubble nests but inhabit different nesting environments. The nesting habitats of the frogs range from entirely aquatic (*Physalaemus fischeri*) to

The Journal of Experimental Biology (2015) 218, 1618-1620

nesting well over 20 m away from the nearest water source (*Leptodactylus fuscus*). Working in the Reserva Wisirare, situated in North East Colombia, the team used thermocouples to measure the temperature deep inside the bubble nests and the ambient temperature of the air immediately surrounding it. Repeating this at set times across a 24 h period, Méndez-Narváez and co-authors discovered that temperatures within the bubble nests in the mornings and afternoons were lower than that of the tropical ambient air, while temperatures within the nest were higher at night when compared with their surroundings. Furthermore, these differences between nest and ambient temperatures were more pronounced in the species that build nests at greater distances from the water, suggesting superior insulation in the nests of the more terrestrial breeding species.

The bubble nests were acting to buffer changes in ambient temperature fluctuations, as the variation in nest temperature was lower than corresponding variations in ambient temperature. Moreover, by maintaining higher temperatures within the nest at night, embryonic development was accelerated. To understand the functional significance of this thermal buffering, the team translocated nests of the most aquatic species, *P. fischeri*, from traditional nest locations floating on the water surface to sites several metres from the water edge. Relocating the nests to a terrestrial site led to a large increase in embryo mortality, due to the poorer thermal properties of bubble nests made by aquatic breeding species.

The nesting preference for each species is reflected in the thermal properties of their respective bubble nests, with species nesting further from water having more thermally insulated nests compared with those species nesting directly on the water surface. It is highly likely, therefore, that the increased insulation that the bubble nests provide would have played a pivotal role during the early colonisation of thermally variable habitats in frogs and other vertebrate groups. Indeed, the authors conclude that the thermal properties of the bubble nests are particularly advantageous in environments that experience strong fluctuations in temperature throughout the day, and where the timing of events such as the rainy season is highly variable and unpredictable.

10.1242/jeb.112235

Méndez-Narváez, J., Flechas, S. V. and Amézquita, A. (2015). Foam nests provide context-dependent thermal insulation to embryos of three Leptodactylid frogs. *Physiol. Biochem. Zool.* **88**, 246-253.

Steve Portugal
Royal Holloway
Steve.Portugal@rhul.ac.uk

Take your time to resolve sensory conflicts

Our senses tell us what is around us, informing us of approaching danger, nearby mates and sources of food. The intensity of these stimuli varies, and in order to cope with this, our senses adapt: in the dark our eyes are keener than in daylight, and in a quiet room our sense of hearing is more sensitive than out in the street. At a cellular level, this process ensures that the same number of action potentials is fired in response to stimuli of different intensities by the neurons that process the sensory information. While adaptation serves to enhance our ability to detect important things around us, the brain loses information on the absolute value of stimuli. However, for some tasks this information is critical. How can the nervous system deal with these seemingly contradictory demands?

In a paper recently published in *PLoS Biology*, a team from universities in Oldenburg, Berlin, and Tuebingen, Germany, shed light on this process by looking at auditory communication in grasshoppers. A male grasshopper, as it tries to identify the call of a potential mate, should adapt its hearing to deal with the varying intensity of the auditory stimulus, but, at the same time, can only detect her location by comparing the difference in intensity of the call between his two ears (the closer ear will hear a slightly louder call). To tackle this problem, the team first had to see where in the nervous system adaptation occurs.

The team performed recordings of neurons within the ear and the local neurons to which they talk as the grasshopper's ears transduce sound information to local neurons. These neurons in turn relay the information to two separate channels going up into the central brain: a channel for the sound pattern (which encodes the identity of the sound, and benefits from adaptation) and another for the difference in intensity between the ears – the 'location channel' – which encodes location, and suffers from adaptation. The team found that, by the time the sound information has reached the local neurons, it has been perfectly adapted: they fire the same number of spikes in response to sounds of different intensities. Crucially, this adaptation takes around 50 ms, which means that within that initial time window the local neurons still have information on the intensity of the sound: the more intense the stimulus, the more action potentials these cells fire. The cells in the location channel could potentially read out the information collected in the first 50 ms in order to detect the location of the call.

To test this hypothesis, the team recorded from one such neuron, AN2, to see its response to an acoustic stimulus. They noticed that AN2 only fires action potentials during the first 50 ms of the stimulus, actively shutting itself off after that time. This suggests that this location neuron is tuned to the process of adaptation within the ear and the local neurons, responding to when the information encodes the location of the call, and ignoring it when it encodes the call identity, which would only confuse it.

This work therefore shows how the nervous system's changing response to a stimulus over time can overcome the problem of both having to remove a source of sensory information and depending on it for a behavioural task, a principle that could apply to sensory processing in all animals (such as you and me).

10.1242/jeb.112201

Hildebrandt, K. J., Ronacher, B., Hennig, R. M. and Benda, J. (2015). A neural mechanism for time-window separation resolves the ambiguity of adaptive coding. *PLoS Biology* **13**, e1002096.

Maarten Zwart
HHMI Janelia Research Campus
zwartm@janelia.hhmi.org

Boxfish don't swim the straight and narrow

Agile though awkward looking, coral reef-dwelling boxfish are aptly named for their unusual box-like shape, which is made up of many fused bony plates. This boxy shell, along with the toxins some boxfish secrete, works well as a defense against predation. However, the shell prevents movement of the body during swimming. So when you think of sleek, high performance fish that might be used as bioengineering models for vehicles, boxfish may not be the first that come to mind. However, previous research has shown that when boxfish swim, water moving around the body of the fish stabilizes the fish and keeps it moving forward in a straight path. The body shape was also shown to reduce drag during swimming. The stabilizing and drag-reducing effects of the body shape found in these studies inspired a model car design. But boxfish are highly maneuverable and being persistently forwardly stabilized by the water while swimming would make turning as quickly and easily as they do in their complex habitat difficult – hence, the boxfish paradox.

Sam Van Wassenbergh, at the University of Antwerp, Belgium, and his team of international collaborators set out to resolve this paradox using computer and physical models of two species of boxfishes. The authors first made three-dimensional surface laser scans of two boxfish specimens, *Rhinesomus triqueter* and *Ostracion cubicus*, representing the two extreme shapes of boxfish: triangular and cubic. They then removed the fins and estimated the center of mass for both specimens, to ensure the experimental models would twist, turn, pitch up or down, or stabilize in reaction to the water as the fish would naturally. Lastly, the authors made three-dimensional printed models of the specimens to test drag force and the effect of fluid speed on left and right movement (yaw) of the models in a flow tank.

The authors found that, contrary to early studies, water flowing over both fish shapes was destabilizing, not stabilizing. These results occurred over a range of swimming speeds. Neither the triangular nor cubic fish shape produced the forward stabilizing effect observed before. In addition, the boxfish had greater drag than other fish shapes, though less than an actual box, also contradicting previous findings.

With these results, the authors were able to resolve the paradox. Water flowing against the boxy fish exterior while they swim causes the fish to tilt and turn – instead of staying on a steady course – which aids maneuverability. The authors also suggest that fins play an important role in the skilled maneuvering of these fish and may be used for added stabilization. Van Wassenbergh and his group conclude that it's the independent actions of these smaller, active body parts that are key to the impressive aquatic performance of the boxfish.

Although the ridged form and shape of the boxfishes may not work well for straight, long distance swimming – or for cars – it does suit the needs of these fish in their natural habitat, where they must make quick, sharp turns to forage and escape predators. So as long as these fish limit their time swimming along the straight and narrow, the energetic costs of trying to maintain forward stability will be low. And car manufacturers may have to turn to other aquatic residents for high performance inspiration in the future – a shark-car perhaps?

10.1242/jeb.112227

Van Wassenbergh, S., van Manen, K., Marcroft, T. A., Alfaro, M. E. and Stamhuis, E. J. (2015). Boxfish swimming paradox resolved: forces by the flow of water around the body promote manoeuvrability. *J. R. Soc. Interface* **12**, 20141146.

Casey Gilman
University of Massachusetts Amherst
cgilman@bio.umass.edu