Leopard gecko | Photo: Paweł Kaczmarek

FOR HUNDREDS OF MILLIONS OF YEARS, REPTILES HAVE INHABITED DIVERSE ENVIRONMENTS – FROM ARID DESERTS TO FORESTS AND RIVERS TO THE OPEN OCEANS. WE ARE FASCINATED BY LIZARDS AND ADMIRE TURTLES FOR THEIR LONGEVITY AND PERSEVERANCE, BUT CROCODILES AND SNAKES DO NOT ENJOY FAVOURABLE REPUTATION – WE TEND TO AVOID THEM. HOWEVER, THIS DOES NOT CHANGE THE FACT THAT THEIR SURVIVAL INSPIRES ADMIRATION AND THEIR SKILLS INSPIRE AWE.

Modern reptiles are remnants of a much larger group of animals that flourished during the Mesozoic Era and belong to the group of cold-blooded amniotes (vertebrates capable of embryonic development on land). To date, only four orders of reptiles have survived, with the remaining known evolutionary lines having become extinct. In order to survive, they had to evolve, learn to function, and adapt to diverse conditions. In their struggle for survival, they developed, among other things, complex sensory systems.

Few scientists are involved in the embryonic development of reptiles. Among them are researchers from the Institute of Biology, Biotechnology and Environmental Protection at the Faculty of Natural Sciences of the University of Silesia in Katowice: Weronika Rupik, PhD, DSc, Associate Professor, and Paweł Kaczmarek, PhD. The biologists are part of the Animal Histology and Embryology Team, specialising in research on the development, structure, and biology of selected organs of invertebrates and vertebrates.

'The sensory systems of reptiles enable them to effectively receive and interpret various types of stimuli coming from the environment', explains Weronika Rupik. 'In addition to the senses that respond to mechanical and electromagnetic stimuli, such as sight, hearing and touch, the chemical senses play a particularly important role. Unlike visual or auditory signals, chemical signals can remain in the environment for a long time, penetrate water and air, and provide information even in the absence of direct contact between organisms'.

CHEMOPERCEPTION IS A MIRACLE OF NATURE

It enables the detection and differentiation of chemicals present in the environment. It is one of the oldest sensory mechanisms in the animal world and forms the basis of communication not only in reptiles but also in many vertebrates. Most reptiles (except turtles and crocodiles) can detect chemical molecules using a well-developed vomeronasal organ – also called the Jacobson's organ – located in the vicinity of the nasal cavity. Chemical communication is characterised by a number of adaptive properties, such as the ability to function in limited visibility, the long-lasting persistence of signals in the environment, and the ability to convey information without the need for direct contact between the sender and the receiver. Chemical substances secreted by living organisms, such as pheromones, are interpreted by members of the same species and play a key role in reproductive communication, recognition of sex, physiological status, and territory, while kairomones (also a type of secretion) are interspecies signals used mainly to locate prey and avoid predators.

TUATARA

This endemic species from New Zealand is a source of invaluable knowledge. Tuatara research focuses on their evolutionary distinctiveness, specific anatomy and behaviour. The results confirm that despite surviving since the Mesozoic Era, these reptiles show evolutionary changes in body structure, and their unique anatomical features are the result of a long process of adaptation.

'Tuataras have a poorly developed vomeronasal organ with a low number of receptor cells. Behavioural studies have shown that despite their anatomical limitations, tuataras respond to the scent of prey in a similar way to geckos. They show a spatial preference for food stimuli and initiate an attack. This means that, functionally, the chemoperception of tuataras is effective, although it is achieved through a different evolutionary path', emphasises Weronika Rupik.

Scientists at the Institute conduct their own breeding programmes, including for the brown anole, whose main means of communication are visual signals, and whose eyesight is crucial during hunting and helps in interactions between males and females during the breeding season.

'We also have two species of geckos', adds Paweł Kaczmarek, 'the leopard gecko and the mourning gecko, which have a highly developed sense of smell, although the Jacobson's organ is much better developed in the native sand lizard. Snakes are masters at using this olfactory system. Their paired vomeronasal organ is supported by a strongly forked tongue, which allows them to capture odour molecules and transfer them to the vomeronasal organs. The presence of two organs and a strongly forked tongue allows the animal to compare the concentration of odour molecules on both sides of its head. This directional information enables it to follow a potential mate or prey'.

NAVIGATION AND COURTSHIP

Turtles are among the most ecologically diverse reptiles. They inhabit both aquatic and terrestrial environments, which is reflected in their exceptionally well-developed olfactory system, enabling them to receive chemical stimuli in the air and in water. The ability to perceive these stimuli plays a key role in migration, habitat selection, aggregation (grouping), recognition of individuals of the same species, and mate selection.

Chemical communication in turtles often functions in conjunction with other sensory systems. Being able to find their way by sensing the Earth's magnetic field helps them reach their nesting sites during sea migrations, although the final location of their nests is determined by scent signals.

BODY LANGUAGE

Crocodiles are apex predators, hunting both in water and on land. Although they do not have a vomeronasal organ, their sense of smell is very well developed, and the reception of chemical signals allows them to locate carrion, detect wounded prey, and learn food preferences. Studies on the American alligators have shown that both juveniles and adults react strongly to the odours of carrion and injured prey, exhibiting characteristic feeding behaviours such as tensing and relaxing the throat, head raking, i.e. repeated sideways movements of the head, and direct attacks on the source of the stimulus. Crocodiles are capable of detecting odours carried by both water and air, which significantly increases their hunting efficiency.

Most male anoles (tree lizards of the Iguania clade) have a dewlap – a loose flap of skin under their lower jaw. Anoles communicate with each other by indicating their species and size thanks to the variations in the colouring of their dewlaps. When they have no 'interlocutor', they keep their dewlap folded and hidden, which allows them to blend into the tree canopy and avoid predators. However, when they see another lizard, they begin to bob their head, which eventually leads to push-up like movements. Initially, these may signal a simple message: *I see you*. If the other anole reacts by moving away, the movements usually stop, but if it responds with its own push-ups, this may mean that the 'interlocutor' is a male. If the lizards differ in size, the smaller one is likely to retreat and wait for another chance to become the dominant male. If they are similar in size, they may perform more exaggerated push-ups, communicating: *Don't be silly, can't you see how big I am?* Sometimes, neither will back down, and then a fight or chase ensue. However, when the encountered lizard is a female and ends up retreating, it sends a clear signal: *I'm not interested*. If, on the other hand, it moves forward, the push-ups become faster and the male extends his legs to send a second signal to his potential mate – unique patterns in fabulous colours on the underside of his belly. This unique pattern tells the female if the male belongs to the right species, and the intensity and range of colours indicate how healthy his genes are. Waving their feet may suggest submissiveness.

Some lizards can see ultraviolet radiation. Iguanas of the genus Dipsosaurus possess this ability and use this specific form of communication during the mating season. The secretions of their femoral glands strongly absorb UV radiation, which contrasts with the reflective sandy ground. This allows them to locate the less volatile pheromones from a greater distance and, when they get closer, to analyse them more accurately using their sense of smell.

Studies on snake embryos have shown that communication already happens at this stage of development.

'This is possible thanks to the close proximity of eggs, which snakes lay close together in a characteristic bundle. The beating hearts of the embryos cause vibrations that are mutually received. This forces the synchronisation of the heart rates of the embryos developing in the egg bundle, resulting in almost simultaneous hatching. An experiment involving placing eggs laid at different times next to each other shows that younger embryos, want to catch up with older ones and accelerate their heart rate and hatch earlier', says Paweł Kaczmarek.

COLOUR CHANGE

The ability of chameleons to change the colour of their skin is a fascinating phenomenon. It turns out that they do it not only for camouflage. This process takes place thanks to guanine nanocrystals in specialised pigment cells in the skin (called iridophores). These crystals can change the distance between each other, reflecting different wavelengths of light. The change in colour from red to blue or green depends on the tension or relaxation of the skin. Chameleons change colour mainly under the influence of emotions (stress, fear, aggression), temperature and for communication purposes. A stressed chameleon moves melanin granules from the centre of the so-called melanophore to the projections, where they disperse, causing the colour to darken. When these animals start a fight, they take on bright colours, sharpen the patterns on their skin, inflate their throat, and arch their back. Females of North American lizards of the genera *Crotaphytus* and *Gambelia* signal that they have already been fertilised and are no longer interested in any male advances by changing colour (to orange or yellow).

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'Reptiles provide opportunities to study the early evolutionary stages of sensory communication. New research tools, especially 3D modelling, enable an innovative look at the structural and functional aspects of the organs involved in communication between reptiles and the world around them', concludes Weronika Rupik.

Tuatara (New Zealand) | Photo: Paweł Kaczmarek

Trimeresurus sp. (Malaysia, Borneo) | Photo: Weronika Rupik

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