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Snake uses its split jaws as a knife and fork

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ABSTRACT

Animals with no limbs (like snakes) are expected to have a disadvantage when handling their food. Although most snakes swallow their prey whole, we found that a species of snakes manoeuvres its split jaws to overcome the indigestible parts of its food.

Image credits: Yosuke Kojima

Many animals use their limbs to handle their food and obtain edible pieces from it. To take a relatable example, we humans peel fruits, fillet fish, and break crabs with our hands and tools. In contrast, most animals that lack limbs (like snakes) would be clumsier. If you imagine us eating without hands (or tools), you might think that limbless animals have no choice but to swallow their food whole or take a bite out of a chunk. However, some limbless animals have evolved surprising skills to overcome their limitations of eating without the benefit of limbs or cutlery.

Snail-eating snakes in Southeast Asia (family *Pareidae*) extract their soft-bodied prey from their shell by inserting their lower jaws into the opening of the shell. This strategy is facilitated by their unique jaw morphology. In most snakes, the right and left jaws are separated and move virtually independent of each other. Snail-eating snakes retain this condition, and furthermore, have their upper and lower jaws completely detached. Consequently, their lower jaws have become free-moving and able to slide back and forth in an independent manner.

Some snails not only have their shell but also another hard structure, called the operculum. Such operculate snails are hazardous for snakes because the operculum is indigestible and can get stuck in the snake's intestines. However, our observations in a rainforest of Borneo showed that a species of snakes, the blunt-headed snail-

eating snake (*Aplopeltura boa*), has a special skill to exploit its tough prey.

We collected 8 blunt-headed snail-eating snakes and offered them operculate snails. Our observation showed that this species of snakes handled the tough food in two steps. First, the snakes extracted the operculate snails from their shell as other snail-eating snakes would do. This was already skilful, but the next step was even more surprising. The snakes precisely repositioned the extracted snail in their mouth so that the junction of the operculum and the soft body came to lie along the lower jaw. Then, the snakes cut off the operculum using strong sliding movements of the lower jaw. While one side of the lower jaw is severing the snail, the upper jaws and the lower jaw on the other side maintained a stable grasp on the snail. So, the two sides of the lower jaws worked independently like a knife and fork.

These actions are evidently impossible with typical vertebrate jaws (vertebrates are animals that have a spinal column, including us), which open and close like a trap door. Our behavioural and morphological investigations showed that the lower jaws of the blunt-headed snail-eating snakes slide back and forth more than one third the length of their skull. The bilaterally-separated, highly-mobile jaws enable the snakes to artfully handle food in their mouth. It is assumed that the extensive jaw mobility is originally an adaptation to extract snails specifically. We consider that the addition of freely-moving jaws have resulted in the evolution of novel feeding behaviours and functional versatility of the jaws.

We also saw that the snakes spent considerable time for food handling. It usually took 1–2 minutes to extract the snails from their shells, and the snakes used roughly the same amount of time to remove the operculum (repositioning and severing in total). Now, why do blunt-headed snail-eating snakes prey upon operculated snails, which require roughly double the handling time? We found that operculate snails were common in the habitat of the snake. When it comes to the right size snails, operculate snails were more than ten times abundant than non-operculate snails. Therefore, skilful snail-eating snakes presumably gained a lot of new feeding opportunities by this behavioural innovation.

Generally, the jaws of snail-eating snakes are specialized for only one role, extraction of food. Most species in this group have a larger number of teeth on the right lower jaw than on the left lower jaw. Their asymmetrical jaws are efficient at extracting snails from their clockwise twisted shell. The blunt-headed snail-eating snake, however, has been known as an exception with its nearly symmetrical jaws. Our results showed that the jaws of this species are a two-in-one tool; they are used to extract snails and to cut the food. This implies that their jaws may be designed to balance both roles, although the link between the form and function is not fully understood so far. Further investigations are required to understand how nature has invented and sophisticated the tool-like jaws through evolution.