# Consuming Viscera: *Tyrannosaurus rex* and Preferential Organ Feeding

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**Abstract**: This article explores the potential role viscera played in the diet of *Tyrannosaurus rex*. Well-known for possibly having unique feeding strategies like decapitating ceratopians and consuming large quantities of bone, both strategies for exploiting nutrients, *Tyrannosaurus* could have likewise sought to access the rich nutrients of the viscera. Given its dental structure and powerful hind limbs, the tyrant king was well suited for exploiting the internal organs of large herbivores.

## 1. INTRODUCTION

As paleontologists investigate the habits and lifeways of *Tyrannosaurus rex*, elements of diet play a central role in understanding the activities of the tyrant king. While some of these studies explore the well-trodden debate of scavenger, predator, or both, others, such as Chin et al (1998), Fowler et al (2012) and Reichel and Hans-Diete (2012), to name a few, focus on what *Tyrannosaurus* consumed and how it was consumed. Knowing that *Tyrannosaurus* had intricate strategies to exploit nutrients from rich structures (triceratops neck muscles) and less rich structures (bone), what role did exploiting viscera play in the Tyrannosaurus diet? This article suggests that *Tyrannosaurus* exploited viscera as critical sources of nutrients and that its dentition and other physical attributes allowed it to be successful in doing so either as a sub-adult or as an adult, especially with larger herbivores.

## 2. PREFERENTIAL FEEDING ON INTERNAL ORGANS

DePalma et al (2013) discusses the difficulty in studying feeding behavior that can never be observed in the wild due to the extinction of predator and prey. They note that such endeavor must focus on evidence from the fossil record seen through the lens of “analogy with modern counterparts” (DePalma et al 2013:12560). This analogy is possible, according to Weishampel (1997), by studying the habits of animals living a life potentially similar to one’s subject. This is the approach taken by this paper to explore consumption of the internal organs by *Tyrannosaurus*.

Internal organs are excellent sources of nutrients and consumption of viscera is a tried and true feeding strategy. Hill (1980), Haglund (1997), Carson et al (2000), and Behrensmeyer et al (2003), among others, note that accessing and consuming viscera occurs early in the feeding strategies of many carnivores. Peterson and Ciucci (2010) note that speed of consumption is important for wolves as scavengers quickly appear at a kill. They note that "wolves usually tear into the body cavity of large prey and pull out and consume the larger internal organs, such as lungs, heart, and liver" (123). Only once the organs have been exhausted do the wolves turn to larger muscle groups.

Vultures are also quite adept at exploiting internal organs. The griffon vulture is able to dig inside the body cavity due to the length of its neck and has a specially adapted "gutter-shaped tongue" to help grip and remove organs for feeding (Cook 2012:18). Clearly, eating internal organs first is an advantageous practice to both quickly recover resources expended in hunting and in case the kill must be abandoned permanently or temporarily. Exploiting these key nutrients is an advantage over others who cannot access the same nutrient rich organs.

While a universal target, different species appear to target and avoid different organs. Cougars (Ballard 2018), lions (Rudnai 2012), coyotes (Davenport et al 1973), wolves (Acorn and Dorrance 1998), bobcats (Cartaino 2010), and foxes (Cartaino 2010) preferentially feed on organs such as the heart, liver, and lungs. Several predators, especially lions, avoid consuming elements of the gastrointestinal tract, while others will consume elements after some processing. Bradshaw (2017) describes a Morelet's crocodile (Crocodylus moreletii) removing and disposing of a tapir stomach, and then shaking out the intestines before consuming them. Avoiding or flushing the gastrointestinal tract is advantageous as these organs are not as nutritious as those noted above and are a significant source of bacteria. Further, in large herbivores, these organs may be occupied by large amounts of plant matter that is of no use to the predator. That said, some predators, such as wolves, will empty stomach contents of large herbivores and eat the stomach lining (Peterson and Ciucci 2010).

## 2. *TYRANNOSAURUS* FEEDING

Brusatte (2012) suggests, "carnivorous theropods exploited a narrower set of dietary strategies than extant carnivoran mammals" (167). This statement does not exclude activities such as preferential consumption of internal organs, but rather firmly roots such resource exploitation well within the feeding strategy suggested by studies of *Tyrannosaurus* feeding behavior. *Tyrannosaurus* was a smart consumer, with Fowler et al (2012) noting *Tyrannosaurus*'s method for decapitating a *Triceratops* in order to access the prey's nutrient-rich neck muscles. If *Tyrannosaurus* would go through the trouble of decapitating a Triceratops to access nutrient-rich neck muscles, it must have taken advantage of the viscera when feeding, especially considering the variety of large prey available (Farlow 1976, 1994; Ruxton and Houston 2002).

Leaving those calories and nutrients would have been inefficient. Preferentially feeding on the internal organs in order to access the nutrients contained therein clearly aligns with exploiting the richest nutritional resources of the carcass.

**Bone Consumption**

It is necessary in examining nutrient exploitation to scrutinize the role of bone in the *Tyrannosaurus* diet. Some studies, such as Chin et al (1998), highlight the consumption of a large amount of bone based on coprolite evidence while others, such as Fastovsky et al (2005), note minimal bone-digestion in *Tyrannosaurus*-associated coprolites (278). Brusatte (2012) and Hone and Rauhut (2009) also express doubt on the regular consumption of bones by theropods in general. While there is evidence of bone ingestion and bone can be a source of some nutrients, it is much less rich than other tissues and presents a low return on investment. Further, the frequency of the occurrence and its place in the order of operations involved in consuming a prey is unclear.

Resolving the consumption of bone may rest in the size of the prey consumed. For example, the excellent work of Varricchio (2001) on tyrannosaur digestion provides significant evidence for bone consumption. However, said evidence is related to feeding upon juvenile hadrosaurs, which given their relative size to an adult tyrannosaur could have necessitated a feeding strategy wherein each bite taken consisted of both bone and flesh. The rarity, per Brusatte (2012), of bone in theropod coprolites (167) could evidence that predators avoided bone when the relative size of the prey to predator allowed for targeting on a larger carcass. Feeding on a larger animal, say a sauropod, would have allowed for more feeding area on the carcass where bone could be avoided in preference to muscle and internal organs. Such feeding could still follow the puncture-pull method suggested by Erickson and Olson (1996) and tested by Rayfield (2004).

**Internal Organs**

While accessible with the proper amount of biting, tearing, and clawing, prey size could present challenges to accessing the viscera, especially considering the body size of available prey, which included hadrosaurs and large sauropods (Paul 2008: 307). It was likely an easier endeavor for prey the size of a hadrosaur versus that of a sauropod, depending on the size and age of the *Tyrannosaurus*. Accessing and feeding on the internal organs of a sauropod presents quite a task. Using a combination of jaws and claws to open the abdomen, *Tyrannosaurus*, depending on prey size, would have had to partially or fully enter the body cavity with its head to manipulate and remove the gut pile. As the organs are removed, there is a propensity for the pile to fall back into the body cavity due to connective tissues. Conceivably, with larger prey, *Tyrannosaurus* could be shoulder deep or more into a carcass in order to access the right organs. Once accessed and freed, the *Tyrannosaurus* could pull the sought-after organ out of the cavity. *Tyrannosaurus* has several attributes that would have helped accomplish the task of feeding on the viscera, especially in removing organs from the body cavity. As noted by Reichel and Sues (2012), *Tyrannosaurus* had teeth angled in different areas of its jaws to serve different functions: front teeth gripped, side teeth punctured, and back teeth cut and directed tissues to the throat. Further, the wide shape of *Tyrannosaurus* teeth would allow it to securely grab what could be very large organs and remove them without shredding them, something narrower and sharper teeth could not have done.

Further, Krauss and Robinson (2013), highlight that *Tyrannosaurus* had large feet. It also had a large tail and strong legs. While Krauss and Robinson (2013) note the feet as an advantage in pushing over a ceratopsian prey, they would have also been useful in providing traction as *Tyrannosaurus* pushed into a prey's abdominal cavity. In reverse, the feet and legs would have also proven useful in helping it pull large organs out of the cavity.

What is unclear is if the forelimbs would have been of any use in exploiting the internal organs of a prey item. The forelimbs certainly had the capacity in range of motion and strength to provide some potential assistance in the feeding process (Carpenter and Smith 2001; Krauss and Robinson 2013; Hutchinson et al 2011; Lipkin and Carpenter 2008; Lockley, Kukihara, and Mitchell 2008; Rothschild 2013; Stanley 2017). Perhaps the forelimbs could help hook into and remove the stomach and slash and tear at the diaphragm and other connective tissues. Smaller forelimbs require smaller shoulders and fold up conveniently, as the predator works in a confined body cavity. The forelimbs could have also helped control the gut pile if the *Tyrannosaurus* needed to open its mouth and reposition to pull out various organs.

## 3. CONCLUSION

Feeding is a game of nutrient exploitation. For predators, this can take many shapes, but trying to unravel the feeding behaviors of long extinct animals is complicated. Predators have to be strategic resource users given the energy expended and danger encountered in securing prey. *Tyrannosaurus rex* was a particularly clever predator, with one study noting that the tyrant king decapitated Triceratops to access nutrient-rich neck muscles. Such targeted strategies are questioned by those seeing *Tyrannosaurus* as a less meticulous consumer, taking mouthfuls of flesh and bone together. *Tyrannosaurus* preyed upon many different sized animals and may have needed modified strategies due to the size of the meal. The presence of bone in coprolites may evidence preying on smaller animals where bone was unavoidable and does not evidence an acceptance of bone, which is nutritionally lacking. Thus, such a feeding strategy is not a barrier to the exploitation of other nutrient rich tissues such as the internal organs, especially since if it fed on larger beasts, bones could be easily avoided, even when feeding on muscles. Further, *Tyrannosaurus* had the dental structure and powerful hind limbs needed to access and move large gut piles and could use its usual puncture-pull feeding mechanics. Regardless if encountered via scavenging or hunting, *Tyrannosaurus* almost certainly took advantage of feeding on internal organs and perhaps did so in a similar order of operations to modern predators like lions.

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