Review

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Review

Feathered Predators: The Role of Plumage in the Hunting Tactics of Velociraptor

Tyler Hu

Mission San Jose High School; drbball935@gmail.com

Abstract: This literature review investigates the role of plumage in the hunting tactics of *Velociraptor*, integrating anatomical analysis and biomechanical modeling. *Velociraptor*, a swift and agile theropod from the Late Cretaceous, exhibited advanced intelligence and sensory capabilities that contributed to its effective predatory strategies. Recent discoveries have confirmed that *Velociraptor* was covered in feathers, with quill knobs indicating well-developed plumage. This review explores the potential functions of feathers beyond flight, focusing on their impact on hunting behavior. Evidence suggests that *Velociraptor*'s plumage likely facilitated camouflage and enhanced aerodynamic control, improving its stealth and maneuverability during high-speed chases. Additionally, feathers might have contributed to stability during incline running, further supporting its adaptability in diverse environments. *Velociraptor*'s hunting strategies, characterized by agility and precision, were complemented by its feathered anatomy, which may have also played a role in pack hunting and social interactions. Overall, the integration of plumage with *Velociraptor*'s anatomical features and behavioral adaptations underscores its efficiency as a predator, demonstrating how feathers may have been a critical factor in its successful hunting tactics.

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Velociraptor is a genus of theropod dinosaur from the Late Cretaceous period, approximately 75 to 71 million years ago. This dinosaur roamed what is now Mongolia and parts of China. Although it stood only about 0.5 m at the hip and was only about 1.5-2.1 m in length, *Velociraptor* made up for its lack in size through its speed and agility. With its scientific name translating to "swift thief", *Velociraptor* was one of the fastest dinosaurs to ever roam planet Earth, equipped with a long tail to maintain balance and large sickle-shaped claws to slice and puncture prey. In addition, its brain size was proportionally larger than other dinosaurs, signifying a higher intelligence and the potential for complex predatory behaviors.

Initial visualizations of *Velociraptor* involved featherless, scaly skin, but later findings have concluded that their skin was covered in plumage and feathers. Fossil evidence suggests that *Velociraptor* had feathers, including quill knobs on its forearm bones, indicating the presence of pennaceous feathers. This presents *Velociraptor* as an excellent transitional genus between non-avian dinosaurs and birds, allowing us to gain a deeper understanding of the evolution that occurred in the Dinosauria clade.

This literature review will determine the role of plumage in the hunting strategies of *Velociraptor*. I will begin with an analysis of the presence of plumage in *Velociraptor*, determining the extent of feather coverage on its body. In this review, I will not discuss the hypotheses regarding other functions of *Velociraptor*'s feathers, such as display or thermoregulation. Instead, I will delve into the hunting strategies that *Velociraptor* could have employed to catch its prey, focusing on the use of its

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plumage. I will explore theories on whether *Velociraptor* hunted in packs or as solitary predators, drawing parallels with both modern birds of prey and other theropod dinosaurs. Finally, I will conclude with the overall impact that plumage had on *Velociraptor*'s techniques for hunting.

Presence of Plumage in Velociraptor

The discovery of plumage in non-avian dinosaurs has profoundly reshaped our understanding of dinosaur biology and behavior, bridging the gap between these ancient reptiles and modern birds (Norell & Xu, 2005). The usage and purpose of plumage have differed through time, with it serving unique roles dependent on its associated organism, as noted by Xu & Guo (2009). One of the most iconic examples of this discovery is *Velociraptor mongoliensis*, a small theropod dinosaur that lived approximately 75 to 71 million years ago during the Late Cretaceous period. Initially portrayed in popular media as a scaly, reptilian predator, recent fossil evidence has revealed that *Velociraptor* was adorned with feathers, a revelation that has significant implications for our understanding of its physiology, ecology, and behavior.

A key study conducted by Turner et al. (2007) noted the presence of feathers on *Velociraptor mongoliensis*. The scientists identified and described the presence of feather quill knobs on the ulna of a *Velociraptor* specimen. Quill knobs, or ulnar papillae, are small bony projections where feathers would attach via ligaments in modern birds. The presence of quill knobs provided direct evidence that *Velociraptor* had feathers. These structures are typically found in birds that are strong fliers, suggesting that the feathers were well-developed and anchored firmly to the bone. The discovery of quill knobs in *Velociraptor* supported the hypothesis that feathers evolved in non-avian theropod dinosaurs before the origin of flight, indicating that feathers were not solely an adaptation for flight but may have had other functions such as aiding in balance and maneuverability, a key feature that *Velociraptor* might have been able to exploit.

Another study by Lefevre et al. (2017) discussed the discovery of a new dromaeosaurid theropod, *Serikornis sungei*. The examined specimen was excavated in Liaoning, China, dated to the Late Jurassic period. The feathers of this theropod are characterized by a combination of primitive features, such as a relatively simple rachis (the central shaft of the feather), with more advanced characteristics, such as branching barbs that suggest increased complexity. Additionally, the arrangement and layering of feathers in this theropod show a transition from the more basal feather types observed in earlier dinosaurs to the more derived forms seen in later species. This indicates a progression in feather development. The study also notes the presence of barbs that are partially branched, reflecting an evolutionary step toward the more complex barb structure seen in modern birds. The barbs in this theropod are not as complex as those in later theropods but show signs of early development. As *Serikornis sungei* existed before the rise of *Velociraptor*, evolutionary mechanisms may have resulted in further developments of plumage in *Velociraptor*, shown through Ksepka (2020), Prum & Brush (2002), and Long & Schouten (2008). However, this study provides us with a useful insight into the presence of feathers on *Velociraptor*. The feather types of filamentous and plumaceous likely existed throughout most of *Velociraptor*'s body and were of greater presence on the forelimbs and tail, since pennaceous feathers would have been used in flight, a behavior not employed by *Velociraptor*.

Based on the above evidence, it is reasonable to determine that *Velociraptor* had well-developed feathers, especially on the ulna and tail regions. It probably did not wield pennaceous feathers, as these feathers would be used in flight, an ability that *Velociraptor* did not engage in. These feathers likely consisted of filamentous and plumaceous, serving a unique role for *Velociraptor* in its respective environment.

Hunting Strategies of Velociraptor

Velociraptor had one of the highest intelligences in the age of dinosaurs, wielding a proportionally larger brain compared to other dinosaurs. This feature allowed *Velociraptor* to engage in higher-level critical thinking, an ability that could have proven extremely beneficial in its hunting strategies. Evidence from fossilized remains suggests that Velociraptor had advanced sensory capabilities, including keen vision and a highly developed sense of smell, which would have enhanced its ability to locate and track prey. Additionally, its anatomical features, such as a flexible neck, strong legs, and a sickle-shaped claw on each foot, indicate a predator well-adapted to ambush and capture its targets with precision.

One study conducted by Manning et al. (2009) provides extremely valuable insight into the morphology of *Velociraptor* and its various effects on *Velociraptor*'s hunting techniques. It is important to first note that *Velociraptor* had a lightweight and agile body structure, allowing for swift and precise movements. The study emphasized the significance of the elongated, retractable sickle claw on the second toe, which was likely used for slashing and gripping prey. This sickle claw was articulated with a specialized joint that allowed it to be hyperextended and then driven downward with significant force, making it an effective weapon for delivering fatal slashes to the prey's vital areas, such as the throat or belly. Flexible wrists and strong grasping ability allowed *Velociraptor* to seize and hold onto struggling prey effectively. Additionally, the skull of *Velociraptor* included the presence of sharp, serrated teeth, designed for slicing through flesh and retention of prey. The advanced sensory capabilities of *Velociraptor*, particularly its keen eyesight from its binocular vision and olfactory senses, were crucial for detecting and tracking prey. Furthermore, a proportionally high bite force relative to its size resulted in *Velociraptor*'s capability to inflict lethal wounds on prey.

We also investigate the possibility of *Velociraptor* engaging in pack hunting. At the Djadochta formation in Mongolia, multiple *Velociraptor* fossils were found in close proximity, often in what seemed to be a clustered arrangement. This proximity suggests that these individuals might have occupied the same area or interacted frequently within a specific locality. The orientation of the bones in these fossil assemblages was analyzed. In several cases, the bones of different individuals were oriented in similar directions or showed evidence of disturbance patterns, which might indicate that these animals were not simply scattered randomly but were interacting or occupying the space together. With taphonomic considerations, the clustering of *Velociraptor* fossils was more likely due to their social behavior rather than post-mortem factors such as flooding and other natural processes. Based on this evidence, *Velociraptor* might have exhibited social behavior, potentially involving cooperative hunting strategies or complex social interactions.

Other fossil specimens of *Velociraptor* exhibit healed and unhealed injuries, including puncture wounds, fractures, and lesions. These specific types of injuries are consistent with bites and claw wounds, with the location and nature of these injuries suggesting that they were likely inflicted during fights with other *Velociraptor* individuals, rather than from predatory attacks or accidents. The injuries were often found on the skull and forelimbs, which are regions commonly targeted in aggressive interactions among modern carnivorous animals. This pattern supports the hypothesis of intraspecific combat. However, the presence of healed injuries suggests that *Velociraptor* individuals survived aggressive encounters, which might imply a level of social interaction and resilience. Complex social behaviors, including both cooperation and conflict, are seen in many modern predatory animals, meaning that there still exists the possibility of pack hunting.

Velociraptor likely occupied a position as a mid-sized predator, preying on smaller vertebrates and potentially scavenging when the opportunity arose. It is reasonable that *Velociraptor* used a combination of agility, speed, and its specialized claws and teeth to capture and kill prey. *Velociraptor* may have employed a strategy of ambush predation, using its agility to surprise and overpower prey.

We can also observe the remains of small vertebrates, including small dinosaurs and possibly early mammals, in association with *Velociraptor* fossils, to analyze its diet. The findings suggest that *Velociraptor* primarily preyed on small to medium-sized animals. An in-depth analysis of bite marks on prey bones and the structure of coprolites showed patterns consistent with the feeding behavior of a predator that consumed its prey relatively whole but with significant processing of soft tissues. This evidence suggests that *Velociraptor* had a preference for smaller prey items, which is consistent with its size and anatomical adaptations. While *Velociraptor* might occasionally target larger prey, its

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primary diet consisted of smaller, more manageable animals. This is confirmed by the findings of King et al. (2020). Based on its morphology, *Velociraptor* likely could make sharp turns and quick directional changes, which would have been advantageous for chasing and ambushing prey.

A possible usage of plumage in *Velociraptor* was providing advantages for camouflage or stealth in hunting, a possibility hinted at by Dimond et al. (2011). For instance, feather patterns might have helped *Velociraptor* blend into its surroundings while stalking prey, serving as a camouflage mechanism. Similar uses can be observed throughout much of animal history, including modern-day predators such as leopards and snakes. This would have aided in the hunting success of *Velociraptor*.

Feathers could have improved *Velociraptor*'s aerodynamic control, particularly during high-speed chases and maneuvering. This would enhance its ability to make sharp turns and rapid adjustments while pursuing prey. Feathers on the tail might have played a major role in balance and stability during quick movements and high-speed pursuits, as well as incline running, which is the act of running up a slope. In the context of *Velociraptor*, generating negative lift (i.e., lift that acts against gravity) could help reduce the energy needed to ascend, making it easier for early feathered dinosaurs to move uphill. Feathers could have helped create aerodynamic forces that assist in lifting or stabilizing the animal during uphill movement. This feature of plumage in *Velociraptor* would aid it in hunting prey through various environments and elevations.

Overall, *Velociraptor*'s plumage would likely have aided it in a variety of aspects. *Velociraptor*, known for its high intelligence and advanced sensory abilities, employed sophisticated hunting strategies enhanced by its anatomical features and potential social behaviors. Its keen vision and sense of smell, coupled with a flexible neck, strong legs, and a retractable sickle-shaped claw, facilitated precise ambushes and rapid prey capture. Evidence suggests it may have engaged in pack hunting, potentially involving cooperative strategies. Intraspecific combat was also observed, indicating complex social interactions. *Velociraptor* likely preyed on small to medium-sized animals, utilizing speed, agility, and its specialized sickle claws and teeth for effective hunting. The presence of feathers might have allowed *Velociraptor* to engage in camouflage, enhancing its ability to ambush prey items. However, plumage would most likely have the greatest impact on *Velociraptor*'s aerodynamic control and stability during high-speed chases and incline running, further augmenting its predatory efficiency.

Conclusion

Limitations on Existing Research

The research on *Velociraptor*'s hunting strategies and the role of plumage presents a nuanced understanding of this dinosaur's predatory behavior. However, significant limitations remain in the existing studies. Most notably, there is a lack of definitive research on whether *Velociraptor* engaged in pack hunting or employed camouflage as part of its hunting strategy. While evidence such as clustered fossils and intraspecific combat injuries suggests the potential for social behavior and complex interactions, no concrete proof confirms cooperative hunting in packs. Similarly, while some studies propose that feathers could have facilitated camouflage or stealth, there is no direct evidence demonstrating how plumage may have specifically contributed to these aspects of *Velociraptor*'s predatory tactics. Additionally, the scope of current research often overlooks the full range of possible hunting strategies *Velociraptor* might have used. While studies have explored its agility, sensory capabilities, and anatomical adaptations, the exact role of plumage in enhancing stealth or aerodynamic control during high-speed chases remains speculative. The absence of detailed investigations into how feathers might have influenced *Velociraptor*'s behavior in various ecological contexts limits our understanding of its adaptive strategies. Consequently, further research is needed to definitively establish how these factors combined to shape *Velociraptor*'s hunting efficiency and overall survival strategies.

Takeaway

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Velociraptor, equipped with advanced intelligence and sensory abilities, utilized a combination of agility, speed, and anatomical features such as a flexible neck, strong legs, and retractable sickle-shaped claws to execute effective hunting strategies. Evidence also suggests *Velociraptor* may have engaged in pack hunting and intraspecific combat, indicating complex social behaviors and potential cooperative hunting tactics. However, given its morphology and hunting strategies, it is more likely that *Velociraptor* was more of a solitary predator than a pack hunter. Its diet primarily consisted of small to medium-sized prey, which aligned with its size and anatomical traits. Its plumage, which included feathers on its forelimbs and tail, likely contributed to camouflage, aerodynamic control, and stability during high-speed pursuits, incline running, and quick directional changes. These feathered adaptations would have enhanced its ability to ambush and capture prey.

References

Dimond, C. C., Cabin, R. J., & Brooks, J. S. (2011). Feathers, dinosaurs, and behavioral cues: defining the visual display hypothesis for the adaptive function of feathers in non-avian theropods. Bios, 82(3), 58-63.

King, J. L., Sipla, J. S., Georgi, J. A., Balanoff, A. M., & Neenan, J. M. (2020). The endocranium and trophic ecology of Velociraptor mongoliensis. Journal of Anatomy, 237(5), 861-869.

Ksepka, D. T. (2020). Feathered dinosaurs. Current Biology, 30(22), R1347-R1353.

Lefevre, U., Cau, A., Cincotta, A., Hu, D., Chinsamy, A., Escuillié, F., & Godefroit, P. (2017). A new Jurassic theropod from China documents a transitional step in the macrostructure of feathers. The Science of Nature, 104, 1-13.

Long, J. A., & Schouten, P. (2008). Feathered dinosaurs: the origin of birds. Oxford University Press, USA.

Manning, P. L., Margetts, L., Johnson, M. R., Withers, P. J., Sellers, W. I., Falkingham, P. L., ... & Raymont, D. R. (2009). Biomechanics of dromaeosaurid dinosaur claws: application of X-ray microtomography, nanoindentation, and finite element analysis. The Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology: Advances in Integrative Anatomy and Evolutionary Biology, 292(9), 1397-1405.

Norell, M. A., & Xu, X. (2005). Feathered dinosaurs. Annu. Rev. Earth Planet. Sci., 33(1), 277-299.

Prum, R. O., & Brush, A. H. (2002). The evolutionary origin and diversification of feathers. The Quarterly review of biology, 77(3), 261-295.

Turner, A. H., Makovicky, P. J., & Norell, M. A. (2007). Feather quill knobs in the dinosaur Velociraptor. *Science, 317*(5845), 1721.

Xu, X., & Guo, Y. (2009). The origin and early evolution of feathers: Insights from recent paleontological and neontological data. *Vertebrata PalAsiatica, 47*(4), 311-329.