A winged, but flightless, *Deinonychus* by Stephen A. Czerkas

FLYING DROMAEOSAURS

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Abstract

Dromaeosaurs have been regarded as theropod dinosaurs that were among the closest avian ancestors which were strictly terrestrial having not yet evolved the ability to fly. Consequently, phylogenetic analyses have resulted in the claims of birds having evolved from "the ground up" within a dinosaurian ancestry. Though widely accepted, the relationship between birds and dinosaurs has remained highly controversial and disputed by advocates of birds as having been derived from an arboreal, non-dinosaurian type of archosaur. The cladistical interpretation of the dinosaur/bird relationship hinges upon the presumption of the dromaeosaurs inability to fly. Recent discoveries of dromaeosaurs have revealed impressions of feathers and avian characters in the skeleton that nearly equal and even surpass that of *Archaeopteryx*. Yet despite this, the ability to fly has been discounted due to the shorter length of the forelimbs. Described below are two such dromaeosaurs, but preserved with impressions of primary flight feathers extending from the manus which demonstrate an undeniable correlation towards the ability to fly. This compelling evidence refutes the popular interpretation of birds evolving from dinosaurs by revealing that dromaeosaurs were already birds and not the non-avian theropod dinosaurs as previously believed.

INTRODUCTION

ALL BIRDS living today, including flightless species, are derived from flying ancestors. This distinction further based on having feathers which enabled flight is an essential prerequisite in the definition of a bird. *Archaeopteryx* has long been regarded as the most primitive true bird from which its descendants and possible ancestors can be compared. In order to not be considered as being a true bird, the ancestral stock prior to *Archaeopteryx* must present a clear inability to fly regardless of however bird-like it otherwise may appear. The skeletal anatomy of *Archaeopteryx* is so primitive in its avian structure that how well it could have flown is a matter of debate. But regardless of how well it was capable of flying, fossilized impressions of modern-looking asymmetrical, primary flight feathers reveal that *Archaeopteryx* did fly (Feduccia and Tordoff, 1979).

Dromaeosaurs have been regarded as "non-avian dinosaurs" based on primitive skeletal characteristics which appear to be so distantly related to birds as to suggest that the ability to fly had not yet evolved. In many respects similar plesiomorphic avian characteristics are found in the skeleton of *Archaeopteryx*. However, the preservation of feather impressions, especially those from the manus, clearly signify that *Archaeopteryx* was a true bird. It has been pointed out that without the preservation of feathers, the skeletons of *Archaeopteryx* may very well have been considered as dinosaurs and not birds (Ostrom, 1975). The same maybe said of certain relatively small dromaeosaurs which appear to have remarkably bird-like skeletons more or less resembling that of *Archaeopteryx*. However, even with the discovery of feather impressions on various specimens of dromaeosaurs (Xu, et al., 1999; Xu, et al., 2000; Ji, et al., 2001; Norell, 2001; Xu, et al., 2001), the interpretations have been highly controversial due to highly charged scientifically political philosophical differences which has basically divided scientists into two divergent camps of thought. As with *Archaeopteryx* though, the determination of how avian dromaeosaurs actually are depends upon the preservation of feathers even more so than the avian morphology of their skeleton.

The reluctance to accept the concept of feathers on dromaeosaurs stems from the well established belief of dinosaurs as being all scaly reptilian giants. This admittedly broad generality of what a "dinosaur" is created an obstacle that has, at least in part, obfuscated the objectivity in determining the relationship between birds and dinosaurs. Adding to the confusion, was the fact that the first well known specimens of dromaeosaurs, notably *Deinonychus*, were identified as having avian characteristics while also being obviously too large to have been capable of flight. So since the discovery of *Deinonychus*, the initial life restoration of this dromaeosaur established the conceptual imagery of these dromaeosaurs as being scaly and looking more reptilian, or dinosaurian, than avian (see the frontispiece by Robert Bakker in Ostrom, 1969).

Certainly the size of *Deinonychus* precluded any idea of it having been a flying animal, but over time Ostrom recognized avian characteristics within this dromaeosaur that implied an evolutionary relationship between dinosaurs and birds (Ostrom, 1976). However, just exactly what the relationship between dinosaurs and birds really was has remained even more controversial ever since. Scientists studying the origin of birds have for the most part fallen into two camps with diametrically opposing views of the ancestral avian forms either: evolving within dinosaurs "from the ground up"; or from a non-dinosaurian arboreal archosaur "from the trees down". While both camps have vigorously disagreed with each other and found little common ground in their divergent opinions, it is highly significant that both sides have regarded dromaeosaurs as "dinosaurs".

Phylogenetic analysis, more popularly known as cladistics, has gained tremendous support over the past two decades, in part by generating a broad consensus that birds are derived from theropod dinosaurs called maniraptorans which includes dromaeosaurs as among the closest non-volant avian ancestor to true volant birds. Cladistics has been regarded as being the most rigorous method for determining how animals are related. Still, cladistics has a vocal minority of critics which claim that the method is unreliable as certain bird-like physical characteristics may be the result of convergence between unrelated forms rather than direct relationships.

A major criticism of dromaeosaurs as being a precursor to birds is that they existed too late in time to represent an ancestral form. Also, the size of the first dromaeosaurs to be known, such as *Deinonychus* and *Velociraptor*, were all considered too great for an ancestor of birds. But recent discoveries have revealed that much smaller dromaeosaurs did exist much earlier in time. Some of these dromaeosaurs are well within the size range of *Archaeopteryx* and even smaller (Xu, et al., 2000). These smaller forms also had forelimbs that had much longer proportions than the larger dromaeosaurs from later in time. Looking all the more bird-like, the small dromaeosaurs appear to be equal or even more capable of flight than *Archaeopteryx* except in one detail. The total length of their arms is not quite as long as those on *Archaeopteryx*. As a result, even the most rigorous phylogenetic analyses have regarded dromaeosaurs as being incapable of flight and as strictly terrestrial precursors of birds.

The most significant evidence to support the cladistical analysis of birds having been derived from dinosaurs has come from the discovery of various fossils of theropods which have had impressions of feathers preserved (Chen, et al., 1998; Ji, et al., 1998; Xu, et al., 1999; Xu, et al., 2000; Ji, et al., 2001; Norell, 2001). These feather impressions have stimulated new heated debates as to the authenticity of the feathers and what it all meant towards the dinosaur/bird relationship. But the number of specimens now present an overwhelming display of examples demonstrating that different kinds of bird-like dinosaurs were covered in feathers. Specimens, such as those of *Caudipteryx,* have even had symmetrical primary feathers preserved extending from the manus. But otherwise, none of the feathered dinosaurs have revealed the presence of asymmetrical primary feathers which would provide a clear association with the ability flight. In particular, the fossil of one dromaeosaur, NGMC 91, appears to be ideally suited to represent what the dinosaur/bird proponents have maintained from the beginning: that the ancestral precursors of birds included small feathered dromaeosaurs which could not fly. In that specimen, the body, tail, legs and arms were all covered with feathers, but what is conspicuously missing are indications of primary feathers coming off from the hands. Since the primary flight feathers emanate from the second digit and metacarpal of the hand in birds, the absence of such feathers would suggest an inability to fly. However, the specimens described below are of dromaeosaurs possibly co-generic with NGMC 91, and though they lack most of the indications of feathers preserved on that specimen, both of the new specimens have feather impressions coming from the manus which clearly indicates that these animals were capable of flight.

SYSTEMATIC DESCRIPTION

Aves Linne 1758
Maniraptora Gauthier 1986
Dromaeosauridae Matthew and Brown 1922
Cryptovolans pauli, new genus and species

ETYMOLOGY

Cryptovolans means “hidden flyer” from Kruptos = *Crypto-*, (Greek) for “hidden”; *-volans*, for “flying”; *pauli,* in honor of Gregory S. Paul for his insightful work on theropods.

DIAGNOSIS

Cryptovolans pauli is characterized by the presence of primary flight feathers as being a bird. It differs from other known dromaeosaurs in having completely co-ossified sternals, forming an avian sternum; no less than 28 or more than 30 caudal vertebrae; and does not have the theropod proportions in the third manal digit in which phalanx III-3 should be the longest. Instead, phalanx III-1 is longer than III-3.

DISCUSSION

Since the days of Thomas Huxley, when he first proposed an evolutionary relationship between birds and dinosaurs (Huxley, 1868), the subject of the origin of birds has been one of the most important and controversial issues among vertebrate paleontologists and ornithologists. For most of the past three decades, several scientists have vigorously argued that birds had evolved either “from the ground up”, or “from the trees down” (see Feduccia, 1999 for an in depth overview). One of the few details which members in both camps of thought agreed upon was that dromaeosaurs were not birds, but dinosaurs. The discovery of flight feathers on *Cryptovolans* reveals that in this regard both camps have been wrong.

Those who have believed that birds evolved from the “trees down” have regarded the avian-like morphology in the skeletal structure of dromaeosaurs as being convergent, or basically looking bird-like without having a direct ancestral relationship with birds. Whereas the proponents of the “ground up” concepts have regarded dromaeosaurs as being among the closest known ancestral form of theropod dinosaur next to becoming a bird, but without actually being one. In this regard, it has remained critically instrumental that dromaeosaurs not be too bird-like and be portrayed as completely terrestrial animals, without having the ability to fly. Both sides have centered their arguments for or against a dinosaur/bird relationship upon the common understanding of dromaeosaurs as being terrestrial dinosaurs.

Recently, the fossil of a small dromaeosaur preserved with feather impressions, NGMC 91/91-A, was presented as a terrestrial, non-avian, theropod dinosaur (Ji, et al., 2001). It was then described as “not a bird” (Norrel, 2001) which strongly concluded that non-avian theropod dinosaurs, such as this dromaeosaur, led towards the origins of true birds from the ground up. The fossil was remarkably well preserved and appeared to represent an ideal example of a feathered dinosaur incapable of flight just as cladistical studies have so outspokenly predicted.

The interpretation that the dromaeosaur, NGMC 91/91A, could not have been capable of flight was based primarily on the length of the arms not being as long as the wings of *Archaeopteryx*, and that no flight feathers were found emanating from the hands. However, the wing proportions of NGMC 91/91A are nearly identical to that of *Cryptovolans* which has primary flight feathers preserved emanating from the manus of two specimens, LPM 0200/0201 and LPM 0159. The length of these feathers appear to be proportionately longer than those on *Archaeopteryx* which gives *Cryptovolans* an equal or even greater total wing length when including the feathers. This suggests that the proportionally longer feathers may have compensated for the comparatively shorter wing bones in *Cryptovolans*. How short a wing could be and still support primary flight feathers remains conjectural. But using the length of the skeletal parts of the wing in *Archaeopteryx* is now seen to be invalid for determining whether flight was possible or not. The proportional measurements of the fore and hindlimb in the *Cryptovolans* specimens reveal that the avian wing could be as much as a full 20 per cent shorter than expected in comparison with *Archaeopteryx*, and still possess flight feathers. This places the wing lengths of *Microraptor* and *Sinornithosaurus* well within the range of supporting primary flight feathers which suggests that both of these dromaeosaurs could fly.

Even though the feathers in the NGMC 91/91-A specimen appear to represent just exactly what cladists would expect in representing a non-avian theropod, it is clear that the lack of primary feathers on that specimen is due to arbitrary preservational factors. Such incomplete preservation of feathers is not uncommon among the fossil birds from Liaoning. The presumed absence of manus feathers should also have been seen as problematic as it is inconsistent with the condition in *Caudipteryx* which has primary feathers even though it has considerably shorter wings than on these dromaeosaurs (Ji, et al., 1998; Zhou and Wang, 2000).

The skeletal morphology within the manus also provides strong indications that primary feathers were present but not preserved in NGMC 91/91-A. In particular, the second metacarpal is elongate and rather robust as seen in *Archaeopteryx*. Also, the first phalanx of the second digit is equally broad or even thicker than in *Archaeopteryx*. And since the broadening of these bones has a direct functional correlation to the attachment of primary feathers in birds, having such a strong resemblance to *Archaeopteryx* in this regard should have been a direct indication that primary feathers existed in this dromaeosaur as well.

The sternum is not readily visible in the dromaeosaur NGMC 91/91-A, but it is present in LPM 0200/0201 and LPM 0159. The sternum of the smaller specimen, LPM 0159, appears to be co-ossified together as in the larger specimen, LPM 0200/0201. It is imperfectly preserved though which obscures the shape of the outer edges. The highly co-ossified sternum of LPM 0200/0201 distinguishes *Cryptovolans* from that of *Sinornithosaurus*, IVPP 12811, which although much larger in size has separate unfused sternals (Xu, et al., 1999).

As in the case with *Sinosauropteryx, Sinornithosaurus, Beipiaosaurus, Microraptor* and NGMC 91/91-A, the preservation of feathers when associated with animals regarded as “dinosaurs” have been strongly contested as to whether or not they truly represent feathers (Gibbons, 1997; Feduccia, 1999). Part of this stems from imperfect preservation which makes identification difficult, but largely the criticism has been rather biased coming from those who believe feathers are unique to birds and therefore could not be present among dinosaurs.

The feathers on the *Cryptovolans* specimens are not completely preserved throughout the body of any one individual. And although some feathers are difficult to interpret due to the limits of their preservation, the primary feathers extending from the manus are unequivocal in their avian morphology. That the primary feathers are asymmetrical as in birds which can fly is further contrary to what most scientists have expected. These feathers and the implications they present demonstrate that both opposing camps regarding the origins of birds have misinterpreted the evidence significantly. Neither side interpreted dromaeosaurs as being true birds. Instead, both camps have portrayed dromaeosaurs incorrectly as dinosaurs in an attempt to support their dogmatic, yet opposing views. The discovery that *Cryptovolans* was a flying dromaeosaur mandates a major revision in thought.

Since *Cryptovolans* was a dromaeosaur capable of flight, this is a strong indication that larger dromaeosaurs, such as *Deinonychus* and *Velociraptor*, were secondarily flightless as speculated by Greg Paul (1988, 2002). Their avian characteristics, however primitive in appearance, were held over while readapting for a more terrestrial lifestyle and do not reflect preadaptive levels of development which might have led towards the ability to fly. Such reversals towards flightlessness not only occurred among the dromaeosaurs but must have been prevalent among other Mesozoic birds just as much as seen among more modern birds. Flightlessness among Mesozoic birds not only resulted in terrestrial variants which have been categorized as "bird-like dinosaurs", but also in highly derived cases some adapted to extremely different environments and lifestyles. Notably, the fully aquatic forms such as the hesperornithiforms, including *Enaliornis*, demonstrate the broad extremes to which the loss of flight had already spread as early as the Early Cretaceous (Martin and Tate, 1976).

Not acknowledging that there is such a strong tendency towards flightlessness among birds has remained a major flaw in the current methodology of cladistics which does not sufficiently account for such reversals. Without such considerations of terrestrial forms possibly being secondary flightless, no method of phylogenetic analysis can present an accurate interpretation of avian relationships. Not only has this failed to have been properly employed, but by not doing so, cladistics has presented a highly misleading interpretation of the evidence by arbitrarily insisting that the ancestral origins of avian flight must have been from an exclusively ground dwelling theropod dinosaur. Since dromaeosaurs can no longer be regarded as terrestrial precursors of birds, using them as the evolutionary link between dinosaurs and birds in the manner that cladists have proposed is shown to be invalid. Nonetheless, the discovery that dromaeosaurs were actually birds, being either volant or secondarily flightless, also illustrates the shortcomings of those who supported the arboreal hypothesis of avian evolution by insisting such "bird-like dinosaurs" had no direct relationship to birds.

The relationship between dinosaurs and birds is clearly not exactly what either the "ground up" or the "trees down" proponents have so vigorously claimed. But there are partial truths within both sides that need to be reevaluated and put into a more proper perspective. The discovery of primary flight feathers on *Cryptovolans* demonstrates that these small dromaeosaurs were not the dinosaurian precursors of birds, but were in fact already birds which could fly. In this new context, dromaeosaurs that are obviously too large to fly or have wings which are much too short to have been capable of sustaining powered flight should be regarded as secondarily flightless forms derived from true birds. This new interpretation would remove dromaeosaurs from the Dinosauria and place them firmly within the class Aves. Avialae of Gauthier (1986) is not being utilized here as it is regarded as being an inappropriate sub-classification of members within the more inclusive terminology, Aves. Also, the transferal of the Maniraptora, specifically including the Dromaeosauridae (Matthew and Brown, 1922), into the class Aves is applied here and removed from the Theropoda (Marsh, 1881). This distinction is made based on the discovery of *Scansoriopteryx*, an arboreal maniraptoran which in addition to a generally overall plesiomorphic skeletal structure, notably appears to retain a pre-theropod character status in the manus where the third metacarpal and phalanges are longer than those of the second digit, and each phalanx is progressively shorter than the proximal one (Czerkas and Yuan, this volume). Further sustaining this conclusion is that the third digit in the manus on the type specimen of *Cryptovolans*, LPM 0200, and the referred specimen, LPM 0159, both have the peculiar retention of having the penultimate phalanx as being shorter than phalanx, III-1. This significant abnormality suggests that *Scansoriopteryx* and *Cryptovolans* are ancestral avian forms and that the "theropod" condition in the hand of later birds occurred independently and convergently with true theropods.

It is apparent that the "Theropoda" has unintentionally become a parataxon in which some members may eventually be proven to be true birds though secondarily flightless, while others may be considered as being derived from a pre-avian and post-arboreal ancestry. In addition to the dromaeosaurs, the removal of other bird-like, or "non-avian dinosaurs" from the Theropoda is also almost a certainty. But prior to this happening, the distinction needs to be made on whether the flightless forms have really passed through an ancestral stage that included flight, or not. This distinction of having an ancestor that could truly fly is paramount in the definition of a bird. The problem of convergence and reversals may make this determination difficult or even impossible in many cases. And it is clear that not all theropods should be considered as birds apriori. A distinction has to be made to avoid confusion, in that true theropods should by definition represent a separate terrestrial radiation of pre-bird descendants which led away from the ancestry of birds, rather than towards it. And it should be pointed out that even a body covering of feathers may not be sufficient to demonstrate if an animal had been derived from a true flying bird since non-volant forms certainly must have had feathers at some stage prior to flight. Furthermore, the discovery of proto-feathers on pterosaurs strongly suggests that feathers are not exclusive to birds and may have existed on direct or indirect ancestors of birds which may not have achieved the ability to fly (Czerkas and Ji, this volume).

In retrospect, it is obvious that preconceived dogma prevented the proper identification of dromaeosaurs, such as *Cryptovolans*, as being birds which could fly until finally the discovery of primary flight feathers irrefutably revealed the truth. With avian characteristics in the skeleton that are directly associated with the ability to fly being even more derived than in *Archaeopteryx*, it is remarkable that neither ornithologists or dinosaurologists acknowledged that dromaeosaurs were in fact birds. Instead, one side dismissed such derived avian characters as being only convergent, while the other side claimed that such avian modifications did not represent any indication that an ability to fly existed, but only that these avian traits resulted by serendipity, as a preadaptation towards having the ability to fly. Clearly, massive bias influenced these misinterpretations.

The revelation that dromaeosaurs, such as *Cryptovolans*, were not simply dinosaurs, or even "bird-like dinosaurs", but were in fact actual true birds which could fly significantly alters the mainstream interpretations on the origin of birds and avian flight. It should now be clear that neither contingent supporting the arboreal or terrestrial origin of birds have accurately presented the dinosaur/bird relationship. To a large extent, this misrepresentation of the evidence stems from partisanship between scientists divided by methodologies and philosophical differences. This allegiance to either the arboreal or terrestrial aspects of bird origins obfuscated the issue further with alternative hypotheses falling out of favor and being largely ignored. Notable among these are advocates of a common ancestry which were presented soon after the beginning of the last century (Osborn, 1900; Broom, 1906; Abel, 1911; and Heilmann, 1926). In particular, Broom's conjecture that birds came from "groups immediately ancestral to the Theropodous Dinosaurs" (Broom, 1913, Feduccia, 1999) is strikingly predictive of a pre-theropod, arboreal proto-maniraptoran such as specimens now represented by *Scansoriopteryx* (Czerkas and Yuan, this volume), as well as by *Cryptovolans* with its third digit of the manus not yet reflective of the theropod condition. Furthermore, Abel's (1911) conclusion "that the birds and the Theropoda are descended from a common arboreal stem group" suggested that the return to terrestrial life occurred in theropods before flight was achieved, and in birds after flight was acquired. Heilmann (1926) went so far as to suggest that *Ornitholestes* and *Struthiomimus* were secondarily terrestrial being derived from arboreal ancestors that climbed with both their hands and feet. Long after these hypotheses had become so surprisingly obscure, Greg Paul (1984, 1988) went even further in presenting a most unconventional suggestion that some bird-like theropods were secondarily flightless. This was in stark contrast to the more politically correct cladistically based dogma that was developing in full force at about the same time which vigorously promoted the idea of bird-like theropods, including dromaeosaurs, as being terrestrial non-avian ancestors of volant birds. Most scientists ignored or criticized Paul's unique speculation with the notable exception of George Olshevsky who fully endorsed theropods as being secondarily flightless (1992). Paul's daring and insightful contribution to Science is acknowledged here by naming the flying dromaeosaur in his honor, *Cryptovolans pauli.*

The discovery of flying dromaeosaurs reveals a highly different picture of the avian world during the Mesozoic than what the broad consensus of conventional wisdom has so widely popularized. Birds did not evolve from terrestrial theropod dinosaurs. The origin of birds stems further back to a common ancestor of pre-theropod status that was arboreal. The proto-maniraptoran, *Scansoriopteryx* and *Cryptovolans* are the only known members of such arboreal pre-theropods. True theropods readapted to a terrestrial lifestyle before flight was achieved, splitting away from the arboreal ancestors of *Scansoriopteryx*. The origin of avian flight evolved from among the arboreal pre-theropods. Unknown types of volant birds could have existed even long before *Archaeopteryx*. By the Late Jurassic and Early Cretaceous, there was a great diversity of very primitive and comparatively advanced birds that co-existed. *Archaeopteryx* was not the only toothed bird to fly with a long bony tail. Dromaeosaurs with their long stiffened tails, such as *Cryptovolans*, continued to fly even while still other toothed or beaked kinds of birds had shortened their tails into modern looking pygostyles. But as birds had conquered the air, some of their descendants lost the ability to fly and in doing so, further broadened the avian diversification into aquatic and terrestrial lifestyles. This terrestrial radiation of Mesozoic birds certainly incorporates many bird-like animals that have been incorrectly regarded as "theropod dinosaurs". Most specific types are yet to be confirmed, but the flight feathers on the wings of the dromaeosaur, *Cryptovolans*, demonstrate that all dromaeosaurs were birds and not the non-avian dinosaurs as previously believed.

ADDENDUM

Coincidentally, just prior to when this volume was going to press, a short paper was published as a "Brief Communications" in the journal *Nature* on one of the specimens described above (Norell, et al. 2002). The specimen was referred to as BPM 1 3-13 in the *Nature* article and is identified herein as LPM 0200 for the main-slab and LPM 0201 for the counterslab. In order to demonstrate that "feathers of modern aspect evolved in dinosaurs before the emergence of birds and flight", Norell concentrated four main points of his paper to illustrate: 1. that the high quality of the preservation provided conclusive evidence that the feathers were real and not some kind of artifact; 2. that these feathers were pinnate and already modern in their morphology, consisting of a rachis and barbed vanes; 3. that the feathers were symmetrical and therefore consistent with being from a flightless animal; and 4. that since these feathers were on a "non-avian dromaeosaur" this was therefore an indication of modern feathers having evolved in dinosaurs before the emergence of birds which could fly.

Even without seeing the actual fossil in person, the usual predictable criticism from outspoken opponents to the dinosaur/bird relationship have used the news media to undermine the authenticity of the fossil having feathers and what it represents. One leading ornithologist even went so far as to claim that he could not discern any feathery structures at all, and then lost more of his credibility by contradicting himself in suggesting that the feathers could have been "salted" as a composite. But regardless of any claims to the contrary, Norell's article represents an independent verification to this study that the feathers in this specimen are real and belong to a dromaeosaur. His observations impartially substantiate the conclusions presented here that the specimen is completely authentic and has no indication of any tampering. Furthermore, there is no indication that any tampering has been utilized to enhance NGMC 91/91A, the first dromaeosaur described by Norell (2001), or the second dromaeosaur specimen, LPM 0159, described herein. So the issue is not really about the integrity of these fossils. What is at stake is the accuracy of interpreting what these fossils represent. That is the issue.

The first two points cited above in Norell's paper are in accord with this study. The feathers are real, modern in their morphology, and are blatantly obvious. The third and fourth of Norell's observations and conclusions noted above are not in agreement here. The feathers are not symmetrical or those of a flightless animal. Feathers adjacent to that which Norell illustrated to make his point are clearly asymmetrical just as in modern flying birds (See FIGURES 12 and 13). These feathers are not from the hind legs as Norell suggests, but are typically avian primary feathers extending from the manus. Verifying this point is that the primary feathers from the opposite manus are also present, though not so obvious due to the preservational factors (See FIGURES 8, 9, 10). The barbs and vane structure of these less perfect feathers are unequivocal when seen under the microscope. Additional confirmation that the feathers in question are from the manus comes from the second dromaeosaur, LPM 0159, described herein (See FIGURES 14 through 17).

The misinterpretation of the primary wing feathers as being from the hind legs stems directly to seeing what one believes and wants to see. The powerful influences of having the preconceived ideas that dromaeosaurs were non-avian dinosaurs which could not fly must have overruled the thought of any feathers as representing flight feathers. The absence of considering this possibility is very conspicuous in the papers on NGMC 91/91A and BPM 1 3-13 = LPM 0200/0201 which emphatically regarded dromaeosaurs as not being able to fly (Ji, et al., 2001; Norell, 2001; and Norell, et al., 2002). In order to demonstrate an affinity between birds and dinosaurs, it has been said that without the feathers preserved on *Archaeopteryx*, it could have been misidentified as a flightless theropod dinosaur (Ostrom, 1975). It is unfortunate that this same kind of logic was not applied to these dromaeosaurs because such a mistake has occurred by regarding them as dinosaurs instead of birds. Clearly, this mistake of interpretation occurred not only with the dromaeosaur, NGMC 91/91A in which the primary feathers were not preserved (Norell, 2001), but the denial of the primary flight feathers happened again even when they were preserved (Norell, et al., 2002). But the cause of the misidentification of a bird incorrectly as a dinosaur cannot be solely attributed to having feathers or not. It is much more pervasive than that. As another case in point, Norell did not point out that the dromaeosaur, LPM 0200/0201 has a fully ossified sternum (See FIGURES 6 and 7), but instead regarded it as two sternal plates (Norell, et al., 2002). That the sternals are actually fused together is readily obvious even to the naked eye, so it is reasonable to attribute Norell's familiarity with separate sternal plates in other kinds of dromaeosaurs (Norell and Makovicky, 1997) as a preconception that misled him. Had Norell noticed that the sternal plates were fully ossified together, this should have drawn attention to the fact that this is a highly derived avian characteristic directly associated with the ability to fly. But again, since by the widespread definition of dromaeosaurs is that "they did not fly", the obvious continued to remain hidden. This kind of problem is serious and all too prevalent, as can be seen by ornithologists who cannot identify a feather if it is found associated with an animal believed not to be a bird. The cause cannot be attributed solely to the quality of the fossils, as much as to the blinding influences of preconceived ideas and to conflicting political philosophies within the Sciences. To some, the idea of flying dromaeosaurs will not be welcome as it is not what most ornithologists or paleontologists concerned with the origin of birds ever anticipated.

Nonetheless, while it directly contradicts what most have believed for so long, dromaeosaurs can no longer be considered as either just dinosaurs with no relationship with birds, nor can they be regarded as the strictly terrestrial precursors of birds, because the evidence as seen by the dromaeosaurs described herein clearly demonstrate that they already were birds which had the ability to fly.

Cryptovolans pauli by Stephen A. Czerkas