

Bird flight origin theories in general

The question of the origin of bird flight has been much debated since the late 19th century but to this date has not been successfully solved. The material presented here, I believe, offers the final theory to settle this problem. It is likely that a reasonable person viewing the data and argument will immediately see that the answer to the puzzle, so readily readily available has strangely been passed over.

There are **two** traditionally opposing schools of thought: the Arboreal, which holds that flight began as gliding down from trees, and the Cursorial, which advocates it was that some action connected with terrestrial running that led to liftoff.

Of these two the **Arboreal** notion is increasingly difficult to argue because since the 1990's numerous dinosaur fossils have been discovered belonging to able runners that possess body and arm feathers at different stages of evolution. Moreover, as described in the *Neptunians* chapter of this book, the Arboreal theory is also assailed by two significant **problems**, that oddly enough, its critics have so far missed.

The difference in approach:

The traditional theories have been based on specifically **flight** related actions, whereas in the present discussion we approach the topic from an entirely **new** perspective, as being a particular, readily identifiable mode of general vertebrate locomotive movement. It is true that most recently several researchers have come to the conclusion that flight may have originated from an action not directly related to flight itself, specifically from jumping during certain behaviors, such as leaping by a carnivorous bipedal dinosaur from a height to pounce on a victim. Although this view is correct in general, these arguments are not sufficiently solidly based to be fully convincing. (*here cite authors*).

The present theory is built, as is the WAIR proposal, presented in 2003 by K. Dial, on currently observable bird behavior, one that is far more common and near universal which strangely has never been noted in the literature.

In addition, the theory is also supported by a mechanical analysis of vertebrate limb locomotory kinematics, revealing a new method for classifying such movements, and making it possible to identify in the most rigorous sense the likely source of bird flight.

This analysis undertakes a survey across the taxa and introduces a novel type of classification of all possible vertebrate limb movements involved in locomotion. This organization yields a simple systematic matrix of classes of kinematic behavior, among which the source of flight must necessarily reside. It only remains necessary to find the behavior that offers significant natural selection. As shown in this book, such an action is readily identifiable.

Because this new proposal is terrestrially based, although not cursorial, it supports the flight-from-the-ground-up notion.

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In summary, through observations of the kinematics specifically of bird takeoff, and of specific aggression behaviors we can discover locomotive limb behaviors, apparently **not** been earlier, which enable us to lay down a logical series of no more than three steps which afford a continuous line of evolutionary sequence satisfying all the requirements of a convincing theory.

Method

Uniformitarian

Uniformitarianism is the principle stating that certain presently ongoing functions are the keys to past events, or simply that what goes in before our eyes is no different from what went on in the past. This idea first appeared in studying earth history and is the basis of modern geology. It may be surprising, but this notion is the key to pointing out the origin of avian flight as well. Our theory is generated from currently observable bird behavior and therefore it, too, is **uniformitarian**. The survival of this function is unequivocally demonstrated by birds both during certain aggressive acts and each time they take into the air.

The **second** point in validating this uniformitarianism is to show that the action in question, performed by birds today is essentially relevant to a dinosauran protobird. This can be achieved by surveying the locomotive behavior of all extant vertebrates and showing that the function of lift generation is potentially available to all vertebrates, whereby no less than three classes of this taxon have in fact achieved flight. To infer that such mechanical behaviors must include those of the dinosaurs is well founded; its **relevance** to dinosaurs and to the protobird has high statistical probability.

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The differentiation between takeoff and flight is essential

Not recognizing the essential distinction between **takeoff** and **flight** has been a main obstacle in all previous attempts at solving the problem. We must differentiate between takeoff lift and advanced, full flight simply because the two are **not** the same kinematic action. In takeoff the bird changes its body and neck angle employed on the ground and simultaneously extends its legs to jump and flaps its wings to lift. In full flight the legs remain immobile, locked in position and only the wings move, while the head, neck and body becomes a single rigid, horizontally set aerodynamic object.

During full flight, the legs can take two variant methods of leg flexure: a) the immobile hind limbs are either posteriorly fully extended, or b) they are flexed under the body although the feet may flex or extend. **!add PIX** Occasional leg position adjustments in flexure may serve to control direction.

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Eagle clips

Three eagle clips (plus heron, Muybridge...)

Our investigation starts with observations on the takeoff technique of several birds drawn from three video frame sequences

(still and/or animated frames) of two eagle and a heron during the moments of transition from initial takeoff and flapping flight. These frames of sequential movement reveal the essential avian behavior pattern which yields a firm basis for searching for the source of flight.

This data is visible in the selected still frames presented here, but appear even more convincingly in animation when we run the full set of frame sequences stepwise in a computer viewer program. Manually stepping the video frames allows for varying the speed and direction of the movement.

Can we observe any systematic patterns in these action frames?

The answer is yes. We can clearly see in **all** three video clips that when taking off these large birds do not jump and flap only once and then immediately enter into full flight, but rather, for **several** strokes they **cyclically extend** and **flex** the **both** wings **and** legs, that is, rotate them several times in relation to the body (or to the pectoral and pelvic girdles), **simultaneously**, and in **opposite directions**. *Fig. 000.*

Although the other joints of the limbs also rotate (i.e., flex and extend) as well, only the rotations of the **humerus** and **femur** (humero-femoral or H/F rotations,) are important here.

When the wings are raised highest and are extended, the legs likewise are fully extended but projecting downwards and when the wings are lowered and flexed as far as allowed while up in the air, the legs are raised up to the body and are similarly flexed.

This mechanical process, which can be called **CR** or **coordinated rotation**, is a crucial clue, one that has never been noted and described in the literature, perhaps because theorists have mainly focused on the wing action of full flight, where leg action is absent.

As in terrestrial jumping, both the arms and legs are moving synchronously and in parallel—but this time when up in the air, without legs springing from the ground. But while leaping is not the source of avian lift, this is curious limb behavior in takeoff is **a significant clue**. For it poses an interesting **question**: once airborne, **why** should the birds continue to engage in the action mode of **jumping**, with legs flexing and extending in synchrony with the wings, and not merely flap their wings?

Clarification of terms: rotation, extension, flexion

At this point we must clarify our terminology of limb movements. The technical terms for such movements can be ambiguous. That is, while the **extension** of the arm refers to extending it in the forward **anteriorly**, **extending it backward** is termed **flexion**. **Rotation**, or torsion, signifies turning on the long axis. Since in this book discussion of limb movements is frequent and essential, to avoid confusion it is best to modify terms:

- a. extension is the straightening of the limb or a limb segment in any direction,
- b. flexion is the bending of the limb or segment at the joints,

- c. rotation refers to any change of the particular angle of the limb or segment, with direction specified according to the circumstance. (For example, an both an extended or a flexed arm may be rotated at the shoulder forward, backward or sideways.)
- d. torsion will be used according to its technical definition
- e. adduction and abduction, which present no problems, will be also employed to ensure clarity.

Wing stroke timing/phase evidence of CR.

Evidence for a mechanistic **coordinated rotation** of arm and leg rotations is supported by the character of the timing of upstroke and downstroke during a wing cycle. It is an established fact that the **upstroke is faster** than the **downstroke**. The fact that the forelimbs and hindlimbs rotate in exact synchrony strongly suggests that such timing is not accidental but is built into the appendage kinematics.

With regard to **symmetry**, there are, of course, types of vertebrate locomotion where either only the front or the back limbs are mobile. This topic is covered in more detail in Chapter 000. The swimming frog, keeping its arms against the sides, is one example. In this mode, which can be termed "**asymmetrical**", force is not absent in front limb control, but it is applied to keep that limb pair from motion. In contrast, birds perform an **variant asymmetrical CR** in full flight where the wings move in **parallel** while the inactive legs remain flexed under the body, or posteriorly extended. Hopping animals, like kangaroos and humans when skipping similarly keep the arms immobile and flexed against the thorax.

(As a matter of **experiment**, it may can observed that when humans **jog** or **skip**, with flexed arms held steady, as soon as the elbows and lower arm are separated from the thorax, the humeri immediately begin to oscillate in harmony with the legs, changing into the **running** mode, where the right and left limbs move **alternately**.

Ultimate proof of CR automatism

Ultimate proof -- To demonstrate that CR in birds is an integral, automatic mechanical process, we can find no better subjects than humans because as shown in our analysis of vertebrate limb kinematics both birds and humans are subjects to the rules of CR, because birds and humans are the only extant true bipeds and because human arm design permits great mobility.

Experiment for automaticity:

Setup: We lie on our stomach supported on a chair, keeping the arms and legs in the air. The appendages and the body should be as relaxed as possible.

Action: When either the arms or the legs are consciously moved om w hatever path, the corresponding limbs will involuntarily also move in the same pattern. For instance, if the legs simulate walk, the arms will move as in walking, and if the arms perform the swimming chest stroke, the legs will react with the appropriate hind limb swimming stroke. Significantly, if

Conclusion: We can infer from this experiment that— as long as these limbs are not otherwise forcefully prevented from moving the simultaneous **coordination** of the movements of the humerus and femur is **involuntary**. And if CR is spontaneous in humans, and it also manifests in countless instances of vertebrate locomotion, it is **reasonable** to conclude that CR is likewise spontaneous, **involuntary in birds**. See 000 for additional demonstrations for CR automaticity.

Not balance

It is important to point out that whenever **balance** has been cited to explain arm movements in running and leaping, this apparently complementary action has been assumed to be voluntary. However, this is not the case. One of several simple experiments will illustrate this.

Two experiments on the balance factor:

1) If we lie on our sides on a bed, with a relaxed body, the most comfortable limb positioning, that is, the one with the greatest spontaneous efficiency is one where the arms and hands are flexed and kept near or against the thorax and where the legs are also flexed, but not enough to impede the movement of the abdominal muscles of respiration. Since there is no need here to balance the body, the simultaneous parallel flexions of the limbs is not a matter of balance but one of coordinated rotation. Of course, generally, the factor of balancing is also a factor designed into CR behavior.

Additionally, as we lie on our side, rotating either the humeri or femora will tend to bring about counterrotation by the other, which again indicates the presence of CR.

2) a. First, we stand erect and lean slightly forward, just enough to reach the point past which the body would be thrown out of balance, then rotate one leg backwards, so that its toe is aligned with the back of the other foot, the arms will hang vertically.

b. If we then raise the rotated leg slightly from the ground, the arms will spontaneously rotate backward. This is unexpected because balance is not aided by the arms, rather they move according a non-ambulatory or cursorial CR pattern that nevertheless integrates of arm and leg movements.

However, if we lean forward even more the hands then rotate to hang in front, now taking part in a different CR function, one more concerned with balance than with limb locomotion.

Conclusion: the movements of spontaneous CR are **not** necessarily bound with **balance**. For additional demonstrations see section *Explanations*.

6a Proof of CR by absence of one agent

The existence of CR is also shown by its absence when one or more factors are removed, demonstrated in the following experiment.

Disengagement of coordination (pix are in Tudge/Appendix. p 3)

1. Stand straight with relaxed arms loosely hanging. (Relaxation of the shoulder, arms and hands is important.)
2. Initially keeping the soles level on the ground, jump or strike with foot "claw". The arms remain unresponsive. (Cf. Irish style dancing where arms stay at the sides throughout all movements.) This illustrates that the arm architecture must engage that of the legs in order to form an integrated structure. If starting from a tiptoed stance the arms rise and fall at the shoulders, but still remain vertical.

Generalization among birds-- Is this peculiar to eagles?

Is CR in takeoff peculiar to eagles and herons? The answer appears to be in the negative: for both everyday observation or any photographic, film or video record of avian takeoff suggests that without any exceptions this behavior is **universal** among all birds. Compelling evidence is offered in a collection of 00 photographic **examples** in the section *The key point - parallel symmetrical CR.*

Coordinated limb behavior in vertebrates and the flight stroke:

We can devise many human experiments and provide instances of animal behavior* which reveal the presence of a definite, built-in mechanical behavior that automatically and without exception regulates the rotational interaction of the front and hind limbs. In this systematic behavior a locomotion-related movement by either appendage pair always activates the other pair. It can **also** be demonstrated that due to sharing the basic limb anatomy and its inherent kinematic coordination the **flight stroke action** of the bird wings is essentially embedded in all vertebrate pectoral appendage movements, starting with fish, and passing through all the other vertebrate classes. Obviously, locomotion is a matter of moving the body in relation to a substrate, and this process is necessary when moving through an aquatic, terrestrial, subterranean, or aerial medium. Therefore it is not surprising that vertebrate locomotory limb motions have common elements and even common stroke paths, something that has enabled flight to arise in reptiles (pterosaurs), dinosaurs (birds) and mammals (bats).

An antagonist pair of forces may be of any proportion, including equivalence, in which case movement is prevented. But normally such a pair has a prime mover, or **agonist**, which determines direction of movement, while the **antagonist** is secondary and supports and refines the control of the function. The arm-leg CR the humero-femoral counterrotation occurs in just such an antagonist pair action frame.

* e.g., Animal experiments: K Dial's is one. Here moving up inclined surface, with alternating leg motion generates flapping in the arms. It has not been recognized, however that if humans go through the same action either running up a slope, or simply running bent forward, we also flap the arms, simply following the rules of a particular CR variety. Further details on this are in section 000.

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Arms or legs?

How is the source of flight related to humero-femoral counterrotation?

Arms or legs?

An **antagonist**, or mutually opposing pair of forces can be configured as two equal forces, in which case the configuration is stable and movement is absent, or as one where one is the prime mover, or agonist, and the

other is the antagonist, or secondary response. The agonist dominant and is the initiator of action. In the arm-leg CR the humero-femoral rotations form an antagonist pair and **either** the arms or legs may be the **prime movers**. The **significance** of this is that since in an antagonist framework action **either** member of the framework may be dominant and will necessarily generate the action of the other member we can look for the source of lift not only in **arm** actions but among **leg** actions. Traditional and current theories based on arm action leading to flight have not been successful precisely because they have not considered that through a leg action performed with sufficient energy and speed, a biped with feathered arms would spontaneously attain lift, **without** any way attempting to rise into the air by arm flapping. The protobird could have engaged an activity executed by its legs and still become airborne.

A special point: It may be argued that there is no counterrotation of arms and legs in various mammalian locomotions, such as the ricocheting transport in kangaroos or hopping mice, etc., where the forelegs do not move. The explanation is that the counter-rotational pattern in the eagle takeoff is only one of the several modes of CR, and ricocheting is a different mode, where the legs move synchronously while the arms are rigidly held against the thorax in a flexed posture. The section on the *CR matrix* tabulates such variations.

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here?

But what about the correct pattern of lift stroke? --- It is built in!

The architecture of limbs is such that segments or joints can rotate together or independently of each other. Moreover, because the joints are structurally asymmetrical, and because the so-called rotator muscles run diagonally across the bones, there is a built-in twisting of the parts of the arms as the joints are rotated. Analysis of joint asymmetry is a basic tool in paleontological reconstruction of the likely limb movements in fossils.

A muscle might be attached at the right side of the upper arm and inserted at the left side of the lower arm. With such architecture, if the arm is rotated at the joints, the segments axially twist in various patterns. Such spontaneously generated kinematic patterns are best seen in graceful movement by animals, human dancers, and so on. There are several such mechanically prescribed paths, and one of these is the figure-8 flight stroke. Of course, some animals have restricted limb movements and rotations arising from adaptation to speed in running.

Thus the protobird would **not** have to develop the anatomy and behavior for lift stroke technique. As demonstrated in the *MacroPart* chapter this function is **resident** in the asymmetric architecture of appendicular rotations of all vertebrates. The foreleg stroke of movement in water is essentially identical with those of flying in the air. Research on pectoral fin propulsion in **fish** has stated (cit.) that fish propel themselves in water employing the figure-8 flight stroke that birds employ. It has also been often said that the otherwise flightless **penguins** fly through the water employing motion pattern of arms that they once used in aerial flight. As mentioned above, since the **same** basic elements apply to all vertebrate limb coordination it is not surprising that inherent preadaptive **potential** has evolved flight in **three** of the **five** vertebrate classes—reptile, bird, mammal.

Humans in water, exactly for the same reason, instinctively move their arms (and legs) through a figure-8 path in both the dog-paddle and the breast stroke modes of swimming in order to move through that medium. A greater number of mammals succeed in swimming by using ground travel motions of their limbs. Terrestrial locomotive movements follow greatly flattened figure-8 paths. The limbs of horses, cats, dogs, and other specialists in running are limited in lateral abduction and adduction, hence they cannot move legs in a broad frog-like stroke when swimming, yet they achieve propulsion with such laterally flattened figure-8 stroke paths. The natural, dynamic gestural motions of forelimbs and hindlimbs are never in a single plane, but move through different planes as movement proceeds. Movements in the various styles of dance in all cultures are built from such paths which arise from the most natural movements described by the asymmetry of joints.

???? Gliding is clearly not flight, but the takeoff stroke of gliding is the same as that of flying, that is, an extension of legs and arms, except that after the initial segment of the stroke sequence a glider's limbs become locked in the extended position and the full flight stroke is not completed. ????

End of Batch 1