Aerodynamics of bird flight pdf

Bird Flight's dominant aerodynamic forces that influence flight are lifting and dragging. The difference in air pressure above and below the wing produces a lift. When the bird holds its wing at an angle of view to the air current, the air flows faster above the upper surface than above the lower surface, thus creating less pressure over the wing than under it and causing the ascent. At the same time, drag, or resistance moving air, drags the wing backwards. The combined effect of these two forces lifts the wing and drags it backwards. While most of the lift on the bird's wing comes from the low air pressure at its top, a certain amount of lift is generated from under the air, striking the subsurface wing. The air flow at the bottom stops at a point close to the front of the wing, or then gradually accelerates until it is near the rear, or rear edge, by the time it has reached the same speed as the air traveling over its upper surface. If the front edge of the wing is slightly tilted upwards and placed in the airflow, the air will hit the lower surface more directly, thereby increasing the lifting force on the wing from below. The more the wing leans upwards, the more lift it will get, but only to a certain point: when the angle approaches the vertical, the pressure of the air on the lower surface begins to push the wing back, not upwards. If the wing is tilted too much, the lifting force eventually disappears, and the resistance is so great that it stops the buoyancy of the bird, or the movement forward. This leads to what is commonly called a stall, and the bird must recover the proper wing angle and flight speed or it will crash. Click here for the Lift Chart flock of homemade pigeons each in a different phase of its flap. Birdfage is the main mode of travel used by most bird species, in which birds take off and fly. Flight helps birds with feeding, breeding, avoiding predators, and migrating. Birdflight is one of the most difficult forms of movement in the animal world. Every aspect of this type of movement, including hovering, taking off and landing, involves many complex movements. As different bird species have adapted over millions of years through evolution to specific environments, prey, predators and other needs, they have developed specialization on wings, and have acquired different forms of flight. There are various theories about how bird flight evolved, including flying from falling or sliding (trees down hypothesis), from running or jumping (ground up hypothesis), from wing-assisted tilt running or from proavis (pouncing) behavior. The basic mechanics of flying bird lift and drag bird flight basics are similar to those of aircraft in which aerodynamic forces maintain uplift and resistance. The lifting force is produced as a result of the airflow which is airfoil. The air shape is such that the air provides a pure upward force on the wing, while the air movement is directed downwards. Additional clean lifting can come from the airflow around the bird's body in some species, especially during intermittent flight, while the wings are folded or semi-folded (wed. lifting body). Aerodynamic resistance is a force opposite to the direction of movement, and therefore a source of loss of energy in flight. The force of resistance can be divided into two parts, lift-induced resistance, which is an integral cost of the wing-produced elevator (this energy ends primarily in wingtip vortices), and parasitic resistance, including rubbing the skin to drag away the friction of the air and body surfaces and a form of resistance from the frontal area of the bird. The optimization of the bird's body and wings reduces these forces. Wings Home article: Wing Bird Kea in flight. The bird's forelimbs (wings) are the key to flying. Each wing has a central sleazy to hit the wind consisting of three bones of limbs, humerus, ulnar bone and radius. The hand, or manus, which generically consisted of five digits, is reduced to three digits (digits II, III and I, II, III depending on the diagram that followed) and serves as an anchor for the primaries, one of the two groups of flight feathers responsible for the shape of the air wing shape. Another set of flight feathers, behind the carpal joint on the ulnar, are called secondaries. The remaining feathers on the wing are known as hidden, of which there are three sets. The wing sometimes has rudimentary claws. In most species, they are lost by the time the bird is an adult (e.g., highly visible ones are used for active climbing of khovcin chicks), but the claws are preserved in adulthood by secretary, screamers, finfoots, ostriches, a few swifts and many others, like a local trait, in several samples. Albatross have locking mechanisms in the joints of the wing, which reduce the load on the muscles during the hovering flight. Even within the species, the morphology of the wing may be different. For example, adult European pigeon turtles have been found to have larger but more rounded wings than minors - suggesting that the morphology of the juvenile wing facilitates their first migration, while the choice for flight agility is more important after the first molting of minors. Female birds exposed to predators during ovulation produce chicks that grow wings faster than chicks produced by females free of predators. Their wings are also longer. Both adaptations can make them better off avoiding bird predators. Wing Shape This section may require cleaning in accordance with Wikipedia quality standards. The specific problem is: it appears to be a lack of rigor - reads like a personal opinion and not enough quotes Please help improve this section if you can. (September 2015) (Learn how and when to delete this template message) The wing forms a shape is important in determining the bird's flight capabilities. Different forms correspond to different trade-offs between advantages such as speed, low energy consumption and maneuverability. Two important parameters are the ratio of the sides and the loading of the wing. The ratio of aspects is the ratio of the wingspan to the average chord (or square of the wingspan divided by wing area). Loading a wing is the ratio of weight to the wing area. Most bird wings can be grouped into four types, with some falling between two of these types. These types of wings are elliptical wings, high-speed wings, high-aspect ratio wings and soaring wings with slots. The wings of budgerigar, as seen on this female pet, allow it excellent maneuverability. Elliptical wings Technically, elliptical wings are those that have elliptical (i.e. a quarter of ellipses) meeting appropriately at the tips. An example is the early Supermarine Spitfire. Some birds have vaguely elliptical wings, including the wing of an albatross of high-donce sides. While the term is convenient, it would be more accurate to refer to a curved cone with a fairly small radius at the tips. Many small birds have a low ratio aspect with an elliptical nature (when propagating), allowing tight maneuvering in confined spaces such as can be found in dense vegetation. As such they are common in forest predators (such as Accipiter hawks), and many passers-by, especially non-migrating ones (migrating species have longer wings). They are also common in species that use rapid take-off to avoid predators such as pheasants and partridges. High-speed wings High-speed wings are short, pointy wings, which combined with heavy wing loading and fast wings provide energy expensive but high speed. This type of flight is used by the bird with the fastest wing speed, falcon peregrine, as well as most ducks. The same wing shape is used by auks for a variety of purposes; Auks use their wings to fly underwater. The Peregrine Falcon has the highest recorded dive speed of 242 mph (389 kph). The fastest straight, powered flight is the spine tail fast at 105 mph (170 km/h). The pink tern uses its low wing load and high side ratio to achieve low flight speed. The high wing wing relationship of the aspect High wing aspect relations, which usually have a low wing load and far longer than they are wide, are used for a slower flight. It can take the form of almost soaring (used by kestrels, terns and nightjars) or in soaring and sliding flights, particularly dynamic soaring Seabirds that uses wind speed changes at different altitudes (wind haircuts) over ocean waves to provide lift. Low flight speed is also important for birds that plunge dive for fish. Soaring wings with deep slots These wings favor larger species of inland birds such as eagles, vultures, pelicans and storks. Storks. Slots at the end of the wings, between primaries, reduce induced resistance and wingtip vortexes, capturing energy in the air flowing from the bottom to the top of the wing at the tips, while the shorter size of the wings helps in takeoff (the high aspect of the ratio of wings require a long taxi to get airborne). Flight Birds use three types of flights. They differ in wing movement. A sliding flight of small flamingos flying in formation. In a gliding flight, the upward aerodynamic force is equal to the weight. The engine is not used in the flight of the plane; energy to counteract the loss of energy due to aerodynamic resistance is either taken from the potential energy of the bird, causing a downward flight, or replaced by the growth of air currents (thermal), called soaring flight. For specialists of soaring birds (mandatory soaring), the decision to participate in flight is closely related to atmospheric conditions that allow people to maximize flight efficiency and minimize energy costs. Flapping flying When the bird slams, as opposed to sliding, its wings continue to develop the ascent as before, but the elevator rotates forward to provide thrust that counteracts the resistance and increases its speed, which also has the effect of also increasing the lift to counteract its weight, allowing it to maintain height or climb. Flapping involves two stages: a down kick that provides most of the thrust, and an up-kick that can also (depending on the bird's wings) provide some traction. Each up-stroke wing is slightly folded inwards to reduce the energy cost of flapping the flight wing. Birds constantly change the angle of attack within the flap, as well as with speed. Related flight Little birds often fly long distances using technique in which short bursts of flapping alternate at intervals in which the wings are folded against the body. This is a flight scheme known as a bound or flap-bound flight. When the bird's wings fold, its trajectory is primarily ballistic, with a small amount of body lifting. The flight model is thought to reduce the energy required by reducing aerodynamic drag during the ballistic part of the trajectory, and increases muscle efficiency. The overhanging ruby hummingbird can beat the wings 52 times per second. Several species of birds use soaring, with one family specializing in hovering - hummingbirds. True hang-up occurs by generating lifting only through flapping, not by passing through the air, requiring significant energy costs. This usually limits the ability to smaller birds, but some larger birds, such as a snake or osprey 1920 may hang for a short period of time. Although it is not a real pair, some remain in a fixed position relative to the ground or water, flying in the oncoming wind. Wind. kestrels, terns and hawks use this wind soaring. Most birds that soar have a high aspect ratio of wings that are suitable for low flight speed. Hummingbirds are a unique exception - the most experienced hoverers of all birds. The hummingbird flight differs from other birds' flights in that the wing lengthens throughout the impact, which is a symmetrical figure of eight, with the wing producing a lift both on the ascent and on impact up and down. Hummingbirds were beaten with wings at 43 times per second, while others may be above 80 times per second. Taking off and landing, the male buffhead runs on the water during takeoff. The magpie goose is taking off. See also: Bird landings take-off is one of the most energetically demanding aspects of flight, since the bird must generate enough airflow through the wing to create an elevator. Small birds do this with a simple jump up. This does not work for large birds that should take a run to create sufficient airflow. Big birds take off, face to the wind, or if they can, sitting on a branch or rock so they can just fall into the air. Planting is also a problem for large birds with high wing loads. This problem is solved in some species, aiming for a point below the intended landing area (such as a nest on a rock) and then pulling up in advance. At the right time, the flight speed after the goal has been reached is almost zero. Landing on water is easier, and larger species of waterfowl prefer to do this when possible, landing in the wind and using their feet as drifts. To quickly lose altitude before landing, some large birds such as geese engage in a fast alternating series of lateral clips or even briefly flipping upside down in a maneuver called a whiff. The coordinated flight formation of a wide range of birds fly together in a symmetrical V-shaped or J-shaped coordinated formation, also called the echelon, especially during long-haul flights or migration. It is often thought that birds resort to this scheme of formation to fly in order to save energy and increase aerodynamic efficiency. Birds flying at the tips and at the front changed positions in a timely manner to distribute flight fatigue evenly among the members of the herd. The wings of the leading bird in the echelon create a pair of opposite rotating vortex lines. The swirls, the rear birds have a washed-out part behind the bird, and at the same time they have an upwash on the outside that hypothetically can help the flight of the rear bird. In a 1970 study, the authors argued that every bird in the V formation of 25 members could achieve a reduction in induced resistance and as a result increase their range by 71%. Studies of waldrapp ibis show that birds spatially coordinate the phase wing and show the consistency of the wing's trajectory when flying in V positions, allowing them to Make the most of the energy upwash available throughout the flap cycle. In contrast, birds flying in a stream just after another have no wingtip consistency in their flight patterns and their flapping out of phase, compared to birds flying in V models in order to avoid the detrimental effects of downwash due to the flight of the leading bird. Adaptation to the flight This section does not provide any sources. Please help improve this section by adding links to reliable sources. Non-sources of materials can be challenged and removed. (April 2020) (Learn how and when to remove this message pattern) Chicken wing diagram, the view from above the most obvious adaptation to flight is the wing, but because the flight is so vigorously demanding birds have evolved several other devices to improve efficiency when flying. The bodies of the birds are ordered to help overcome air resistance. In addition, the skeleton of the bird is hollow to reduce weight, and many unnecessary bones have been lost (such as the bony tail of the early bird Archaeopteryx), along with the jagged jaw of early birds, which was replaced by a light beak. The skeletal bone has also adapted into a large keel suitable for fixing large, powerful flying muscles. The ears of each pen have hooks called barbules, which fasten the ata of individual feathers together, giving the feathers the strength needed to hold the gunpowder (they are often lost in flightless birds). The barbs retain the shape and function of the pen. Each feather has a main (large) side and a minor (smaller) side, which means that the shaft or rahisis do not run in the center of the pen. Rather it runs longitudinal center with little or small side to the front and a large or main side to the back of the pen. This feather of anatomy, during flight and flapping wings, causes the rotation of the pen in the follicle. The rotation occurs in the movement up the wing. Large side points down, allowing air to slip through the wing. This significantly violates the integrity of the wing, allowing for much easier upward movement. The integrity of the wing is restored in downward motion, allowing part of the lifting inherent wings of birds. This function is most important in removing or reaching the elevator at very low or slow speeds where the bird reaches and grabbing air and pulling itself up. At high speeds, the wing air foil function provides most of the lift needed to stay in flight. The large amount of energy required for flight led to the evolution of the single-directional pulmonary system to provide the large amount of oxygen needed for their high respiratory rate. This high metabolic rate produces a large number of radicals in cells that can damage DNA and lead to tumors. The birds, however, do not suffer otherwise it is expected to shorten life expectancy as their cells have developed a more effective antioxidant system than those found in other animals. (quote necessary) Evolution of Bird's Flight Main article: The origins of bird's-eye view black-footed kititwijks fly at Cape Hay in the High Arctic. Most paleontologists agree that the birds are descended from small theropod dinosaurs, but the origin of bird flight is one of the oldest and most hotly contested disputes in paleontology. Four main hypotheses: From the trees down that the ancestors of the birds first slid down from the trees and then acquired other modifications that allowed the true food to fly. From scratch, the ancestors of these birds were small, fast predatory dinosaurs, whose feathers evolved for other reasons, and then evolved further to ensure the first ascent and then the true flight. Wing-using Tilt Works (WAIR), a version from scratch in which bird wings originated from front modifications that provided downforce, allowing proto-birds to run up extremely steep slopes such as tree trunks. Pouncing proavis, which claims that the flight evolved by modifying from wood ambush tactics. There has also been debate about whether the earliest known bird, Archaeopteryx, can fly. It appears that Archaeopteryx had brain structures and inner ear balance sensors that birds use to control their flight. Archaeopteryx also had the arrangement of wing feathers like that of a modern bird and similarly asymmetric flight feathers on its wings and tail. But Archaeopteryx lacked the shoulder mechanism by which the wings of modern birds produce quick, powerful blows; this could mean that he and other early birds were unable to slam the flight and could only glide. The presence of most fossils in marine sediments in habitats devoid of vegetation led to the hypothesis that they may have used their wings as an auxiliary to run across the surface of the water in the manner of basilisk lizards. In March 2018, scientists reported that Archaeopteryx is likely to be capable of flying, but is significantly different from modern birds. From the trees down it is unknown how well Archaeopteryx can fly, or if it can even fly at all. It was the earliest hypothesis, inspired by examples of vertebrate sliding, such as flying squirrels. This suggests that proto-birds like Archaeopteryx used their claws to clamber up trees and glide from the tops. Some recent studies have undermined the trees down hypothesis, suggesting that the earliest birds and their immediate ancestors did not climb trees. Modern birds that feed on trees have much more curved claws than those that feed on the ground. Claws birds and closely related non-bird theropod dinosaurs, as in modern ground birds feeding. From scratch Feathers Feathers common in coelurosaurid dinosaurs (including early Tyrannosaurus Dilong). Modern birds are classified as kelurososaurs by almost all paleontologists, although not by a few ornithologists. The original features of the feathers may have included insulation and competitive displays. The most common version of the from scratch hypothesis asserts that the ancestors of birds were small terrestrial predators (rather than road runners) who used their ancestors to balance, chasing prey, and that ancestors and feathers later evolved in a way that provided sliding and then feeding flight. Another land up theory states that the evolution of flight was initially driven by competitive displays and struggle: displays required longer feathers and longer, stronger limbs; Many modern birds use their wings as weapons, and the descending blows have similar actions to that of a flapping flight. Many of archaeopteryx fossils come from marine sediments, and it has been suggested that the wings may have helped the birds run on the water in the manner of the Lizard Jesus Christ (general basilisk). Recent attacks on the hypothesis from scratch try to disprove the assumption that birds are modified dinosaurs coelurosaurid. The strongest attacks are based on embryological analyses, which conclude that the wings of birds are formed from numbers 2, 3 and 4 (appropriate to the index, middle and unnamed fingers in humans; the first of the 3 digits of the bird forms the alula they use to avoid disruption on low-speed flights, such as landing); but the hands of coelurosaurs are formed by numbers 1, 2 and 3 (thumb and first 2 fingers in humans). However, these embryonic analyses were immediately challenged on embryonic grounds that the hand often develops differently in hoards that have lost some numbers during their evolution, and so the birds' hands evolve from numbers 1, 2 and 3. The wing tilt (WAIR) was caused by the observation of young chukar chicks, and suggests that the wings have developed their aerodynamic functions by having to run fast on very steep slopes, such as tree trunks, for example, to escape from predators. Note that in this scenario the birds need downforce to give their feet an increased grip. But early birds, including Archaeopteryx, lacked the shoulder mechanism that the wings of modern birds use to produce quick, powerful strokes. Since the downforce that WAIR requires generated upstrokes, it seems that the early birds were incapable of WAIR. Pouncing proavis model proavis theory was first proposed by Garner, Taylor and Thomas in 1999: We suggest that birds evolve from predators that specialize in ambushes from elevated sites, Their predatory hind limbs in a jump attack. Attack. and later, on the basis of elevators, the mechanisms developed under selection to improve body position control and movement during the air part of the attack. The choice for enhanced control based on the elevator has led to improved lifting rates, incidentally, turning the lash on plaque as the rise in production has increased. Choosing for a longer flight range will finally lead to the origin of true flight. The authors believed that this theory has four main advantages: it predicts the observed sequence of acquisition of character in avian evolution. He predicts an archaeopteryx-like animal, with a skeleton more or less identical to terrestrial theropods, with multiple adaptations to flapping but very advanced aerodynamic asymmetrical feathers. This explains that primitive pouncers (perhaps like Microraptor) can coexist with more advanced flyers (such as Confuciusornis or Saepornis) because they do not compete for flying niches. This explains that the evolution of elongated rachis-bearing feathers began with simple shapes that gave an advantage by increasing resistance. Later, the more refined shape of the pen can begin to also provide a lift. The use and loss of flight in modern birds Birds use flight to get prey on the wing, to feed to commute to the forage site, and to migrate between seasons. It is also used by some species for display during the breeding season and to reach safe isolated nesting sites. Flying is more vigorously expensive in large birds, and many of the biggest species fly soaring and sliding (without flapping their wings) as much as possible. Many physiological adaptations have evolved, making flying more efficient. Birds, which settle on isolated oceanic islands where there are not enough terrestrial predators, often lose the ability to fly. This illustrates both the importance of flying in avoiding predators and its extreme demand for energy. See also Birds portal Flight Call Flying and Sliding Animal Insect Flight List of Soaring Birds Ratites Compromises for Air and Water Patagium Notes - Intermittent Flight Research. Received on March 6, 2014.

B Tobalske, B; et al. Intermittent flight of Finchy's zebra: Unfixed gears and body lifting. Received on March 6, 2014. Baumel JJ (1993) Guide to Aviation Anatomy: Nomina Anatomica Avium. 2nd Ornithological Club Ed. Nuttall. Cambridge, Massachusetts, USA - Videler, JJ (2005) Bird Flight. Oxford University Press. ISBN 0-19-856603-4 pages 33-34 - Cabodevilla, H.; Moreno Sarate, L.; Arroyo, B. (2018). Differences in wing morphology between minors and adult European turtles Pigeons Streptopelia tourtour: the effects on migration and predator escape. Ibis. 160 (2): 458–463. doi:10.1111/ibi.12564. hdl:10261/174622. Matt Kaplan (March 25, 2011) Terrified birds grow longer wings. Nature. doi:10.1038/news.2011.187. Received on March 27, 2011. a b Tucker, Vance (July 1993). Slide birds: Reducing induced resistance on Wing Council Council Between the feathers of primary. In the journal Experimental Biology. 180: 285–310. S.A. Posel; Brandt, J.; Miller, T.A.; Katzner, T. E. (2018). Meteorological and environmental variables influence flight behavior and decision-making about the mandatory soaring bird, California Condor Gymnogyps Californianus. Ibis. 160 (1): 36–53. doi:10.1111/ibi.12531. Parslow, B. (2012). Modeling the bird wing and wakes up, Ph.D. thesis - Kristen E. Crandell and Bret W. Tobalske (2011). The aerodynamics of the tip turn up in the rotating wing of the pigeon. In the journal Experimental Biology. 214 (11): 1867–1873. doi:10.1242/jeb.051342. PMID 21562173. Bret W. Tobalske, Jason W. D. Hearn and Douglas R. Warrick, Aerodynamics of Intermittent Boundaries at Flying Birds, Exp. Fluids, 46, page 963-973 (2009), DOI 10.1007/s00348-009-061 4-9 (available August 2, 2016) - Brendan Body, Bird Control and Observations: Further Impact of Air Resistance on Small Birds, 2009 (available August 2, 2016) - Tobalske, B.V., Peacock, V.L. and Dial, K.P. (1999). The cinematics of a patchwork flight into the Finch zebra at a wide range of speeds (PDF). In the journal Experimental Biology. 202 (13): 1725–1739. PMID 10359676.CS1 maint: several names: list of authors (link) - Rayner J.M.V. (1985). A bound and wavy flight in birds. In the journal Theoretical Biology. 117 (1): 47–77. doi:10.1016/s0022-5193(85)80164-8. b c Ingersoll, Rivers; Heismann, Lucas; David Lentink (September 26, 2018). Biomechanics hover performance in neotropical hummingbirds against bats. Scientific advances. 4 (9): eaat2980. doi:10.1126/sciadv.aat2980. ISSN 2375-2548. PMC 6157961. PMID 30263957. a b c Scandalis, Dmitri A.; Paolo S. Segre; Joseph W. Bachlman; Groom, Derrick J. E.; Kenneth K. Welch; Christopher K. Witt; McGuire, Jimmy A.; Robert Dudley; David Lentink; Altschuler, Douglas L. (October 19, 2017). The biomechanical origin of extreme wing alometry in hummingbirds. Natural communications. 8 (1): 1047. doi:10.1038/s41467-017-01223-x. ISSN 2041-1723. PMC 5715027. PMID 29051535. a b c Ravi, S.; Crall, J.D.; McNeilly, LA; Gallardi, S.F.; Bivener, AA; Combs, S.A. (March 12, 2015). Hummingbird stability of flight and control in a free stream of turbulent winds. In the journal Experimental Biology. 218 (9): 1444–1452. doi:10.1242/jeb.114553. ISSN 0022-0949. PMID 25767146. Raptor Center Cascades (February 28, 2012). Cascades Raptor Center Show Behavior of the Year 2012. Received on March 31, 2018 - via YouTube. General information Osprey. www.newyorkwild.org. Received on March 31, 2018. Nature of the Wild West (April 4, 2013). Osprey soars like a hummingbird hunt in Yellowstone National Park. Received on March 31, 2018 - via YouTube. - Tobalske BW, Warrick DR, Clark CJ, Powers DR, Hedrick TL, Hyder GA, Biewener AA (2007). Flight 3D kinematics Exp Biol. 210 (13): 2368-82. doi:10.1242/jeb.005686. PMID 17575042. Hedrick, T.L.; Tobalsk, B.V.; Ros, I.G.; Warrick, D.R.; Bivener, A.A. (December 14, 2011). The morphological and kinematic basis of the flight of hummingbird stroke: scaling the flight muscle transfer factor. Proceedings of the Royal Society B: Biological Sciences. 279 (1735): 1986–1992. doi:10.1098/rspb.2011.2238. ISSN 0962-8452. PMC 3311889. PMID 22171086. Gill V (July 30, 2014). Hummingbird edges out helicopters in hover contest. BBC News. Received on February 26, 2019. Butt, Bruce (October 1, 2007). Why do migratory birds fly in a V-shaped formation?. A scientific American. Received on January 16, 2014. Florian T. Muichres; Dickinson, Michael H. (January 2014). Fly with a little flap from your friends. Nature. 505 (7483): 295–296. doi:10.1038/505295a. ISSN 0028-0836. PMID 24429623. S2CID 4471158. Lissaman, P.B.S.; Schollenberger, Karl A. (May 22, 1970). Formation of the flight of birds. Science. 168 (3934): 1003–1005. Bibkod:1970Sci... 168.1003L. doi:10.1126/science.168.3934.1003. PMID 5441020. S2CID 21251564. Portugal, Steven J.; Hubel, Tatiana J.; Fritz, Johannes; Stephanie Heese; Daniela Trobe; Voelkl, Bernhard; Stephen Hale; Wilson, Alan M. and Usherwood, James R. (January 16, 2014). Exploitation and prevention of downwash by phasing out the formation of ibis (PDF). Nature. 505 (7483): 399–402. Bibkod:2014Natur.505. 399P. doi:10.1038/nature12939. PMID 24429637. S2CID 205237135. Brush, A.H. (July 1998). Taking wing: Archaeopteryx and the evolution of bird flight. Auk. 115 (3): 806–808. doi:10.2307/4089435. JSTOR 4089435. A review book that provides good, non-technical summary issues. Shipman's book.. (1999). Taking wing: Archaeopteryx and the evolution of bird flight. Simon Schuster. ISBN 978-0-684-84965-2. Alonso, P.D.; Milner, D.C.; Ketcham, R.A.; Coxon, M.J. and Rowe, T.B. (August 2004). Bird nature of the brain and inner ear of Archaeopteryx. Nature. 430 (7000): 666–669. Bibkod:2004Natur.430. 666A. doi:10.1038/nature02706. PMID 15295597. S2CID 4391019. b Center,. (2006). Accumulated orientation in theropods and basal birds, and the origin of the flapping flight (Automatic PDF loading). Act of Paleontology of Polonique. 51 (2): 305–313. Videler, JJ (2005) Bird Flight. Oxford University Press. ISBN 0-19-856603-4 pages 98-117 - Videler, John (January 1, 2005). How Archaeopteryx could run on water. Archaeopteryx. 23. Received march 31, 2018 - through ResearchGate. Dennis F.A.E. Voeten; (March 13, 2018). The geometry of the winged bones shows the active flight in Archaeopteryx. Natural communications. 9 (923): 923. Bibkod:2018NatCo... 9..923V. doi:10.1038/s41467-018-03296-8. PMC 5849612. PMID 29535376. Ben Guarino (March 13, 2018). This feathered dinosaur probably flew, but not like any bird you know. Washington Post. received on March 13, 2018. a b Feduccia, A. (1999). The origin and evolution of birds. Yale University Press. ISBN 978-0-300-07861-9. See also Feduchcha, A. (February 1995). Explosive evolution in tertiary birds and mammals. Science. 267 (5198): 637–638. Bibkod:1995Sci... 267..637F. doi:10.1126/science.267.5198.637. PMID 17745839. S2CID 42829066. Constant Dead Connection - Glen, C.L. and Bennett, M.B. (November 2007). Feeding regimes of Mesozoic birds and Non-Australian theropods. Current biology. 17 (21): R911-2. doi:10.1016/j.cub.2007.09.026. PMID 17983564. S2CID 535424. Archive from the original (abstract) dated December 8, 2012. Prim, R. and Brush, A.H. (2002). Evolutionary Origin and Diversification of Feathers (PDF). The quarterly biology review. 77 (3): 261–295. doi:10.1086/341993. PMID 12365352. Archive from the original (PDF) dated October 15, 2003. Received on April 11, 2019. Mair G.; Paul B.; Peters D.S. (2005). A well-preserved specimen of Archaeopteryx with the features of theropod. Science. 310 (5753): 1483–1486. Bibkod:2005Sci... 310.1483M. doi:10.1126/science.1120331. PMID 16322455. S2CID 28611454. Feduchcha, A. (1993). Burgers. and L. M. Hjappe (1999). The Archaeopteryx wing as the main traction generator. Nature. 399 (6731): 60–62. Bibkod:1999Natur.399... 60B. doi:10.1038/19967. S2CID 4430686. Cowan, R. Life Story. Blackwell's science. ISBN 978-0-7266-0287-0. Videler, J.J. (2005). Bird flight. Oxford: Oxford University Publishing House. ISBN 978-0-19-856603-8. Burke, A.K. and Feduchcha, A. (1997). Models of development and identification of homologies in the bird's hand. Science. 278 (5338): 666–668. Bibkod:1997Sci... 278..666B. doi:10.1126/science.278.5338.666. Summarized by Embryo Research Show Dinosaurs might not have led to modern birds. ScienceDaily. October 1997. Chatterjee, S. (April 1998). Counting the fingers of birds and dinosaurs. Science. 280 (5362): 355a-355. Bibkod:1998Sci... 280..355C. doi:10.1126/science.280.5362.355a. Vargas, A.O.; Fallon, J.F. (October 2004). Birds have dinosaur wings: molecular evidence (abstract). In the journal Experimental zoology Part B: Molecular and Developing Evolution. 304B (1): 86-90. doi:10.1002/jez.b.21023. PMID 15515040. Pennisi, E. (January 2005). Bird wings really look like dinosaur hands (PDF). Science. 307 (5707): 194–195. doi:10.1126/science.307.5707.194b. PMID 15653478. S2CID 82490156. Archive from the original (PDF) dated July 27, 2011. Dial, K.P. (2003). Wing-Aid Incline Running and Flight Evolution. Science. 299 (5605): 402–404. Bibkod:2003Sci... 299..402D. doi:10.1126/science.1078237. PMID 12532020. S2CID 40712093. Generalized in Morell, Rebecca (January 24, 2008). The secrets of bird's flight have been revealed. Scientists believe they may be a step closer to solving the mystery of how birds went out into the air. BBC News. Received on January 25, 2008. Kit, MV and Dial, K.P. (2003). Wing Tilt Running Mechanics (WAIR) (PDF). In the journal Experimental Biology. 206 (pt 24): 4553-4564. doi:10.1242/jeb.00673. PMID 14610039. S2CID 6323207. Alexander Links, David E. Nature Flyers: Birds, Insects, and Flight Biomechanics. 2002 (hardcover) and 2004 (paperback). Baltimore: Johns Hopkins University Press. ISBN 0-8018-6756-8 (hardcover) and 0801880599 (paperback). Brooke, Michael and Tim Birkhead (editors). Cambridge Encyclopedia of Ornithology. 1991. Cambridge: Cambridge University Press. ISBN 0-521-36205-9. Burton, Robert. Bird flight. Facts

about the file, 1990 Campbell, Bruce, and Elizabeth Luck (editors). The Dictionary of Birds. 1985. Calton: TK D Poys. ISBN 0-85661-039-9. Cornell Laboratory of Ornithology is a guide to bird biology. 2004. Press of Princeton University. ISBN 0-938027-62-X. (hardcover) Del Hoyo, Josep et al. Handbook Birds of the World Volume 1. 1992. Barcelona: Lynx Edicions, ISBN 84-87334-10-5. Wilson, Barry (editor). Readings from Scientific American, Birds. 1980. San Francisco: WH Freeman. ISBN 0-7167-1206-7. Attenborough, D.1998. In the life of birds. Chapter 2. Bbc Books. ISBN 0563-38792-0. External Commons links have media related to Flight Bird. Flight in Birds and Planes evolutionary biologist John Maynard Smith Freeview video provided by Vega Science Trust Beautiful Birds in Flight - slideshow of Life magazine 'Pigeon Take Off in slow motion' YouTube video 'Bird Flight I' Eastern Kentucky University ornithology course site, with photos, text and video. Extracted from the aerodynamics of bird flight ppt. aerodynamics of bird flight pdf. aerodynamics of bird flight biology discussion. principle of aerodynamics in bird flight