What it Takes to Fly

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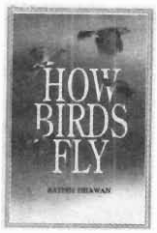

How Birds Fly
Satish Dhawan
National Book Trust
Price:Rs.40/-, 2002.

Bird flight is a subject of much interest to aeronautical engineers. Pioneers of flight like Otto Lilienthal, George Caley and the Wright brothers observed the flight of birds carefully and drew inferences of value to their work of constructing manned flight vehicles. There is considerable interest even today in the subject as the possibilities of micro air vehicles is being investigated with vigour and there are still useful lessons that can be learnt by studying bird flight. Dhawan's book is a systematic and comprehensive treatise on bird flight and will serve as a valuable source book on the subject for years to come. The book brings together hard to get information on topics like bird anatomy, kinematics of bird flight, muscle metabolism, aerodynamics and flight mechanics of soaring and powered flight.

The book begins with a look at the evolution of birds which started about 150 million years ago. It briefly touches upon the evolutionary pathways to bird flight and the current diversity of birds which include champion gliders like vultures, excellent 'power-on' fliers like the swifts, the hovering birds like the humming birds and non-fliers like the penguins. As Dhawan observes, the range and complexity of maneuvers of birds in flight are still not fully explored and there is much that science can learn from studies of bird flight.

Birds are well adapted for life in the air as they have evolved over time special features transforming them into efficient flight vehicles. These include a strong and lightweight skeleton, aerodynamically efficient wings with feathers for lift and thrust, powerful muscles to power the wing and a fast response control system to stabilize and navigate the unstable configuration. The book considers these in section 2. It is interesting to note that the larger bones of birds are hollow with supporting struts inside (to stabilize their thin walls), thus improving their strength-weight ratio. The wings of birds have profiles which resemble, in a general way, those used on aircraft. They were studied for guidance in constructing airplane wings in the early days of aeronautics. Bird's wings are rather thin and misled aviation pioneers (who did not understand scale effect) into believing that aircraft should have thin wings for efficient flight. Modern aircraft have much thicker wings often reaching 18% of their chord and are more efficient aerodynamically. One may further note that birds as flying machines are inherently unstable and are actively controlled in flight. This enhances aerodynamic efficiency and maneuverability during flight.

This feature has been incorporated in some of the latest combat aircraft.

Section 3 is devoted to a study of the kinematics of wing motion in powered flight including take off and landing as well as soaring. This is supported by some original material in the form of high speed photographs of different birds in Appendix C. While the main features of wing motion in cruise and soaring are fairly well understood, there is much that is not clear in terms of details of motion and their influence on aerodynamic forces in the take-off and landing phases of flight. In these phases of flight relatively large aerodynamic forces are demanded which the flight speed of the bird is small. Consequently large flapping motions of the wings are required. Further study of bird flight appears to be necessary in this context and this presents a challenging opportunity to researchers in this area.

Section 4 is an introduction to the aerodynamics of bird flight. Dhawan explains in simple terms the production of lift and thrust by the flapping wings of a bird in steady flight. He explains how the fast moving outboard sections of the wing contribute to thrust if their orientation (incidence) is properly phased with the flapping motion. This section is an introduction to aerodynamics and will be particularly useful to those who are new to the subject. It leads on to the construction of a full flight mechanical model of a bird in steady flight including hover. Section 5 deals with this and also explains soaring flight in thermals and shear winds. It is interesting to note here that Dhawan discusses the concept of stability of the flight path of a bird flying below its 'best glide' speed. At these speeds, a small decrease in flight speed results in an increase of drag which further tends to reduce the flight speed leading to a runaway situation resulting in stall. This phenomenon has its counterpart in the flight of fixed wing airplanes and is important during their landing.

Section 6 is devoted to the consideration of bird's muscles as power plants. Birds not only need steady power for sustaining level flight, but also peak power for short periods for take-off or for escaping from predators. Like other animals, birds generate power through two metabolic pathways (one aerobic and the other non-aerobic) and the muscle is thus a hybrid power plant. On the whole, bird's muscles are as thermodynamically efficient as aircraft engines and this is reflected in some birds achieving a range of about 2000 kms, which is comparable with that of typical transport aircraft as indicated in section 7. Section 8 discusses scale effects which are important in understanding the limits for the sizes of birds and their performance.

In conclusion, it is clear that the book is so extensive in coverage and so deep in insight that a small review like this cannot do justice to the work. A full study of the book is strongly recommended.

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