bird flight physiology study

The expenditure of energy by birds in flight may be among the highest of energy capabilities in the animal kingdom. The heart beat also is remarkably high — 20 beats per second compared with three per second in man during heavy work

A team of biologists and engineers at the National Research Council of Canada has completed a five-year study of bird flight physiology. Their work has helped to unravel some of the mysteries of bird flight which have baffled scientists for decades.

The studies, undertaken by biologists in NRC's Division of Biology and engineers in the Radio and Electrical Engineering Division, exemplify the degree of collaboration which exists among NRC scientists.

Dr. J. S. Hart, Head of the Animal Physiology Section of the Division of Biology was in charge of the physiological studies. O. Z. Roy of the Medical Electronics Section of REED developed the sophisticated telemetric equipment used in the experiments.

The work, stimulated by NRC's Associate Committee on Bird Hazards to Aircraft, produced new information on breathing, body temperature regulation and metabolism in flight. Transmitters weighing less than an ounce carried on the backs of homing pigeons, ducks, gulls and other birds, monitored information on breathing, wing beats, heart rates and other events during flight, which was recorded by transducers placed in a rubber mask over the beak or on various parts of the body. A long nylon fishing line attached to a harness on the bird was used to prevent its escape and pull it down to earth after each test.

Dr. Hart says that answers were sought on three main questions. Is breathing during flight co-ordinated with wing action? How much does body temperature, metabolism and heart activity increase during flight? How is the heat production lost – through evaporation of water from the lungs and air sacs or mostly by air convection through the feathers?

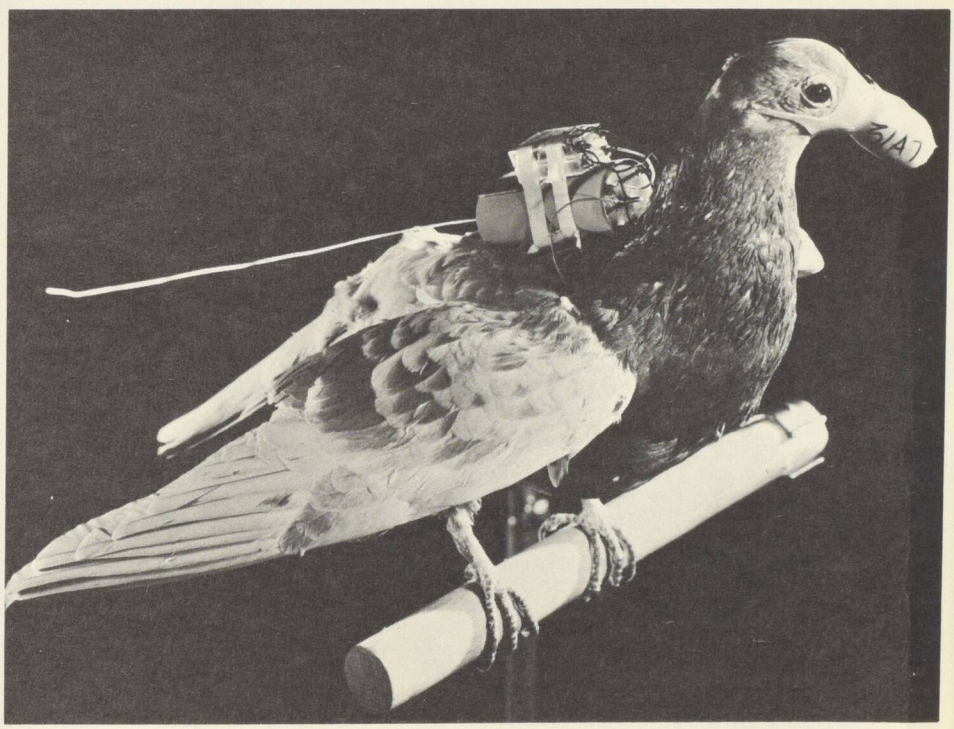
Measurement of body temperature, done for the first time in free flight of pigeons, showed that the normally high temperatures of these birds were elevated even more during flight to a record level of 113 degrees Fahrenheit, compared with a maximum of about 104 degrees Fahrenheit in man during heavy exercise. The body temperature of a pigeon at rest is 107 degrees Fahrenheit.

In the pigeon and in the crow, it was found that breathing and wing beats were perfectly co-ordinated, with inspiration (inhalation) occurring always on the upstroke of the wing, but in most species wing action was much faster than breathing. Basically the two functions are independent, which provides a basis for interrupted song during flight, but there was usually a co-ordination ranging from three to five wing strokes per breath.

Measurements of lung ventilation and oxygen content of the air exhaled from the mask gave very high estimates of heat production in flight. This ranged from 12 to 15 times basal (the rate at which heat is given off by an organism at complete rest) and was equivalent to near maximal increases in well trained animals during heavy exercise. Dr. Hart says that "the expenditure of energy in flight might be among the highest of energy capabilities in the animal kingdom."

The heart frequency in flight is remarkably high with rates up to 20 beats per second in small birds compared with three per second in man during heavy work. From the oxygen consumption and heart rate, it is estimated that a small bird would circulate at least twice its weight of blood every minute.

With the high energy expenditure, the heat dissipation during flight becomes a problem, particularly under warm conditions. Contrary to older theories it was found that about 85 per cent of this heat is lost by convection. In other words, it is dissipated mainly by air cooling through the feathers rather than water cooling; by evaporation from lungs and the many air sacs in the bird's body. This has the advantage of greatly reducing dehydration in long migratory flights, but raises the problem of how this is accomplished in a heavily feathered bird. The results of these studies indicate that heat loss must be so precisely regulated in flight that it is relatively independent of environment temperature. How this is accomplished is still a mystery.



One of the instrumented pigeons used in the bird flight study.

Utilisation du pigeon dans l'étude du vol des oiseaux.