

Mode and Mechanism of Flight in Indian Domestic Pigeon (*Columba Livia*) in Reference To Anatomy: A Review

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Abstract

Human have more interest in birds from earlier. Studies on bird's intelligence and song learning have been largely on laboratory based and birds migration including aspect of navigation orientation and physiology are often studied using captive birds in special cages that record their activities. The Importance of study is to analyze the mode and mechanism of flight and behaviour of domestic living pigeon. The first hint that birds evolved from reptiles appeared in 1861 with the discovered of an beautiful skeleton of a late Jurassic bird named Archaeopteryx, the first known birds discovered in early 1860. The most distinguishing feature of pigeon is the possession of feathers, which don't occurs in animals. The smaller forms are usually called doves and larger forms called pigeon. Thus a pigeon may be described as a feathered, bipedal, flying vertebrate possessing wings. They attract attention because of flight, colourful plumages, springtime songs, strange migration, many fascinating habits and considerable economic value of man

Keywords: Behaviour parameters, Anatomical parameters & physiological adaptation with neuromuscular control and functional design of flight.

INTRODUCTION

More than 500 species of pigeon have been described, they fall under two categories wild and domestic. The common wild pigeon known as the blue rock pigeon or rock dove .The species include the domestic pigeon and escaped domestic pigeons have given rise to feral pigeons. Wild rock pigeons are pale gray with two blocks bars on each wings, although domestic and feral pigeons are vary variable in colours and patterns. There is visible difference in male and female are size of body, colour, sexual organs and behaviour of pigeons. The species is abundant with an estimated populations of 17 to 28 million feral and wild pigeons in europes.They forms large and small flocks for feeding and other acts, the smaller forms usually called doves and larger forms called pigeon .within their flocks there are dominant and subordinate individuals are present. The dominant pigeons are larger in size and usually found in the centre of the flocks, the smaller, subordinate are closer to the edges. Rock pigeons mate for life mainly in spring and summer, most are monogamous a single male breeds with a single female. They reach the sexual maturity at the age of 6 months and reproduction starts at the age of 8 months. The females lays two small eggs in difference of 44 hours first egg laid in afternoon and second egg laid in morning, the weight of the egg is 25 grams. The chicks hatch after 17 days and weight is 20 grams. Samuel Wendell Williston(1851-1918)was an American entomologist and palaeontologist who was the first to propose that birds developed flight Muscle anatomy of the pigeon and experimental coordinate system. The pectoralis is the large ventral muscle primarily responsible for powering the down stroke. Flight muscles not only power the wings but also modify their control surfaces. The power movements consist of an alternating upstroke and down stroke that are dependent on the alternating contraction of the elevator and depressor muscles. Most birds have approximately 175 different muscles, mainly controlling the wings, skin, and legs. The largest muscles in the pigeons are the pectorals, or the pectoralis major, which control the wings and make up about 15–25% of a flighted bird's body weight. They provide the powerful wing stroke essential for flight.

The functions of the two primary flight muscles of birds, the pectoralis and supracoracoideus, are reviewed here in relation to the mechanical power needed to meet the aerodynamic requirements for flapping flight. The vast majority of morphological and physiological work has largely focused on the pectoralis because of its dominant role in powering avian flight. Consequently, much of the review of avian muscle function will focus on the pectoralis, with particular comparison to its antagonist, the supracoracoideus. Preliminary in

vivo analyses of the triceps and biceps muscles, which control wing shape via elbow extension and flexion, are also considered in relation to changes in flight performance required for take-off, landing and manoeuvring flight.

In studies of pigeons taking-off from an elevated perch platform, flying level and landing on a similar perch, measurements of wing, body and tail kinematics reveal little change in wing or tail movements relative to the bird's body. Instead, most of the changes in global orientations of the tail, wing and wing stroke plane, which determine the aerodynamic properties of the bird's flight stroke, which achieved by changes in body. During take-off, pigeons pitch forward (head down) inclining their stroke plane to a more vertical orientation to provide increased thrust for acceleration after the take-off jump from the perch. During landing, the pigeon pitches back (head up), changing its stroke plane to a more horizontal orientation to help decelerate as it lands. Changes in the global stroke plane angle during take-off and landing are significantly greater and less, respectively, than observed during level flight.

MATERIALS AND METHOD

Study was done on pigeon at the department of zoology in S.K.M.University, Dumka Jharkhand India, after ethical approval from the department. The present study was design with the following objective to study and analyse that how pigeon adjust himself and what necessary mechanism of action is required for muscle during flight in pigeon.

Live specimens of pigeon were collected from the local areas. For morphological study of *Columba livia* was observed externally and different parts of their body were measured with the help of a divider and mm graduated scale, whichever required. For the study of thoracic wings, they were removed from the attachment point of the body and examined under the magnified hand lens.



Fig. 1. Morphological structure of Indian domestic pigeon

For anatomical study, the live specimens were sacrificed by immersing the animal into 5% formalin solution. After killing, the pigeon were washed under running tap water. Study of Endoskeleton is more convenient because of its larger size.

Coelom and viscera -The coelom or body cavity is spacious and divided in to anterior thoracic and posterior abdominal cavity by a membranous oblique septum or diaphragm. The thoracic cavity is further divided into 3 compartments i.e. anteroventral pericardial cavity, enclosing the heart, and two dorsolateral pleural cavity each enclosing a lung. The pericardial sac rests between the two lobes of liver. The large abdominal cavity contains digestive, excretory, and reproductive organs.

Body shape is streamlined (Boat shaped) needs minimum resistance to wind that easily propelled through the same manner. Compact body is light but strong dorsally & heavier ventrally which maintain balance in air. Feathers are covered like blanket, having air space inside which help in flying upward and downward. These unique structures are light, elastic, waterproof, and most important in flight.

Warm bloodlessness-pigeons are warm blooded animals. The perfect aeration of blood is responsible for the high temperature of body (40-46c) which is necessary for flight. The Head & neck parts are mobile and can rotate upto 360 degree , beak helps to collect food, very useful to make nest building, offence & defence. Hind limb is bipedal locomotion perform by hind limb somewhat interiorly from the trunk to balance. Fore limb modified in to wings – Limb are modified into wings the wings are more powerful organ of fight which helps during the pigeon for ward & upward during flight. Under Endoskeleton most of the bones are pneumatic & filled with air instead of bone marrow. It make the body light, most of the bone are fused together which help in flight. The muscular short tail bears a series of long strong light caudal feathers arrange in a fan like manner and help during flight. Respiration & Air sacs – these are attached to lungs which work as reservoirs of air. They may also act as cooling device in regulation of the temperature of the body. Circulatory system is more advanced a average oxygen supply is required for rapid metabolism. It is done by efficient circulatory system with 4 chamber powerful heart. In Pigeon generally urinary bladder is absent & semisolid urine is excreted out, not retained for long time in body. It helps in reducing the body weight. They have uricotelic excretion – pigeons excrete 60% of their nitrogenous waste in the form of chalky white urates. Urea is formed only as by product of detoxification in kidney and lesser excrete in liver. Brain & eyes are more developed equilibrium is maintained by well developed cerebellum of the brain. In female pigeons single functional ovary is present on the left side of the body also leads to reduced the Weight which is much essential for flight. Pigeons having rapid digestion of food inside the body. Pigeon having two part stomach, a glandular Portion known as proventriculus and muscular portion known as gizzard, the gizzard perform as grinding and disassembling the food, and make it easier for digestive enzymes to break the food. Two pairs of large muscles move the wings in flight, the pectoralis, which is the large ventral muscle responsible for powering the lowers the wing and the supracoracoideus which raises it. The biceps lies anterior to the humerus acting to flex the elbow.

In flight the pectoralis and supracoracoideus are mainly responsible for producing the mechanical power required for sustained flapping flight in pigeon it is unclear whether the activity of these large flight muscles is modulated to achieve manoeuvring flight behaviours, or whether the smaller wing extrinsic and intrinsic muscles are recruited to adjust wing orientation and wing shape. In pigeons left and right pectoralis muscles appear to exhibit differential timing of force development and magnitude, with down stroke of the outside wing phase advanced relative to the inside wing of a turn. EMG activity was noted during 90° turns. Instead, there was evidence of differential activation of the left and right biceps muscles, with the inside biceps showing stronger activity, indicative of increased elbow flexion and reduction of inside wing span. In both sets of studies, however, more detailed kinematics of wing shape and motion during these manoeuvres was not available given the limited resolution of the motion-analysis systems used at the time.

RESULTS AND DISCUSSION

Flight muscles-Birds fly by flapping their wings which are the modified forelimbs, the muscles moving the forelimb are greatly modified.Pectoralis major and Pectoralis minor which lowers the wing and supracoracoideus rises the wing. Accessory muscle and Tensor muscles are also responsible for flight.

The physiological structure of birds bodies shows many unique adaptations mostly aiding flight .birds have light skeletal system but powerful musculature along with circulatory and respiratory system capable of very high metabolic rates and oxygen supply which permit bird to fly. The flight is a highly spontaneous action. Larger birds either run or swim rapidly together forward momentum for a takeoff smaller birds usually take a quick jump by means of their legs followed by the beating by their wings. Birds fly on the principles of an aeroplane. or heavier than air machine, rather than on that of a balloon or lighter than air machine. The fan like tail feathers is used as a rudder for steering during flight, to suddenly check flight and as counter balance in perching. The tail may be spread or folded and elevated or depressed or tilted to direct the course of flight.

Muscle function of flying birds depends on the production of substantial mechanical work performed at a high rate. Although skeletal muscles generally have a similar capacity for generating mass-specific work, the avian pectoralis is well suited to performing work with large length excursions. This is a prerequisite for powering flight because the wings must move through a large excursion during down stroke to produce

effective aerodynamic lift. The pectoralis achieves this by having relatively long fascicles that shorten over a large fraction (up to 42%) of their length. The timing of muscle activation late in upstroke also allows the pectoralis to rapidly develop force under nearly isometric or stretching conditions. This elevates the work that the muscle performs as it shortens.

Muscular system-The musculature of bird is generally highly developed and very efficient. The muscle are greatly specialised to serve different functions, histologically the muscles are striated, unstriated and cardiac. The diaphragm of the pigeon is rudimentary. The muscle of the back are almost atrophied due to inactivity or immobility of the trunk vertebrae. The muscle of neck, tail, wings, legs and ventral side of the body are well developed.

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ANATOMY OF FLIGHT MUSCLES

The pectoralis is a large muscle (approx. 8–11% body mass, that attaches to the humerus of the wing at the deltopectoral crest. Its main portion originates dorsally from ribs. The fibres of the TB and the posterior region of the SB insert on an internal aponeurosis that merges with the more anterior SB fibres before attaching to the DPC. In addition to producing mechanical work during down stroke, the pectoralis also pronates the wing. The smaller supracoracoideus lies deep to the pectoralis, also originating from the keel of the sternum, and is about one-fifth of the pectoralis in mass (approx. 2% body mass). By means of its tendon, which inserts and acts dorsally at the shoulder as a pulley, the supracoracoideus elevates and supinates the wing during upstroke. Whereas the pectoralis is composed of generally long fibres with modest pinnation (pigeon: 31–67 mm, mean 41 mm), the supracoracoideus is a classic bipinnate muscle with short fibres (pigeon: 16–23 mm, mean 20 mm). It produces elevation and supination of the wing by means of a long tendon that passes dorsally over the shoulder, via the triosseal foramen of the avian pectoral girdle, before attaching to the dorsal surface of the proximal humerus adjacent to the DPC. The pectoralis is composed mainly of fast-oxidative fibres (approx. 85% in pigeons) with a smaller component of fast-glycolytic fibres. Fibre-type composition of the supracoracoideus, to my knowledge, has not been examined in pigeons, but in the European starling is composed of a greater fraction (68%) of fast-glycolytic versus fast-oxidative fibres whereas, in zebra finches, Anna's hummingbirds and Atlantic puffins the supracoracoideus.

Mode of flight-Pigeon can perform different kinds of flight and all kinds may be performing at different times by same pigeon in all types of flight.

Gliding or skimming flight- This is the simplest and most primitive mode of flight pigeon holds their wings spread, motionless and glide for a considerable distance without flapping them. Gliding depends for its movement on the velocity required by previous strokes. or by descending from a higher to a lower level or by making use of air currents. This flight can be exhibited for short time and pigeon soon loses velocity or height. This flight is seen in short birds coming for landing. Pigeons gliding from their loft to the ground or in a falcon swooping upon its quarry. Soaring or sailing-Its the most remarkable and highly specialised mode of flight performed by pigeons with a large wing span .The pigeons usually at a high level describe great circles without any movement of the wings . The birds rise without of kinetic energy.

Flapping flight- It is the most common or ordinate mode of flight. all birds fly by flapping their wings up and down .each flapping Includes an effective down stroke and recovery upstroke of the wings. The wings are held vertically and fully spread, In the down stroke they move obliquely forward, downwards and backwards, their distal portions tilted upwards. there is both lift and thrust. in the upstrokes the wings are parity folded and their primary feathers spread out for the air to slip through thus making it easier to lift them. they move up and down backwards. as a result the birds will be propelled forward and sustained in the air. Pigeons can beat their wings at least eight times in one second.

Hovering flight- It is the peculiar variant of flapping flight. in hovering found in hummingbirds, the body is kept vertical while the bird remains poised in the air before a flower or above an object upon the ground,



Fig. 2. Flight morphology of domestic pigeon

Mechanism of flight-Aerodynamics or the science of motion of air is a difficult science. Birds fly on the principle of indirect movement. It moves the air which by its displacement moves the bird. Air displaced by the beating of wings, sets up currents that which keeps the animal aloft and move them forward resulting in flight. According to Newton's third law, the force of reaction of air is equal and opposite to that exerted by the moving wing on the air.

The wing is functional both as an airfoil and as propeller for forward motion. It is thick in front, thin and tapering behind, and presenting in profile a concave streamlined upper and a flat or slightly concave in lower surface. When air flows across the wing the air stream moves faster on upper convex surface than the concave lower surface. The two forces generated suction above and upward thrust below the wing that keeping the bird aloft and moving forward and upward. The air also pushes the wing horizontally backwards and tends to slow down the birds.

Flight Starts by large pectoralis muscles that depress the wings at the shoulder. The dominant role and large size of the pectoralis muscle, therefore, enable a critical assessment of how muscle function is tailored to meet the mechanical power requirements of flapping flight over a range of flight conditions. The smaller supracoracoideus muscle of pigeon, about one-fifth the size of the pectoralis, is the primary wing elevator active during upstroke, particularly at slow to moderate speeds and during hovering. Smaller extrinsic and intrinsic wing muscles assist in modulating wing orientation and controlling wing shape. These muscles probably contribute to adjustments of the wing's performance as an aerofoil and, thus, may indirectly affect flight power requirements. However, because of their small size, the intrinsic muscles of the wing probably contribute little additional mechanical power for flight.

An unexpected result is that shifts in body, tail and wing movement during take-off, level and landing flight of pigeons are achieved mainly by changes in whole-body pitch, rather than by changes in wing or tail motion relative to the body itself. The degree to which turning flight is achieved by left versus right asymmetries of smaller wing muscles, acting to 'steer' the bird around a turn, as opposed to modulation of the larger power-producing pectoralis and/or supracoracoideus muscles remains unclear. Evidence exists that both sets of muscles may contribute to the necessary aerodynamic asymmetries that result in a turning manoeuvre. The low moments of inertia and highly manoeuvrable bodies of birds mean that left versus right asymmetries in turning flight, or fore-aft asymmetries in aerodynamic force production during take-off and landing flight, are likely to be small and challenging to identify.

CONCLUSION

The present study significantly shows the how Pigeon make ready him on physiological and anatomical basis for mode and mechanism of flight. The aerodynamic and metabolic power requirements for flight are of considerable interest to avian and evolutionary ecologists interested in the strategies that birds use to forage and migrate to ensure a successful life history. For this reason, additional characteristic flight speeds and behaviour need to be linked to additional experimental assessments of flight energy metabolism and musculoskeletal function. While quasi-static aerodynamic models can provide a rough estimate of flight costs, the importance of non-steady aerodynamic effects on flight power costs is now well recognized and

cannot be ignored. Thus, additional modelling and experimental studies that seek to yield improved measurements of muscle function and aerodynamic power output are needed.

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