EVOLUTION OF FLIGHT IN BIRD AND BAT

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Our knowledge of the early history of flight in birds remains somewhat obscure on account of the paucity of fossil material available. The structure of the fossil birds Archaeopteryx and Archaeornis suggests that the early birds were arboreal and gliders. The modern birds are terrestrial to a great extent and therefore bipedal, and as such their ancestors were also most probably terrestrial and took to flight by taking off from the ground by flapping their wings. Again, the general organisation of the ratite birds suggests that they were an offshoot of the early ancestors of modern birds long before they took to active flight. Whatever may the steps by which flight in birds came into existence, the fact remains that since its onset, several deviations occurred which resulted in the various types of flight. Each of these has its morphological and physiological background. George and Nair (1952) dealt with the buoyancy index in several Indian birds. Nair (1952) has compared the chemical composition of flight muscles of a number of birds. Nair (1954) brought to light the morphological differences between the wing musculature of flapping and soaring birds. George and Menon (1954) showed that the domestic fowl has a physiological lag due to which it is unable to fly.

The present study has brought to light the convergence between bird and bat in morphological and physiological features, and it has also shed some light on the histo-physiological variations met with in the flight muscles in birds.

Morphological convergence in flight muscles of bird and bat:

The study of the pectoralis and other related muscles of the forelimb of bird and bat has shown that the pattern of the muscular components in the former is essentially reptilian and that in the latter mammalian with the following features of similarity as a case of adaptational convergence in evolution.

(1) In the bird and bat the deltoideus the chief abductor and elevator of the forelimb consists of three parts of which the first possesses attachments to the patagium as an adaptation for flight.

(2) The pectoralis major which is the most powerful adductor bringing about the down stroke of the forelimb is very well developed and defined in

both the bird as well as the bat though to a greater extent in the former.

(3) The subclavius of the bat and the sternocoracoideus of the bird are both well developed muscles. The former serves the function of keeping the clavicle which is the pivotal bone during flight in the bat while the latter keeps in place the coracoid which is in a similar position in the bird.

Histological convergence in the pectoral muscles of bird and bat:

Histologically also the pectoral muscles of bird and bat show considerable resemblance. Pectoralis muscle of the pigeon is composed of two types of fibres, a broad one and a narrow one. The former is non-fatty, whereas the latter is studded with globules of fat. The pectoral muscle of the bat is made up of only one type of fibre, the narrow fat-loaded one. The convergence in this case is in the possession of the narrow fat-loaded fibre with faint striations in the pectoral muscles of both these fliers. The convergence becomes more complete in certain birds for example the green bee-eater, Merops orientalis in which the pectoral muscle is composed entirely of narrow fibres as met with in the bat (George and Naik, unpublished,1956).

Physiological convergence in the pectoral muscle of bird and bat:

Physiologically too, the pectoral muscles of birds and bats are similar. The most obvious resemblance is in the large amount of fat met with in the muscles. This fat occurs in the form of globules within the muscle fibre and is derived from the adipose connective tissue met with around the fibre. Another feature is the presence of myoglobin, the ready supplier of oxygen in the muscle, due to which the muscle gets a faint red tinge. The presence of fat and myoglobin side by side in the muscle tissue is symptomatic of the utilization of fat in flight. This has been shown to occur by stimulating the muscle.

Evolution of histo-physiological features in pectoral muscles:

It has been shown earlier that the fibres in the pectoralis of the fowl are composed entirely of the broad type without the fat cushion around the fibres. Moreover, the muscle is also devoid of myoglobin.

The breast muscle of the lizard calotes is also made up of the large type of fibres. The leg muscle of both bird and bat is also composed exclusively of the large fibres. The large fibres isolated from the pigeon breast muscle were found to contain five times the amount of glycogen present in the small ones(George and Naik, unpuplished, 1956). This confirms the suspicion that the large fibres are glycogen loaded. The fat-loaded narrow fibre is to be regarded as a type which has evolved from the generalised broad one.

The breast muscle of the kite is also composed of the broad type of fibres. This shows that fat is of importance in sustained flight, but not in soaring. The physiology of the soaring bird therefore rests on a different footing from that of the flapping one. The expenditure of energy involved in soaring is relatively less than in flapping flight.

The breast muscle of the pigeon consists of two types of fibres, but the narrow one is more in number, being about 16 times the number of the broad one. This is evidently an advance over the kite and fowl, an advance necessitated by the long distance flight a pigeon should perform. The bat and the bee-eater Merops represents the extreme type of histo-physiological muscle fibre evolution in possessing only the fat-loaded narrow one.

The rates of oxygen consumption and carbondioxide output in the pigeon and bat breast muscle fibres were found to be higher than that of the domestic fowl muscle fibres which also indicates that the breast muscles of the pigeon and the bat are metabolically more evolved than that of the fowl.

General Considerations:

Zoologists are not happy about the classification of birds, since well-defined orders can not easily be discerned in this otherwise large class. This has been tersely expressed by Rand in the following words. " Any attempt to split up the major subdivisions of Aves atonce compels recognition of some twenty or more living groups most of which can be defined only on the basis of peculiarities which seem trivial as compared to those which separate for example Urodela and Anura or Ophidia and Chelonia. These subdivisions of Aves are somewhat unfairly given the dignity of 'orders' , but it is obvious that in the general scale of classification they stand more nearly at the level of the 'families' in other classes". The occurrence of well-defined groups in the lower vertebrates has been due to the extinction of large numbers of allied groups. The birds as the most successful aerial group has not been threatened by any other group in their domain. The competition from bats and other flying animals has been extremely little. So, whole-sale extinction of forms has not occurred among birds, and so much of over-lapping occurs. Evolution in birds has not had its tortuous history of competition as yet. But if one appreciates the quantum of differences, structural, functional and ecological, between the avian orders, within the common aerial habitat, bird evolution also seems to have had its fascinating story.

The ratite birds which perhaps never flew and gallinaceous birds which are more terrestrial than aerial are really distinct evolutionary trends. The soaring birds such as the kite again stand distinctly apart. The presence of exclusively broad type of glycogen-loaded fibres in the pectoral muscles of both the gallinaceous and the soaring birds, show the affinity which exists between them, and also their primitiveness.

The amount of myoglobin in the pectoral muscle of birds has not been extensively investigated (Lawrie, 1952). The variations with regard to the muscle fibres has not also been investigated. As a matter of fact, the variations of the striated muscle fibre which has evolved perhaps independently in arthropods and vertebrates have not been properly studied and their significance not accurately understood. Recently Glenn Richards (1955) has shown that the flight muscle fibres of an insect viz.,the giant water bug are narrow ones in contrast to the ones in the leg. These fibres are similar to the fat-loaded, narrow ones of birds. The same must be true of the flight muscles of locusts. Once such studies has been done, characters which appear trivial in birds might find their roots deep in biochemical and physiological make-ups with far more importance than are apparent on the surface.