

S U M M A R Y

SUMMARY

Birds and bats are both flying animals whose remote ancestry could be traced to the reptiles. In the evolution of the flying habit there have been certain basic changes in the morphologic and physiologic constitution of these animals. The present study on certain aspects of the morphology, histology and metabolism of the flight muscles of some birds and a bat has brought forward the following salient facts which have contributed atleast in a small measure to our present knowledge of the physiological aspects of flight and the convergence in the evolution of these animals.

1. Morphology of the pectoralis and other related forelimb muscles in lizards, birds and bat.

- (1) Though the bird and bat both have arisen from reptilian ancestors and several of their flight muscles show similar orientation, the majority of them in the bat present typical mammalian characteristics while many of the muscles in the bird are basically reptilian with a few avian modifications.

- (2) The presence in the bat of the patagial attachments of the deltoideus clavicularis as in the bird, a well-developed subclavius very similar to the sternocoracoideus of birds and the well-developed set of pectoralis muscles are all avian features as adaptations for flight. But on the other hand the presence of a powerful and well-developed latissimus dorsi with teres major, a single subscapularis and separate supraspinatus and infraspinatus muscles and a poorly developed anconeus are distinctly mammalian.
- (3) In the bird the fusion of the biceps, the presence of two coracobrachialis and the sternocoracoideus and the unparalleled development of the pectoralis set of muscles are special features in birds.
- (4) It is evident that each of these types of flying animals has evolved along its own lines and the modifications of the muscles show two such divergent lines of evolution.
- (5) There is hardly any difference in the musculature between Uromastix, the ground lizard and Calotes, the arboreal form.

2. Comparative histology of the breast and leg muscles in lizard, bird and bat.

- (1) Histologically the breast muscle of the pigeon is made up of two types of fibres, a narrow one studded with large globules of fat, and granules of lipo-protein nature, and a broad one with the inclusions very sparsely distributed and the fat globules minute. the former type is much more numerous than the latter.
- (2) the breast muscle of the local kite is ~~also~~ made up of only the broad type of fibres.
- (3) the narrow fat-loaded type of fibre is totally lacking in the breast muscle of the domestic fowl.
- (4) the breast muscle of the common local bat is exclusively made up of the narrow type of fibre. the inclusions of fat are, however, much more prominent in this animal.
- (5) the leg muscle fibres in all these animals are of the broad less-fatty type. the leg muscle of the fowl is reddish and the striations are prominent.
- (6) the fat-loaded fibres of the breast muscle lose fat globules gradually on stimulation apparently due to their utilization in contraction. the

breast muscle of the starved pigeons is also found to be depleted of their fat globules. Most probably they have been used up to maintain life during starvation. It is therefore concluded that fat inclusions are primarily useful during flight and serve secondarily as reserve store to maintain life during starvation.

- (7) In the evolution of the muscle fibre, the emergence of the myoglobin-permeated more metabolic red type seems to be the first step. The next step is the appearance of the fat-loaded narrow type as a variation from the broad less-fatty red fibre.

3. The lipid and the glycogen content and their reduction in the flight muscle and liver of some birds and bat during sustained activity of the former.

- (1) There is a reduction in the free lipid of the breast and leg muscle as well as of the liver as a result of continuous ^cexcitation of the respective muscle in all the animals experimented with.
- (2) In the case of the fowl alone there is any indication of utilization of bound lipid both in the breast and leg muscle as a result of continued ^cexcitation.

- (3) The high percentage of lipids in the leg muscle of the domestic fowl indicates that it is an animal adapted for vigorous use of its legs.
- (4) The reduction in liver fat as a result of prolonged stimulation of the breast muscle suggests the transport of fat from liver to the flight muscle. It means that the liver serves as depot for fat to be utilized in any emergency. Since muscle and liver both contain glycogen and fat as reserve fuel, they are complementary tissues.
- (5) Since the breast muscle of the kite gets fatigued sooner than that of the other animals experimented with, it appears to be unsuited for sustained flapping flight. The soaring habit of the kite reflects this.
- (6) The glycogen content of the pectoral muscle of the kite is more than that of the fowl, pigeon and bat separately and nearly as much as that of the pigeon and bat put together, while the glycogen content of the liver is more or less the same in all the four animals.
- (7) It is seen that most of the energy utilized in sustained muscular activity is obtained from fat while only a fraction of it from glycogen.
- (8) It is noted in the pigeon that after forced flight

about 77 % of the total energy expended was obtained from fat and about 78 % after both forced flight and electrical stimulation.

- (9) It is concluded that fat is the chief fuel for long and sustained muscular activity in birds and bats.

4. The oxygen uptake and the carbondioxide output of the pectoral muscle fibres of fowl, pigeon and bat.

The oxygen uptake and carbondioxide output of the pectoral muscle fibres of the fowl, pigeon and bat were estimated by the standard Warburg manometric technique. It was observed that the rate of oxygen consumption was lowest in the fowl muscle fibres and highest in the pigeon muscle fibres while that of the bat fibres was intermediate between the two. As regards the carbondioxide output, bat showed the highest and the pigeon next. The Respiratory Quotient of the fowl and the pigeon muscle fibres were more or less 1 while that of the bat was as high as 2.6 thereby denoting a tremendous amount of anaerobic respiration in the bat muscle fibres.

5. Evolution of flight in bird and bat.

The present study has indicated a morphological,

histological and physiological convergence in the pectoral muscles of the bird and bat and its significance in the evolution of flight in these animals. This aspect is discussed.