CHAPTER 6

HISTOCHEMICAL DEMONSTRATION OF CERTAIN OXIDIZING ENZYMES IN THE PECTORALIS MAJOR MUSCLE OF THE ROSY PASTOR (PASTOR ROSEUS), GOOSE (ANSER ALBIFRONS) AND FOWL (GALLUS DOMESTICUS)

Recently some histochemical studies on the localization and distribution pattern of certain dehydrogenases and a lipase in the pectoralis major muscle of a few birds (George and Scaria, 1958a and 1958b) and a bat (George, Susheela and Scaria, 1958a) have been reported. In a quantitative study of succinic dehydrogenase in the breast muscles of a few representative types of birds, the highest enzyme activity was found in the muscle of rosy pastor and lowest in the domestic fowl (Chapter 7). The present histochemical study to demonstrate the localization and distribution pattern of certain oxidizing enzymes such as cytochrome oxidase , succinic, malic, lactic, a-glycerophosphate, D-glucose and glutamic dehydrogenases in the pectoralis major muscle of three birds, the rosy pastor, the goose and the fowl which show marked differences in their mode of flight, body weight, and some important histophysiological features of their breast muscles, was undertaken as an attempt to correlate structure with function.

Material and Methods

Fresh frozen sections of the pectoralis major muscles of the rosy pastor, goose and the fowl were used. Succinic dehydrogenase and cytochrome oxidase were demonstrated histochemically by the method already described (Chapter 2) and

the various DPN-linked dehydrogenases were demonstrated using NT as the hydrogen acceptor by the method adopted (Chapter 5).

Results and Discussion

The sections of the rosy pastor muscle (Figs. 1-2) incubated for the various oxidizing enzymes were stained rapidly to give an intense colour whereas the reactions in the sections of the goose muscle (Fig. 3) were considerably slow and those of the fowl muscle took the maximum time for colour development (Figs. 4 and 5). The localization and distribution

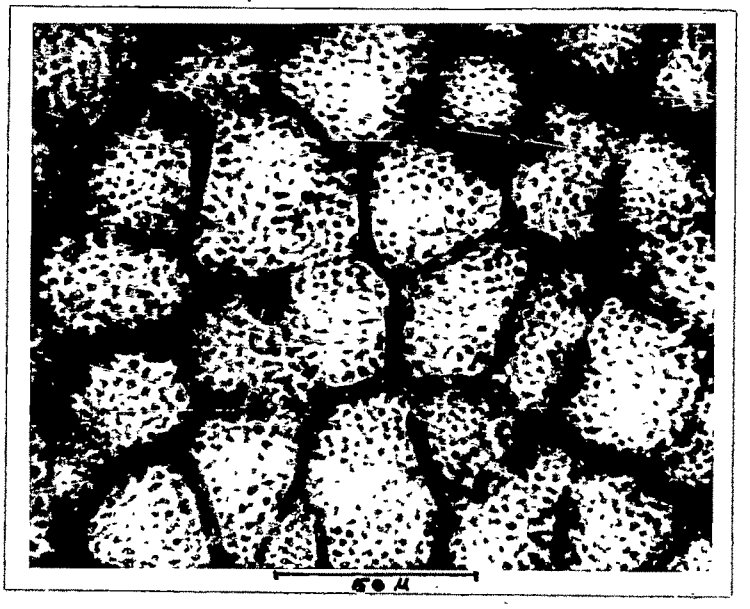

Fig. 1. Microphotograph of the transverse section of the pectoralis major muscle of rosy pastor showing the localization and distribution pattern of succinic dehydrogenase. Incubation period 10 minutes.

pattern of the various oxidizing enzymes was revealed by the presence of indophenol blue and the diformazan granules arranged in a definite pattern, representing the sites of mitochondria as was seen in the pigeon pectoralis (Chapter 2).

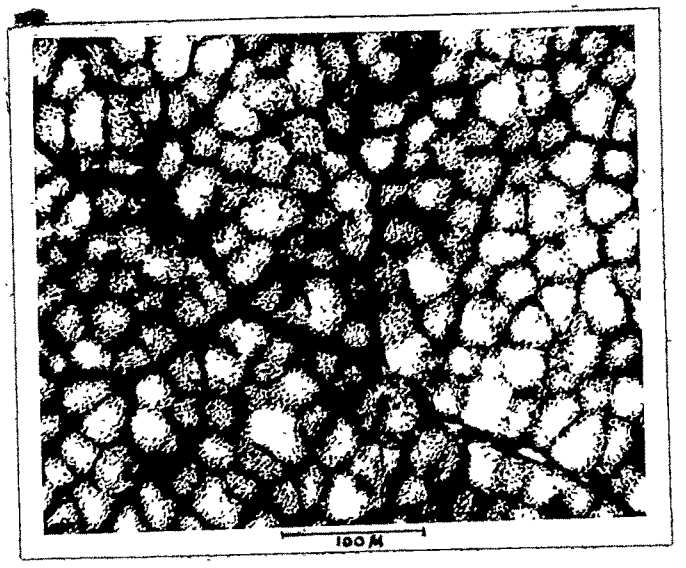

Fig. 2. Microphotograph of the transverse section of the pectoralis major muscle of rosy pastor showing the localization and distribution pattern of cytochrome oxidase. Incubation period 5 minutes.

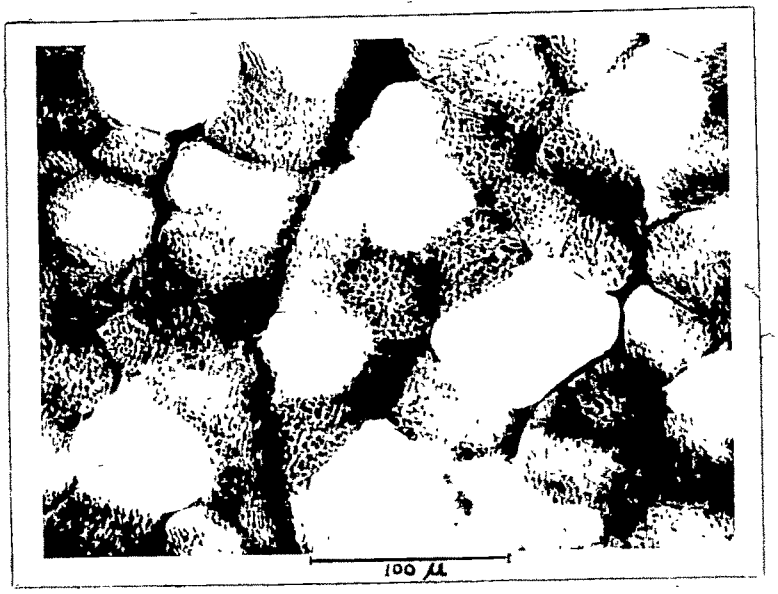

Fig. 3. Microphotograph of the transverse section of the pectoralis major muscle of goose showing the localization and distribution pattern of succinic dehydrogenase. Incubation period 30 minutes.

From these histochemical observations it is clear that the muscle of the rosy pastor which is a migratory bird, shows

as should be expected, a very high concentration of these enzymes in comparison with the goose and fowl muscles. The goose muscle showed a higher concentration of these enzymes than that in the fowl muscle.

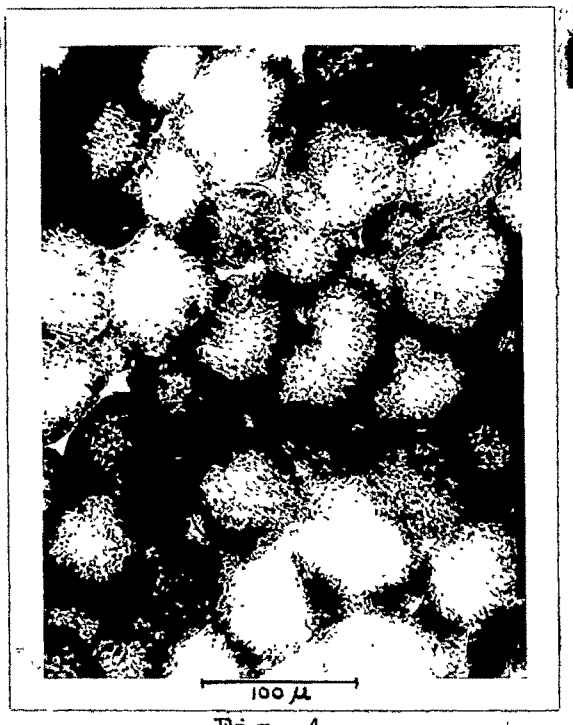

Fig. 4

Fig. 5

Figs. 4 and 5. Microphotographs of the transverse section of the pectoralis major muscle of the fowl showing the localization and distribution pattern of succinic dehydrogenase and cytochrome oxidase respectively. Incubation period for succinic dehydrogenase 2 hours and for cytochrome oxidase nearly 15 minutes.

Paul and Sperling (1952) in a study of the correlation of 'cyclophorase' activity and mitochondrial density in striated muscle showed few or no mitochondria in the breast muscle of the fowl. The electron microscope photographs of this muscle (Bennett and Porter, 1953), however, do show some 'sarcosomes' quite clearly. The presence of the diformazan and indophenol

blue granules, in the breast muscle of the fowl, in the present histochemical preparations for the various oxidizing enzymes indicate the occurrence and the sites of mitochondria in this muscle. It should be emphasized however, that these granules are far fewer in number as compared to those in the rosy pastor and goose muscles. These findings suggest a higher mitochondrial content in the rosy pastor muscle as compared to that of the other two birds.

For a definite correlation of these differences in the enzyme concentrations, with the nature of the muscle action in these birds, it is essential to know in detail their modes of flight and the structure of the muscle, in which respects these birds vary markedly. The rosy pastor is a flapping flier indulging in prolonged flight and its breast muscle is composed entirely of the narrow red type of fibres with an average diameter of 30 - 34 μ. The goose though a very poor flier, has its pectoralis consisting predominantly of the narrow red fibres with an average diameter of 40 - 45 μ and comparatively few white fibres as those of the pigeon breast muscle. The fowl is practically a non-flier and its breast muscle consists of light fibres with large diameter (64 μ) though there is a great variation in the diameter of the fibres (George and Naik, 1957a, 1959b and 1959c). Besides these differences these three birds show a marked difference in their body weight as well as the weight of their breast muscles.

It is well known that these muscles indulging in prolonged and rhythmical activity usually have numerous granules

in their fibres whereas the quick contracting light muscles functioning for a short duration, are relatively poor in these granules. Hence the oxidative capacity of a tissue or a muscle may be in part determined by the density of the granular inclusions of which the mitochondrial part is most important. Apart from these features, a reduction in the amount of SDH with increase in the fibre diameter has been noted in the mixed muscles of the rat (Nachmias and Padykula, 1958), the bat (George, Susheela and Scaria, 1958a) and certain muscles of reptiles (Shah, Unpublished).

In the light of these observations it seems clear that the fowl pectoralis, which is little used, shows an extremely low mitochondrial content and hence a very low oxidative metabolism too, in sharp contrast to the rosy pastor muscle, composed entirely of the narrow red fibres which are studded with mitochondria. The fibre composition of the breast muscle of the goose which is a poor flier needs to be explained. The goose though not a good flier ~~but~~ belongs to an order of birds, Anseriformes, which includes several species of good fliers unlike the Galliformes to which the domestic fowl belongs. So this characteristic of the breast muscle of the goose is more a matter of heredity and this feature is preserved due to its powerful wing beats in flight as well as in running on water and swimming. Finally considering the distribution pattern of the various enzymes in the pectoralis major muscles of the birds studied, it is evident that a correlation

between structure and function could be derived in terms of the fibre architecture, cell inclusions, fibre diameter and the enzyme systems in the muscle, against the nature and mode of flight.