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Dept. of Anatomy,
Fac. Vet. Med., South Valley University.

MORPHOLOGICAL AND MORPHOMETRICAL STUDIES ON THE PECTORAL MUSCLE IN FOWL, DUCK AND PIGEON

(With 1 Table & 11 Figures)

By

SALMA A. MOHAMED

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دراسات مورفولوجية وقياسية على العضلة الصدرية في الدجاج والبط والحمام

سلمى أحمد محمد

أجرى هذا البحث على إثنى عشر طائر بالغ من كل من الدجاج والبط والحمام. وقد تم وصف الصفات التشريحية للعضلة الصدرية (الجزء الصدري) وتحديد وزنها وطولها وسمكها بالإضافة إلى تحديد مساحة المقطع العرضي للحزم والألياف العضلية في الطيور المختلفة. أوضحت الدراسة أن سمك العضلة الصدرية ونسبة وزنها إلى وزن الجسم وكذلك نسبة طول الرافدة القصية وطول عظمة الترقوة إلى طول العضلة قد سجلت أعلى قيمة لها في الحمام يليه البط ثم الدجاج. وفقاً لمساحة المقطع العرضي للألياف العضلية بينت الدراسة أن العضلة الصدرية تتكون معظمها من نوع واحد في الدجاج ، بينما تتكون في البط والحمام من نوعين من الألياف أحدهما صغير والآخر كبير. مساحة المقطع العرضي للألياف الكبيرة تساوى أربع مرات ونصف الألياف الصغيرة في الحمام بينما فى البط فإن مساحة الألياف الكبيرة تساوى مرتين ونصف الألياف الصغيرة.

SUMMARY

This work was carried out on twelve adult birds of each of fowl duck and pigeon. The morphological features of the pectoral muscle (Pars thoracis) were described. In addition the weight, length and thickness of this muscle were also recorded. The cross-sectional area (CSA) of the muscle bundles and muscle fibers were measured. The thickness of the pectoral muscle and the percentage of its weight to that of the body weight, as well as the percentage of the length of the sternal carina and the furcula to the length of

the pectoral muscle show the highest value in the pigeon (flying bird), followed by duck (swimming bird) then the fowl (walking bird). According to the CSA of the muscle fiber, the pectoral muscle of fowl consists almost entirely of one type of muscle fiber, while that of the duck and pigeon consists of two types; small and large. The CSA of the large muscle fiber in pigeon has generally four and half folds that of small fiber, while in duck the former fiber is two folds that of the latter one.

INTRODUCTION

In the recent years there has been a growing use of the poultry meat as replacers of animal meat or in addition to it. The pectoral muscle forms an important article of human diet among the other parts of the birds. The pectoral muscle is routinely palpated for an indication of general health of the bird, in addition it is also used for intramuscular injection. The lack of further studies of the pectoral muscle on the fowl, duck and pigeon necessitates carrying out of the present investigation. Moreover, this work will serve as a usefull reference for comparative study in the different examined species of birds.

MATERIAL and METHODS

This study was carried out on twelve adult healthy birds from each of fowl (Gallus domesticus), duck (Anas domesticus) and pigeon (Columbia domestica). The birds were weighened, then dissected in fresh state for macroscopical examination. For light microscopical investigation pieces from the middle of the pectoral muscle (Pars thoracis) were taken, fixed in 10% neutral formalin, processed for paraffin embedding, sectioned (5 µm) and stained with H & E and PAS stains.

For semithin sectioning, small samples were taken and fixed in formaldehyde - glutaraldehyde fixative (Karnovsky, 1965). Then the samples were transfered to 0.1 M phosphate buffer and put in refregrator. Successive changes using 0.1 M buffer were applied before samples were osmicated in 1% osmium tetraoxide. The samples were dehydrated in ethanol and embedded in ERL (Spurr, 1969). Semithin sections were cut and stained with Methyelne blue - azur II (Richardson et al., 1960).

The morphometrical study was carried out using Quantiment Q 500 MC processing and analysis system (Leica).

The present work has been focused on the major muscle mass of the pectoral muscle which is described as Pars thoracis (Baumel et al., 1979). While the other two small parts (Pars propatagialis and Pars abdominalis) are only slips extending from the pectoral muscle (Vanden Berge, 1975), consequently these parts are not included in this study.

RESULTS

Macroscopical observations:

The pectoral muscle covers the outer surface of the sternum (Fig. 1, 2, 3, 4), inturn the ventrolateral aspect of the body. It is covered by skin and is related medially to the M. supracoracoideus, sternum, coracoid, clavicle and ribs, as well as the sternocostal, interosseous and sternocoracoclavicular membranes. In addition the craniodorsal portion of the muscle is related also medially to the pectoral trunk and its branches, pectoral vein and nerves.

The shape of the pectoral muscle (Fig. 1, 2, 3) correlates with that of the sternum, it is nearly triangular in fowl, rectangular in duck and heart-shaped in pigeon. Its colour differs in the different examined birds, it is white red in fowl, red in duck and deep red in pigeon. The fibers of the pectoral muscle are directed craniodorsally.

The pectoral muscle originates from the ventrolateral part of the carina along its whole length (Fig. 4), and from the lateral aspects of the caudolateral process in all studied species, in addition to the thoracic process in fowl and pigeon. It attaches also to the sternal ribs, the sternocostal membrane and to the interosseous membrane closing the Incisura ovale in the fowl as well as duck, and the Foramen ovale in pigeon.

Cranially, the pectoral muscle is attached to the ramus and hypocleidium of the furcula, hypocleidial ligament and the sternocoracoclavicular membrane. Caudally, it is attached to the caudal boundary of the carina in fowl and pigeon. While in duck it extends somewhat caudally to be attached to the ventral aspect and the caudal margin of the xiphoid cartilage. In all birds the pectoral

muscles of both sides are separated by the ventral free edge of the carina.

The shape of the caudal attachment of the pectoral muscle correlates with the shape of the caudal free end of the sternum or xiphoid cartilage, it is somewhat pointed in fowl, large and straight in duck, small and curved in pigeon (Fig. 4).

The pectoral muscle inserts on the pectoral crest of the humerus and extends to the dorsal tuberosity. The absolute length of the line of insertion of the muscle differs in the various examined birds, it is 1.5 cm in fowl, 2.7 cm in duck and 1.1. cm in pigeon. In spite of this difference, the percentage of the length of the line of insertion of the pectoral muscle to the total length of the humerus is nearly equal (22.3% - 23.4%) in the different birds.

Concerning the measurements of the pectoral muscle and its relations with some neighbouring structures (Table 1), it is demonstrated that the thickness of the pectoral muscle is 1.1 cm in fowl, 1.4 cm in duck and 1.5 cm in pigeon. The percentage of the weight of the pectoral muscle to that of the body weight is 11.45% in fowl, 10.17% in duck and 16.73% in pigeon (Fig. 10).

Table 1: Shows the different measurements of the pectoral muscle (Pars thoracis) and associated structures in fowl, duck and pigeon. Length and thickness (cm), weight (gm) and cross-sectional area (μm^2).

	Fowl	Duck	Pigeon
- Total body weight	1450	2340	490
- Weight of pectoral muscles	166	238	82
- Percentage of weight of muscle to that of bird	11.45	10.17	16.73
- Length of pectoral muscle	15.4	17.6	9.8
- Length of sternal carina	9.0	12.5	7.4
- Percentage of length of carina to that of muscle	58.4	71.0	75.5
- Length of line of insertion.	1.5	2.7	1.1
- Length of humerus			
- Percentage of length of line of insertion to that of humerus	6.6 22.7	12.1 22.3	4.7 23.4
- Length of furcula	9.3	11.0	7.5
- Percentage of length of furcula to that of pectoral muscle	60.4	62.5	76.5
- Thickness of pectoral muscle	1.1	1.4	1.5
- Cross-sectional area of muscle bundle	193832.18	247379.50	266758.62
- Cross-sectional area of muscle fiber			
Small type	1711.65	491.23	398.38
Large type		959.46	1836.71

The percentage of the length of the carina to that of the muscle is 58.4% in fowl, 71.0% in duck and 75.5% in pigeon. The percentage of the length of the furcula to that of the pectoral muscle is 60.4% in fowl, 62.5% in duck and 76.5% in pigeon.

Microscopical observations:

The pectoral muscle bundles are separated from each other by spaces containing connective tissue, blood vessels and nerves. These spaces are generally wide in fowl and narrow in duck and pigeon, but they are relatively narrower in the pigeon than in the duck. This explains that the pectoral muscle is more compact in pigeon and duck than in fowl. The cross-sectional area (CSA) of the muscle bundle (Table 1) is the highest in pigeon followed by duck then the fowl.

The muscle fibers of the pectoral muscle in duck and pigeon are surrounded by numbers of blood capillaries (Fig. 5, 6). But the number of the capillaries is relatively more in duck than in pigeon. In case of fowl these capillaries are poorly developed. This indicates that the pectoral muscle in duck and pigeon has richer vascularity than that of the fowl.

According to the CSA of the pectoral muscle fibers, the fowl contains almost entirely large muscle fibers (Fig. 7). The CSA of the muscle fiber is 1711.65 μm^2. In duck, small and large muscle fibers can be recognizable (Fig. 8). The small fibers are predominant, the CSA of the fiber is 491.23 μm^2. However, the large fiber are few in number and distribute between the small fibers. The CSA of the large fiber is 959.46 μm^2. It is clear that, the size of large fiber is double that of the small one (Fig. 11).

In pigeon, small and large fibers were also demonstrated (Fig. 9), but they are easily distinguished due to the great difference in the size between the two muscle fibers (Fig. 11). Where the CSA of small fiber is 398.38 μm^2 and that of the large fiber is 1836.71 μm^2. The small fibers are predominant and lightly stained, while the considerable large fibers are few in number, deeply stained and located mainly at the peripherey of the muscle bundle.

DISCUSSION

The present work shows that the shape of the pectoral muscle (Pars thoracis) correlates with that of the sternum. Similar result was obtained by Nickel et al. (1977). Roberts (1976) stated that the sternum of birds is greatly expanded and has a deep keel to increase its surface area in order to accommodate the two very large muscles (pectoral and supracoracoid). In this respect, King and Mclelland (1984) reported that in some birds the size of the keel appears to be correlated with the size of the pectoral muscle, they added that in a number of groups like ducks no correlation exists. On the other hand, the present findings indicate a correlation between the length of the sternal carina and that of the pectoral muscle in all examined birds including duck. Where the percentage of the length of the carina to that of the pectoral muscle is the highest in pigeon (flying bird), followed by duck (swimming bird) then the fowl (walking bird).

According to this study the colour of the pectoral muscle is white red in fowl, red in duck and deep red in pigeon. Reece (1997) described the stark white pectoralis muscle in chicken and crimson red muscle in pigeon. The red muscle fibers are the less irritable, give a slower but greater contraction, and can maintain contraction for a longer period than can the white fibers (Karporich, 1959). The red colour is due to an abundance of muscle pigment, myoglobin, and less glycogen and an increase in mitochondria (Telford and Bridgman, 1995). The degree of redness of muscle fibers is due essentially to the content of the myoglobin within the fibers and not to the complexity of the blood supply (Krompecher et al., 1970). The observed deeper red colour in the pectoral muscle of the examined pigeon than in duck; in spite of the number of capillaries surround the muscle fiber in the latter bird is relatively more than in the former one, may be due to the different content of the myoglobin. Petren et al. (1936) mentioned that in guinea pig the exercise may increase the number of capillaries in muscles 40-50 per cent as compared with the sedentary animals. Their suggestion was that, in training, the bulk of muscle increases because of the increase in the number of capillaries. Rivero et al. (1993) recorded that the number of

capillaries in contact with the fibers increased significantly with increasing the samplying depth in the gluteus medius of horse.

The pectoral muscle inserts in the pectoral crest of the humerus as shown in the examined species and described by King and Mclelland (1984), or in the lateral surface of the head of the humerus as recorded by Michael (1983), or in the crest of the lateral tuberosity as stated by Nickel et al. (1977), or in the deltoid crest as reported by Vanden Berge (1975). The latter crest is synonymy to the pectoral crest as mentioned by Baumel et al. (1979). In addition, the present work indicates that the pectoral muscle extends to be attached to the dorsal tuberosity of the humerus. In the different examined birds the percentage of the length of the line of insertion of the pectoral muscle to the total length of the humerus is small and nearly equal (22.3% - 23.4%). Although this strong muscle has a relatively small area of attachment on the humerus the insertion is able to withstand a considerable force (Michael, 1983).

In birds generally the pectoral muscle forms about 15% of the total body weight but in some species with high wing loading for their size it constitutes 21% (King and Mclelland, 1984). In pigeon it forms 25% of body weight (Marshall and Hughes, 1980). The present investigation indicates also that the pectoral muscle of the pigeon consitutes the highest percentage (16.73%) of body weight, followed by fowl (11.45%) then duck (10.17%).

The present findings reveal that the percentage of the length of the furcula to that of the pectoral muscle reaches its highest value in flying bird (76.5%), while the walking bird has the lowest value (60.4%). It is clear that the flying bird which has a powerful furcula as recorded by Moawd (1988), has also the highest percentage of the length of furcula to that of pectoral muscle as demonstrated in the present study. In this connection, King and Mclelland (1984) stated that the relatively large size of the furcula in Archaeoptrex compared to that in modern birds suggests that in this species the pectoral muscle was also well developed and that powered flight was possible.

Corresponding to the cross-sectional area of the muscle fibers, the present work shows that the pectoral muscle of fowl consists almost entirely of large muscle fibers (1711.65 μm^2). NacNaughton (1974) demonstrated also one type of muscle fiber in

pectoral muscle of this bird histochemically. Sams and Janky (1990) reported that this muscle is composed almost entirely of fast, white anaerobic fibers. In the examined duck two types of muscle fibers can be demonstrated, the large fiber (959.46 μm^2) is nearly double in size that of the small fiber (491.23 μm^2). In the investigated pigeon two types can be also easily distinguished, the large fiber (1836.71 μm^2) is four and half folds that of the small fiber (398.38 μm^2). Moreover, the large fibers of pigeon are larger than the muscle fibers of both fowl and duck. In this respect, Banks (1992) reported that the red muscle consists predominantly of type I muscle fibers which are small cells, and the white muscle consists of type II fibers which are large cells. It is concluded that in the birds which depend upon their pectoral muscle during locomotion as flying bird (pigeon) and swimming bird (duck) two types of the muscle fibers can be distinguished. In the flying bird which uses the pectoral muscle more than the swimming bird the large muscle fibers have greater cross-sectional area. On the other hand, the walking bird (fowl) has almost entirely of one type of muscle fibers, this may be due to that the fowl depends upon pelvic limb more than pectoral muscle during locomotion.

LEGENDS

Fig. (1,2,3): Photographs of the lateral aspect of the pectoral muscle (Pars thoracis) in fowl (1), duck (2) and pigeon (3). Pectoral muscle (M).

Fig. (4): Photograph of the ventral aspect of the pectoral muscle (Pars thoracis) in fowl (left), duck (middle) and pigeon (right).

Fig. (5,6): Paraffin section of the pectoral muscle in duck (5) and pigeon (6) showing blood capillaries around the muscle fiber. Haematoxyline and eosin. X 250.

Fig. (7): Semithin section of the pectoral muscle in fowl showing the muscle fibers. Methylene blue-azur II stain. X 400.

Fig. (8,9): Semithin section of the pectoral muscle in duck (8) and pigeon (9) showing the large (L) and small (S) muscle fibers.

Fig. (10): Histogram showing the relation between the total body weight and the weight of the pectoral muscle in the examined birds.

Fig. (11): Histogram showing the size of the cross-sectional area (CSA) of the muscle fibers in the examined birds.

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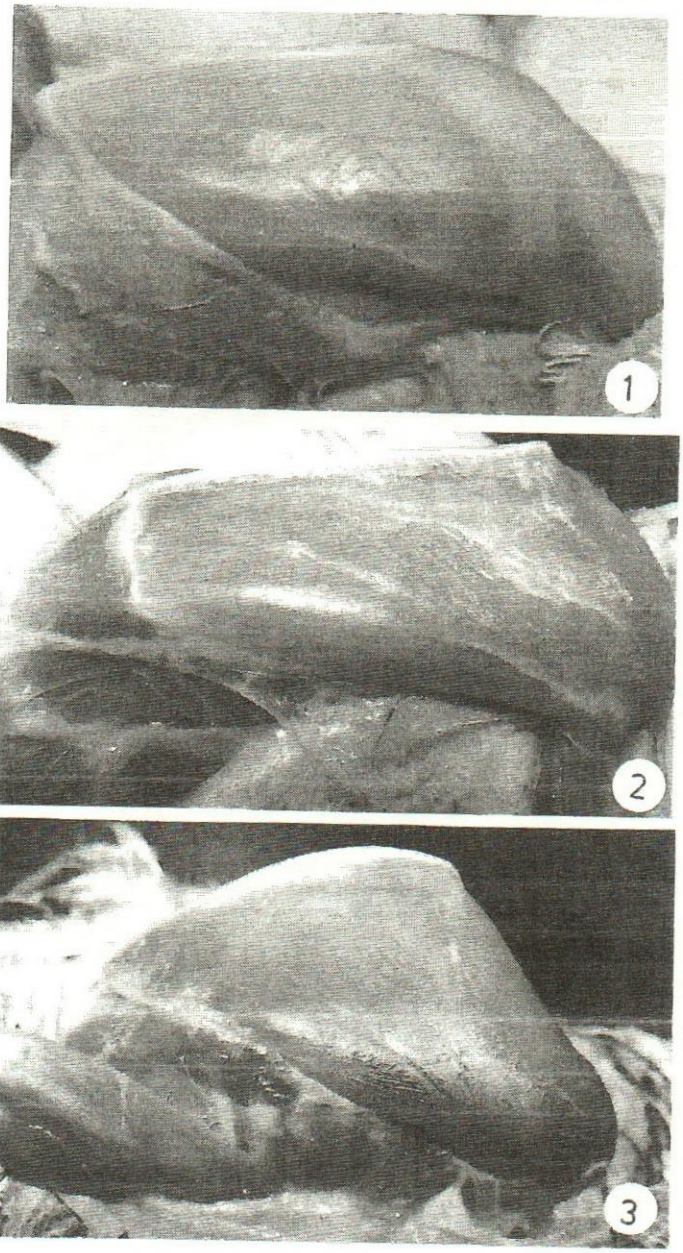
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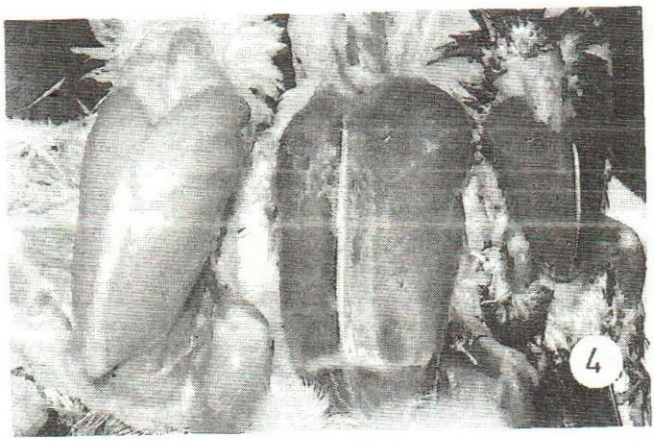
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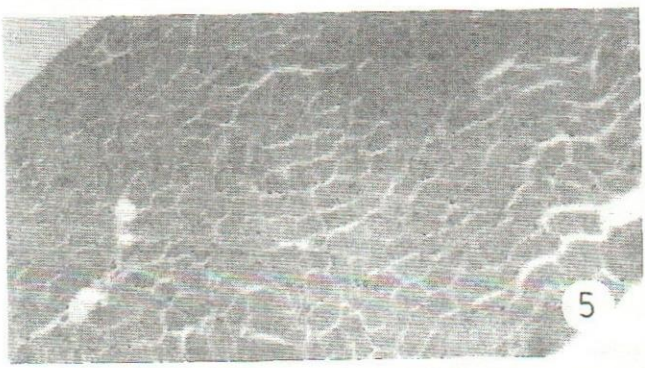
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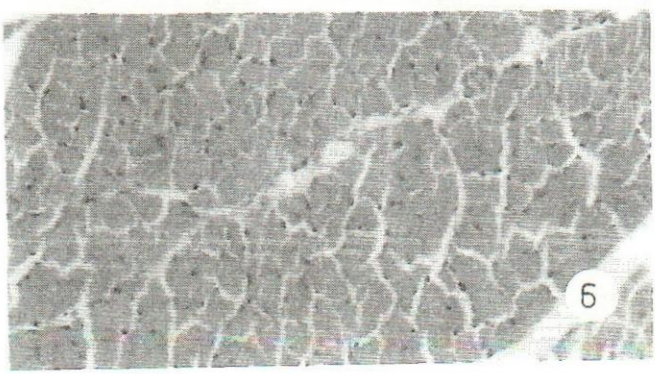
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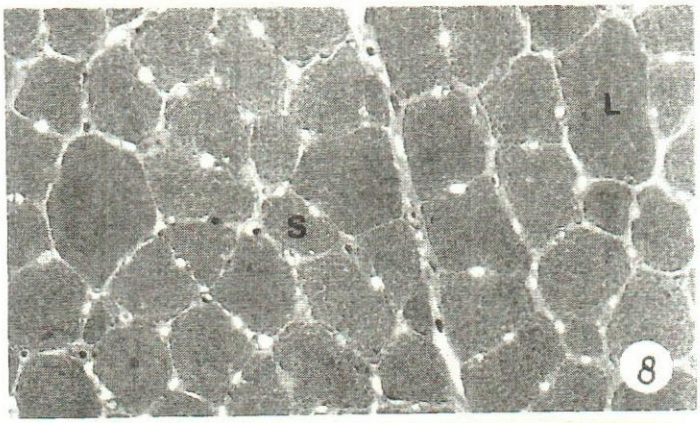

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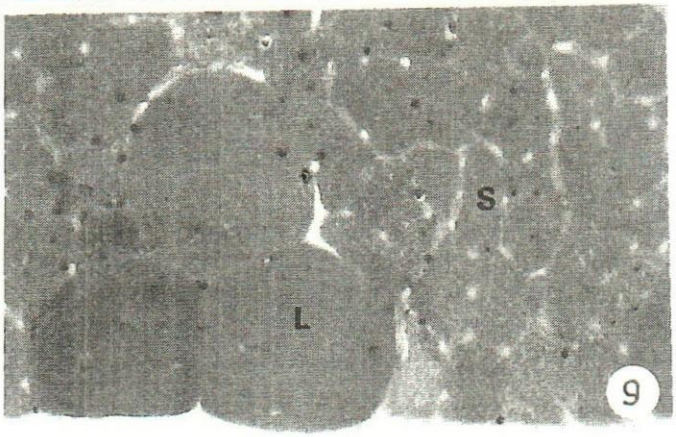

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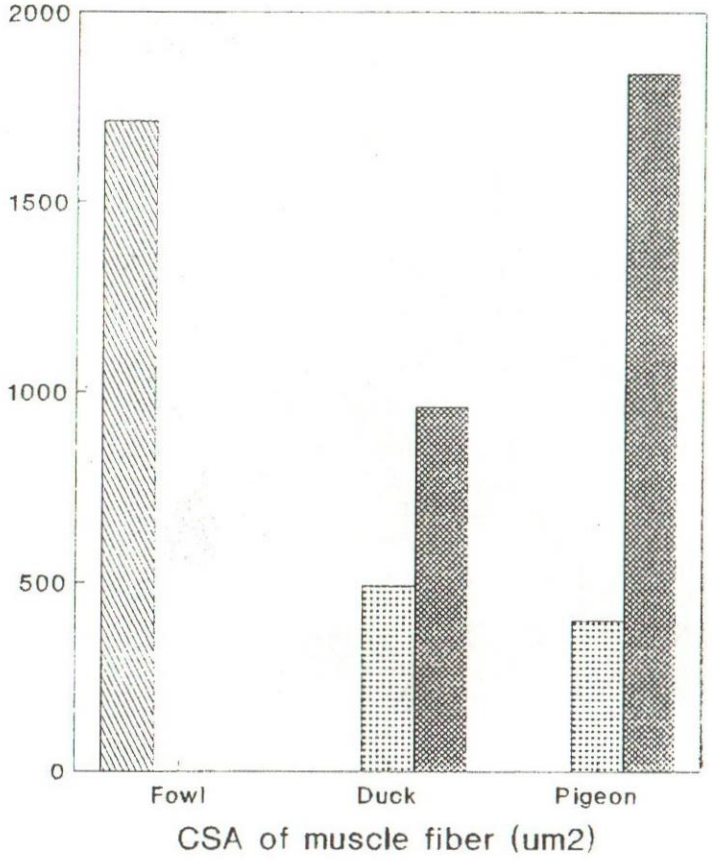
Fig. (11)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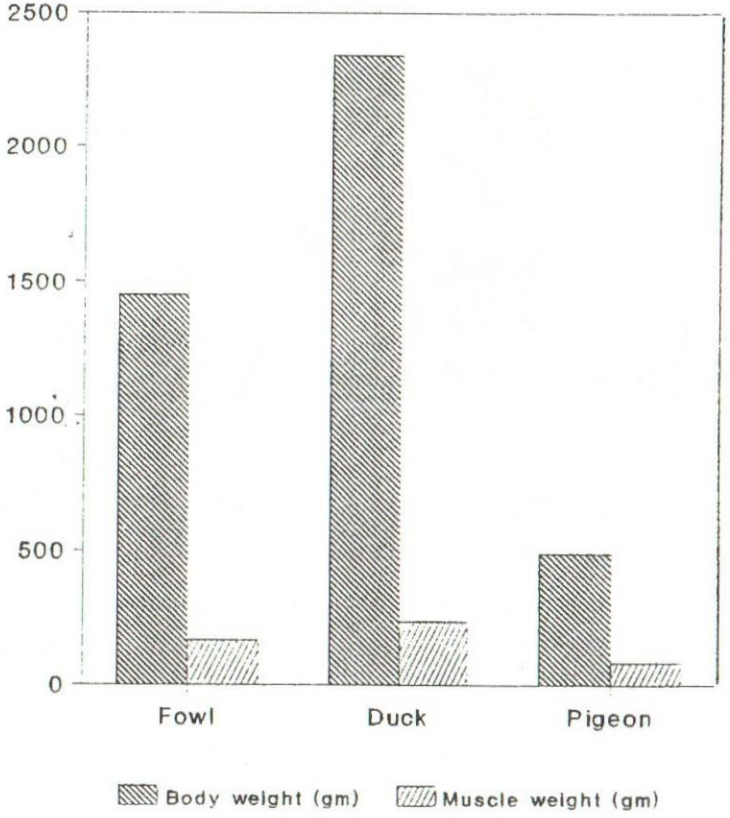
Fowl
Duck
Pigeon
CSA of muscle fiber (um2)

Fig. (10)


2500
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Fowl
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Body weight (gm)
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