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A COMPARATIVE MORPHOMETRIC STUDY ON THE CERVICAL AND LUMBOSACRAL ENLARGEMENTS IN PLGEON, DUCK AND CHICKEN*

(With 6 Tables & 3 Fig.)

By

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دراسه شكلمتريه على التضخم العنقي والقطني العجزى فى البط والحمام والفراخ

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تنقسم الماده السنجابيه لفلقات النخاع الشوكى إلى عشرة طبقات واضحه بناء على الاختلافات الخلويه بين هذه الطبقات .

تمثل الخمس طبقات الاولى ، والتى تحتل القرن الظهرى ، الطبقات الحساسه فى وظيفتها ، بينما الطبقه رقم ٩ ، التى تحتل القرن البطنى ، الطبقه المحركه من الماده السنجابيه .

قيست مساحة السطح الكليه للقطاع وطبقات الماده السنجابيه التى تكون كلا من التضخمين العنقى والقطنى العجزى للنخاع الشوكى لكل من البط والحمام والفراخ باستخدام برنامج خاص لحساب مساحات السطح بالكمبيوتر . ومن هذه الدراسه اتضح ما يلى :

١ - متوسط النسبه المئويه لمساحة سطح الطبقه التاسعه المحركه بالنسبه لمساحة السطح الكليه للماده السنجابيه عند مستوى التضخم القطنى العجزى فى الفراخ (طائر يمشى حوالى ٩٨ر٣٣ ٪ وعند مستوى التضخم العنقى حوالى ٣٢ر٢٥ ٪ .

٢ - متوسط النسبه المئويه لمساحة سطح الطبقه المحركه الى مساحة السطح الكليه للماده السنجابيه عند مستوى التضخم العنقى فى الحمام (طائر يطير) يساوى ٧ر١ مره مثيلتها عند مستوى التضخم القطنى العجزى .

٣ - متوسط هذه النسبه عند مستوى التضخم العنقى فى البط يساوى ٢ر١ مره مثيلتها عند مستوى التضخم القطنى العجزى .

٤ - متوسط النسبه المئويه لمساحة القرن الخامس الى المساحه الكليه للماده السنجابيه عند مستوى التضخم القطنى العجزى فى الحمام تساوى ٤ر١ مره مثيلتها عند مستوى التضخم العنقى .

٥ - تتساوى هذه النسبه فى كل من البط والفراخ عند مستوى كل من التضخم العنقى والقطنى العجزى .

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*: The data of the cervical enlargement is caughted from the Ph.D. thesis entitled "Some studies on the vasculature, cytoarchitecture and morphometry of the cervical enlargement of chicken (Gallus dmesticus), pigeon (Columba livia) and duck (Anas domestica) by Hasouna (1990).

SUMMARY

The gray matter of the spinal cord segments is divided cytoarchitectonically into ten distinct laminae. The first five laminae [1-5] are sensory in function, while lamina 9 forms the motor portion of the grtay matter. The cross sectional areas of the ten laminae of the gray matter in the segments forming the cervical and lumbosacral enlargements of the spinal cord of Duck, pigeon and chicken were calculated and drawn using a Computer-digitizing Set with a special area-calc Program. The obtained results were statistically analysed. In chicken [running bird], the mean percentage of the Cross sectional area of the motor part represented by lamina 9 to the total Cross sectional area of the gray matter at the level of the lumbsacral enlargement is 33.98% equal 1.36 times that at the level of the cervical enlargement (25.35%). On the other hand, the cross sectional area of lamina 9 in the cervical enlargement is 1.7 times that at the level of the lumbosacral enlargement in pigeon [flying bird] and 1.2 times in duck swimming bird depends on the motor area of the cervical and lumbosacral enlargements in locomotion. The mean percentage of the cross sectional area of the sensory part to the total cross sectional area of the gray matter at the level of the lumbosacral enlargement in pigeon is 1.4 times that at the level of the cervical enlargement. However, the mean percentage of the cross sectional areas of the sensory laminae in both enlargements in case of duck and chicken are nearly equal.

Keaywords: **Morphometric study, cervical lumbosacral, enlargements, pigens, duct and chicken**

INTRODUCTION

The structure of the gray matter of the spinal cord in birds was studies by several authors. *STREETER (1904)* described the different cell groups found in the gray matter of the Ostrich, while *HUBER (1936) and MATSUSHITA (1968)* studies these cell nuclei in chicken spinal cord. *ARIENS KAPPERS; HUBER and CROSBY (1965)* described the cell nuclei found in the dorsal and ventral horns of vertebrates in a comparative manner. *REXED*

(1952, 1954) studied the cytoarchitectonic organization of the gray matter in the spinal cord of cat and described ten lamine in the gray substance. *BRINKMAN and MARTIN (1973)* described also ten gray matter laminae in the brachial region of the spinal cord of the domestic fowl. Similar description was given by *MARTIN (1979)* in the lumbar region of the spinal cord in the same bird species.

Recently, a computerized digitizer was used in carrying out the different morphometric studies, *GABR (1982)* studies the cross sectional areas of the developing spinal cord in rabbit, while *HASOUNA (1990)* calculated the cross sectional areas of the gray matter laminae in the spinal segments forming the cervical enlargement of chicken, pigeon and duck.

BADAWI, AHMED and HASOUNA (1992 a,b) studies the cross sectional area of the gray matter laminae in the spinal segments forming the cervical and lumbosacral enlargements in duck pigeon and chicken. However, the main aim of this study is to compare between the obtained values of the two enlargements in the same bird species and then between the three differnt species. The statistical analysis which was carried out on the values of the examined enlargements aimed to prove the interdependence and the close relation between the cross sectional area of the gray matter laminae in both enlargements and the effort made by the muscles innervated by the nerve arising from the spinal cord segments entering in the formation of the two enlargements in the three bird species.

MATERIAL AND METHODS

The material which was examined in the present study was the same which was employed to study the cross sectional areas of the gray matter laminae in the spinal segments forming the cervical and lumbosacral enlargements in the three bird species by *BADAWI* et al. *(1992 a,b)*.

Ten chosen sections from each of the previously mentioned segments were examined and the gray matter laminae were demarcated in a similar manner to that of *BRINKMAN and MARTIN (1973)*. The ten laminae were drawn by using a Leitz-diaplan research microscope connected with a Leitz tracing tube. The calibrated drawn gray matter laminae were magnified 70 times.

The following values were measured by using a Computer-digitizing set which comprises a graphic digitizer [KD, 4030 B] connected with a Micronet P. Computer with special digitizing area-calc program:

1- The total Cross-sectional area of each section.

2- The total Cross-sectional area of the gray matter of each section.
3- The Cross-sectional area of the white matter of each section.
4- The Cross-sectional area of each lamina.

Statistical analysis was carried out to calculate the following:

1- The percentage of the Cross-sectional area of the gray matter to the total Cross-sectional area of each section.
2- The percentage of the Cross-sectional area of each lamina to the correspondig total gray matter.
3- The percentage of the sensory part to the total Cross-sectional area of the gray matter.
4- The percentage of the motor part to the total Cross-sectional area of the gray matter.
5- The ratio between the sensory and motor parts for each segment entering into the formation of the enlargements.

Significant differences between the region of the same species and those of the different species were also estimated using the method adopted by *WATTER (1979) and STEEL and TORRIE (1987).*

The following Abbreviations were used in this paper:

- P= Percent of the lamina - seg. = Segment
- $pool_1$= the Cross-Sectional Area of the sensory portion [La. 1-5] to the total Cross-sectional area of the gray matter
- $pool_2$= percentage of $pool_1$ to the Cross-sectional area of the gray matter.
- SMR= Ratio between sensory and motor parts of the gray matter.

RESULTS

Are presented in Tables1 - 6 and Fig. 1 - 3.

DISCUSSION

The result obtained by calculating the cross-sectional areas of the ten gray matter laminae of the spinal cord segments entering in the formation of the cervical and lumbosacral enlargements in duck, pigeon and chicken and their statistical analysis were recorded in Table (1-6) and in figures (1-3).

The statistical analysis was carried out on the cross sectional areas of the gray matter laminae of the spinal segments forming both the cervical and lumbcsacral enlargements in the three examined bird species and revealed the following:

1- Highly significant differences were recorded in duck between the two enlargements concerning the laminae 1, 2, 5, 9 and 10.
2- Highly significant differences were noticed in pigeon between the two enlargements in the values of the gray matter laminae 1, 2, 5, 6, 7, 8, 9, and 10, in addition to the value of SMR and $Pool_2$.
3- Highly significant differences were recorded between the two enlargements in chicken in the value of laminae 1, 5, 7, 9 and 10, also SMR.
4- Significant differences between the two enlargements were noticed at the level of lamina 7 in duck, lamina 3 and 4 in pigeon and lamina 2 and 6 in chicken.

The general sensory innervation of the skin and feathers at the region of the cervical enlargement is mediated through somatic afferent fibers of the nerve which emerged from the brachial plexus. *BAUMEL (1975)* stated that both of the caudal branch of the ulnar and the superficial branch of the radial nerve conduct proprioceptive impulses from sensory corpuscles located around the base of the flight feathers and supply the smooth muscles of the follicles of the secondary flight feathers. Also the superficial and deep branches of the median nerve are responsible for the cutaneous innervation of the antibrachial region, while the distal cutaneous branch of the axillary nerve serves the area of skin over the dorsal shoulder and proximal arm. The superficial branch of the radial nerve innervates the bases of the secondary flight feathers in the forearm, while the deep branch serves the follicles of the primary flight feathers in the hand. In addition to the above proprioceptive endings and general sensation endings in the skin, cutaneous nerves to the wings are motor to the smooth muscles [Mm. pennarum] concerned with elevation, depression and rotatory movements of flight and contour feathers. According to *LUCAS (1975)* each feather follicle is connected with many feather muscles. The feather muscles are basically three types; erector, depressors and retractors [*LANGLEY, 1904*].

The general sensory cutaneous innervation of the skin and feathers at the lumbar and sacral regions comes from the sensory fibers derived from the branches of the lumbosacral plexus [lumbar and synsacral plexuses by *DYCE, SACK and WENSING, 1987*]. However, *BAUMEL (1975)* stated that the lumbosacral plexus is formed by the ventral branches from 23-30 spinal nerves and the ventral branches of 31-34 spinal nerves from the pudendal plexus. *SCHUMMER (1977)* stated that the lumbosacral enlargement extends form L_3 to Sa_6 spinal cord segments and the pudendal plexus is made up of the four or five ventral branches of the spinal nerves which emerge in the region of Synsacrum. While *HASOUNA (1987)* stated that the Lumbosacral enlargement extend from T7 - Ls8 in Chicken, Ls1-Ls8 in Duck and Ls1 - Ls7 in pigeon.

The integuments of the lumber, sacral and thigh regions is innervated by cutaneous branches emerging from the nerves of the lumbosacral plexus. This area includes the dorsopelvic, femoral, crual, lateral and medial abdominal tracts, in addition to the lateral pelvic, dorsal caudal and crural aptria *(LUCAS, 1975)*. According to the vent region, the ventrolateral tail and most of the ventral abdominal wall; this includes motor innervation of the feather smooth muscles, general sensory cutaneous innervation and proprioceptive innervation from the sockets of the tail bulb and the follicles of the flight feathers. It further supplies the striated muscles around the cloaca, vent and the ventral extrinsic and intrinsic tail muscles. However, *SCHUMMER (1977)* stated that the branches of the pudendal plexus [which emerge in the region of the synsacrum] innervate the ventral musculature of the tail, muscles of the cloaca and anus and muscles of the skin in this region.

The high percent of the cross sectional areas of the sensory laminae at the level of the lumbosacral enlargement in pigeon may be due to the rich somatic afferent fibers directed to the back plumage, dorsopelvic Tract feathers, the upper median tail coverts, abdominal, femoral and crural tract feathers, in addition to the first rectrix [greater sickle], main tail feathers and the upper major tail coverts [lesser sickels].

The important role played by the feathers of the caudal region and tail must be taken into consideration concerning the elevation, depression and rotation movements during flying. As the mean percentage of the Cross-sectional area of lamina 1 in pigeon which is 12.3% at the lumbosacral enlargement so it forms the highest percent among the sensory lamina and it may have an important role in the function of the tail feathers their muscles during flying and landing in a good flyer bird such as pigeon, however such explanation needs further physiological and experimental support.

The examination of the cross-sectional areas of the motor portions of spinal cord segments reveals clearly interdependen- between thier values and the effort exerted by the muscles innervated by their somatic efferent fibers. The pigeon is a good flying bird and depends essentially upon muscles of the wings and the pectoral group in flight; these muscles receive found in the gray matter of the spinal segments forming the cervical enlargement. Consequently, the mean percentage of the cross sectional area of the motor portion of the gray matter which is represented by lamina 9 forms 37.6% from the total cross-sectional area of the gray matter at the level of the cervical enlargement in pigeon. Similar close interdependance appears clearly between the Cross-sectional area of the motor portion found in the gray matter laminae of the spinal segments forming the lumbosacral enlargement and the effort made by muscles innervated by the nerves emerging from it in chicken. As a running bird, chicken depends largely on the muscles of the thigh and leg in movement, these muscles receive their somatic efferent fibers through the nerves coming from the lumbosacral enlargement. As a result, the Cross-sectional area of the motor part represented by lamina 9 is 34% from the total cross-sectional area. Of the gray matter at the level of the lumbosacral enlargement in chicken.

Duck as a diving bird depends on the muscles of the thigh and legs in swimming, in addition to the muscles of the wings in short flying and in elevation and depression. As a result the mean percentage of the cross sectional area of the motor part to the total cross-sectional-area of the gray matter at the level of the cervical enlargement is 26.2%, while that of the lumbosacral enlargement is 22%, however, some duck species are well known to be good flyers.

GOLLER (1963); ARIENS KAPPERS et al. *(1956)* mentioned that the cervical enlargement is more developed in flying than in running birds.

HASOUNA (1987) and BADAWI et al. *(1988)* found that the cervical enlargement is well developed in flying than in running birds.

HASOUNA (1990) and BADAWI et al. *(1992 a)* stated that the Cross-sectional area of the spinal segments forming the (Cervical enlargement) in flying birds is more higher than at any level of the spinal cord in the same species [cervical or thoracic] and more than that of other species of birds [running or diving].

STREETER (1904); GOLLER (1963) and ARIENS KPPERS et al. *(1965)* mentioned that the lumbosacral enlargement in running birds is greater than the cervical one where the musculature of the hind extremities are well developed. *KING and McLELLAND (1975, 1984)* stated that the lumbosacral enlargement in running birds exceeds the cervical one , while in well flying birds the cervical enlargement is greater than the lumbcsacral one. *HASOUNA (1987) and BADAWI* et al. *(1988)* recorded a highly significant differences between the volume of the gray matter at the level of the lumbosacral enlargement in running birds at the level of the lumbosacral enlargement in running birds and that of the flying or diving birds. Moreover, *HASOUNA (1990) and BADAWI* et al. *(1992 2, b)* stated that the Cross-sectional-area of the spinal segments at the level of the cervical enlargement and lumbosacral enlargement exceeds that at any other level of the spinal cord.

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Tables 1,2,3 : Showing the least square means and standard error (X ± S.E.) of the mean percent of the laminae in the cervical [C.E.] and lumbosacral [Ls.E.] enlargements of the spinal cord in pigeon, duck and chicken.

1 (pigeon)

	C.E.		Ls.E.	
P1	2.86	+0.48	12.28	+0.38
P2	4.49	+0.26	5.89	+0.20
P3	3.30	+0.18	3.33	+0.14
P4	3.13	+0.14	2.92	+0.11
P5	6.67	+0.21	4.02	+0.17
P6	8.59	+0.37	7.68	+0.29
P7	30.10	+0.78	36.86	+0.62
P8	2.10	+0.12	2.85	+0.09
P9	37.63	+0.72	22.09	+0.57
P10	0.78	+0.07	2.09	+0.05
Pool1	95.82	+4.19	163.44	+3.32
Pool2	20.44	+0.96	28.44	+0.76
S.M.R.	0.60	+0.08	1.48	+0.06

2 (duck)

	C.E.		Ls.E.	
P1	2.21	+0.17	3.68	+0.12
P2	3.93	+0.19	4.73	+0.13
P3	6.94	+0.42	7.01	+0.30
P4	4.01	+0.18	3.91	+0.13
P5	5.11	+0.17	3.29	+0.12
P6	7.50	+0.33	7.71	+0.23
P7	40.32	+0.72	42.72	+0.51
P8	3.61	+0.28	4.06	+0.20
P9	26.16	+0.90	21.84	+0.64
P10	0.52	+0.60	1.04	+0.05
Pool1	143.74	+2.73	144.31	+2.07
Pool2	21.89	+0.89	22.63	+0.61
S.M.R.	1.50	+0.14	1.22	+0.10

3 (chicken)

	C.E.		Ls.E.	
P1	1.22	+0.13	2.92	+0.09
P2	4.45	+0.22	3.94	+0.15
P3	3.38	+0.18	3.23	+0.12
P4	2.64	+0.11	2.63	+0.07
P5	5.79	+0.21	3.49	+0.14
P6	5.36	+0.35	6.21	+0.23
P7	47.38	+1.07	37.35	+0.71
P8	3.73	+0.18	3.86	+0.12
P9	25.35	+1.03	33.98	+0.68
P10	0.69	+0.09	2.39	+0.06
Pool1	68.46	+2.89	110.63	+1.92
Pool2	17.49	+0.66	16.22	+0.44
S.M.R.	0.84	+0.04	0.53	+0.03

P Percent of lamina .
PooL1 Sum of C.S.A. of sensory laminae
PooL2 Percentage of PooL1 to C.S.A. of gray matter
SMR Ratio between sensory and motor parts

Tables 4,5,6 : showing the mean of squares (M.S.) in the cervical and lumbosacral enlargements of the spinal cord in pigeon, duck and chicken.

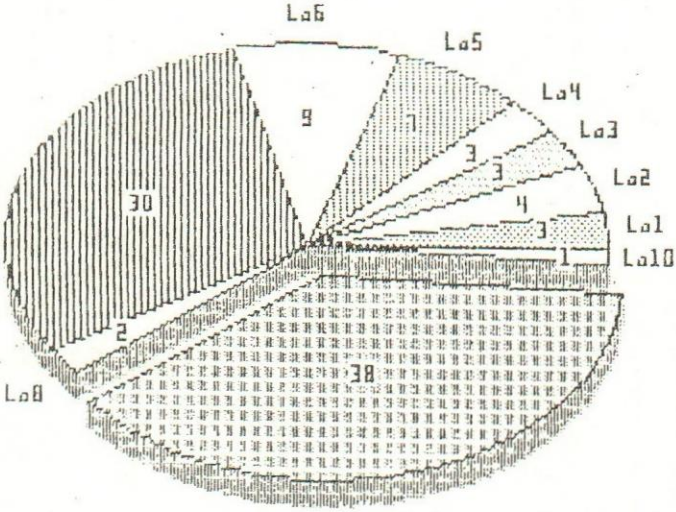
	S.V.	D.F.	Mean of Squares (M.S)												
			P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Pool1	Pool2	SMR
4	Bet. Seg.	1	5467.7**	120.55**	0.03	2.70	431.97**	99.87**	2313.5**	39.87**	14859.47**	105.3**	281331**	3929.1**	44.62**
	With. Seg.	258	23	6.6	3.35	2.02	4.47	13.35	61.16	1.33	51.26	0.46	1758	91.26	0.57
	pigeon														
5	Bet. Seg.	1	115.39**	34.69**	7.63	0.53	176.77**	2.25	308*	10.96	994.9**	14.44**	13.38	28.91	3.96
	With. Seg.	238	2.36	2.88	14.39	2.57	2.18	3.81	41.09	6.43	65.47	0.32	686.8	60.47	1.5
	duck														
6	Bet. Seg.	1	157.59**	14.25*	1.18	0.60	291**	39.96*	5518.7**	0.35	4084.32**	157.45**	97555.08**	88.57	5.54**
	With. Seg.	257	1.41	3.35	2.47	0.94	3.33	3.53	39.67	2.53	84.40	0.65	561.19	34.42	0.14
	chicken														

S.V. Source of Variance

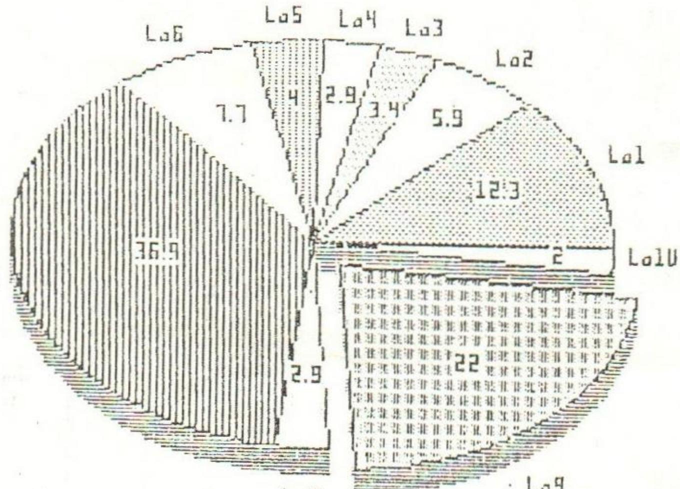
D.F. Degree of Freedom

* Significant

** highly Significant



A



B

Fig. (1): Histogram showing the percentage of the C.S.A. of the laminae to the total gray matter in the spinal segments forming the cervical enlargement [A] and lumbosacral enlargement [B] in pigeon.

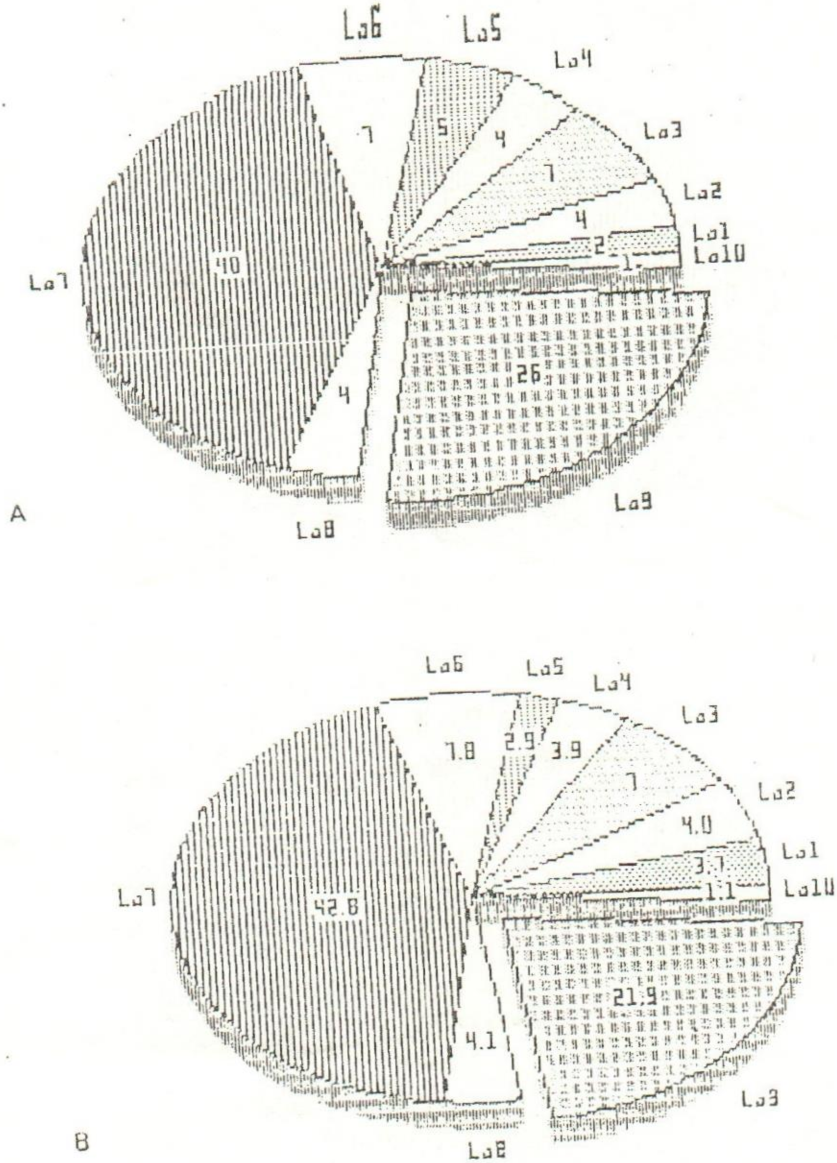
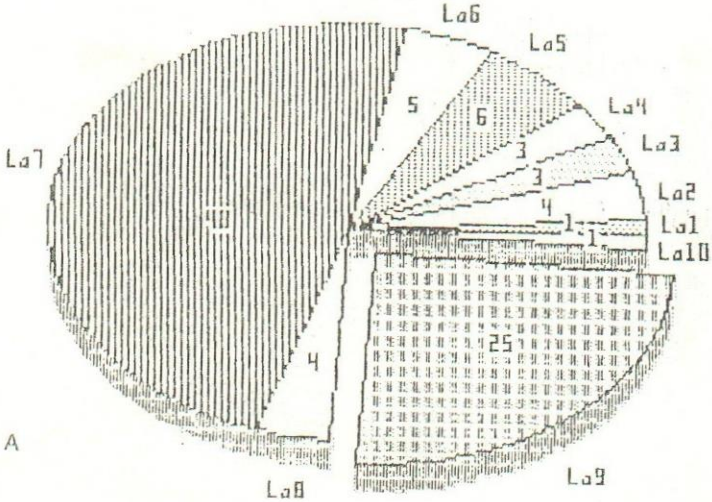
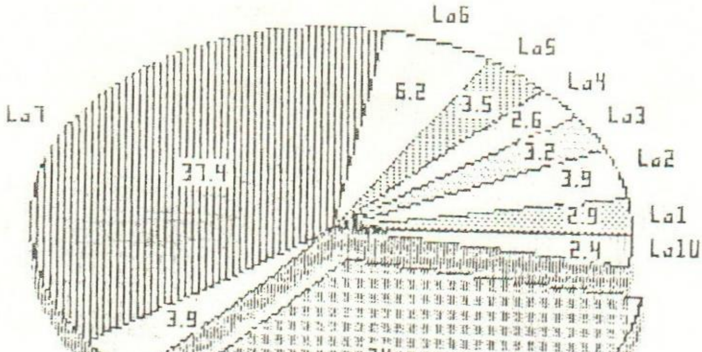


Fig. (2): Histogram showing the percentage of the C.S.A. of the laminae to the total gray matter in the spinal segments forming the cervical enlargement [A] and lumbosacral enlargement [B] in duck.



A



B

Fig. (3): Histogram showing the percentage of the C.S.A. of the laminae to the total gray matter in the spinal segments forming the cervical enlargement [A] and lumbosacral enlargement [B] in chicken.