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Research Article

TOPOGRAPHIC AND MORPHOMETRIC STUDIES ON THE SPINAL CORD OF THE MALE AND FEMALE INDIAN GRAY MONGOOSE *(HERPESTES EDWARDSII)*

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ABSTRACT
This study was conducted to understand the detailed anatomical aspects of the spinal cord of Indian gray mongoose *(Herpestes edwardsii).*Ten adult mongooses with different were used in the present study. The epaxial muscles and the vertebral arches were removed to expose the spinal cord and the spinal nerve roots. The dimensions of the spinal cord segments were measured .The total lengths of the spinal cords were 292.38±11.47 and 244.48±10.83 mm in males and females, respectively. In mongoose the spinal cord terminated between S2 and S3 vertebrae . Moreover, dimensions of the cervical and lumbar enlargements, medullary cone, and the angulation degree of each spinal nerve were comparatively measured in both sexes.

Keywords: *Topography, Morphometry , Spinal cord, Mongoose*

INTRODUCTION
Mongooses are small carnivores occupying various regions from Africa to Southeast Asia (Thulin *et al.,* 2006). The genus Herpestes contains 10 species (Nowak, 1999) and is considered the oldest genus within the carnivores, dating back approximately 30 million years (Hinton and Dunn, 1967). The Indian gray mongoose (Herpestes edwardsii) is a species of mongoose mainly found in southern Asia particularly India, Pakistan, South of Iran , Sri Lanka and some other parts of Asia (Choudhury *et al.*, 2011). According to IUCN Red list 2012 status they are listed as Least Concern mammals (Shil *et al.,* 2012). They are terrestrial, diurnal and generally found in open forests, scrublands and cultivated fields, often close to human habitat (Prater, 1980).

This carnivore mammal preys on rodents, snakes, birds' eggs and hatchlings, lizards and variety of invertebrates (Choudhury *et al.,* 2011). The Indian gray mongoose is one of the few animals that can survive a cobra attack, which makes it one of the deadly snake's few predators. As there is no information about the anatomy of central nervous system of mongoose, this will be a platform for better understanding of anatomy, pathology of diseases and subsequent application in clinical examination and surgical intermediation if needed. The knowledge of the topography of the spinal cord is essential in clinical practice for the diagnosis, prognosis and treatment of vertebral and spinal injuries, and it is sometimes necessary to locate injuries of the central nervous system at a vertebral level. Understanding the central nervous system (CNS) anatomy is especially useful in anesthesiology, in order to block the spinal nerves (Dyce *et al.,* 2004).

The anatomy of the spinal cord has been studied and described in humans (Williams *et al.,* 1995), felines , monkeys (Carvalho-Barros *et al.,* 2003), sheep (Rao, 1990), coatis (Gregores *et al.,* 2010), freshwater dolphins (Machado *et al.,* 2003) and sea lion (Fettucia and Simoes lopes, 2004). Moreover, the anatomical studies of the spinal cord received attention of many anatomical researchers. In this respect Mansour (1980), Abu-zaid (1982) and Abd El-ghany (1995) gave valuable studies on the anatomy of the spinal cord in donkey, buffalo, and goat respectively. The pattern of the spinal cord topography of mongoose has not been reported yet.

Considering the importance of detailed knowledge about the comparative anatomy of the nervous system of vertebrates and its usage in veterinary medicine, the purpose of this research was to describe the anatomic and topographic aspects of the spinal cord in mongoose via the quantitative measurements.

MATERIALS AND METHODS

The carcasses of 10 dead adult mongooses (5male and 5 female) which were found in Shiraz regions were used and these materials have collected for this study during last two years. The ages of the animals were estimated more than one year old by teeth inspection. These freshly found carcasses died naturally and were brought to the veterinary faculty of Shiraz University for post-mortem examinations.

Before the beginning of the dissection, species name, body weight, body length, tail length and the external features were recorded in record sheet. Keeping in ventral recumbent position, a longitudinal incision was made along the dorsal midline. Then the carcasses were fixed by injecting sufficient quantity (3 – 4 cc.) of 10% formalin into the cranial cavity and were kept in 10% buffered formalin bath . After 24h the skin, epaxial muscles, vertebral arches and epidural fatty tissue were removed to expose the spinal cord and the spinal nerve roots .The dura mater was then slit along the dorso-median sulcus .The arachnoid was either lifted off or gently pushed back from the dorsal roots. Thus the spinal cord was examined sequentially without any damage or distortion.

In each animal, the total, regional and segmental length of the spinal cord was measured with a venire caliper with 0.05 mm precision . The length of each spinal cord segment was determined by measuring the distance from the most cranial rootlet of the dorsal root of the adjacent distal spinal nerve. Moreover, the location and length of the enlargements and medullary cone of the spinal cord were measured.

The angulation of each spinal nerve with the spinal cord was determined by measuring the angle of spinal nerve with the line on the dorsomedian sulcus of spinal cord, using a tiny wire fixed on the dorsomedian sulcus from foramen magnum to the end of the sacrum. For each spinal nerve, a suitable sized pin long enough to cross the median longitudinal wire was inserted through the middle of each spinal nerve from intervertebral foramen (Figure 4). The radiogram of the case, showed the longitudinal wire and needles through the middle of spinal nerve trunks for measuring the angulation of spinal nerves in the different regions of the spinal cord in mongoose (Ghazi *et al.*, 1997).

Analysis of particularly morphometric data was carried out with Student's t-test using SPSS program (version 16).

RESULTS AND DISCUSSION

The spinal cord begins at the level of the foramen magnum , where the cranial rootlets of the first cervical spinal nerve root emerges and extends caudally in both sexes, but the termination level of the spinal cord was different in male and female mongooses. In the male mongoose, the spinal cord terminated in the region of middle third of S3 vertebra in 80% of cases , and S2 in other 20% of male animals (Figure 3). However, in female mongoose, the termination of the spinal cord was in the middle third of S2 vertebra in all the samples. The spinal cord in mongoose was formed by 37 segments and divided into 8 cervical, 13 thoracic, 7 lumbar, 3 sacral and 6 caudal spinal segments.

The total and regional length values and their indices were submitted in Table 1.

The segmental length is considered as the length of the spinal cord extending from the most rostral attachment of one spinal nerve rootlet to the rostral most attachment of the succeeding spinal nerve rootlet. The segmental lengths varied along the different regions of the spinal cord

in male and female mongooses. In the cervical region the segment lengths began by a little value at C_1 followed by the highest value at C_3or C_4 and then gradually decreased from C_4 to C_8. In the thoracic region, the length values of the segments were slowly increased from T_1 to T_{13}. In the lumbar region, the gradual increase in segment length continued till it reached the maximum along the whole length of the spinal cord, at L_2 or L_3 (Figure 1).

The spinal cord of was an elongated and cylindrical mass, flattened dorsoventrally, with cervical and lumbar enlargements. The cervical enlargement , consisted of the last five cervical segments, including the caudal third of the third cervical segment to the end of the last cervical segment in both sexes. The length of this enlargement is 42.2±1.58 mm in males and 36.15±1.79 mm in females. The lumbar enlargement was formed by four lumbar segments in male and five in female. In male mongoose it extended from the beginning of L_3 segment , cranially to the beginning of L_6. In the female, the lumbar enlargement extended from the beginning of L_3 to the end of L_7.The length of the lumbar enlargements was is 37.6±2.42 mm in male and 41.3±0.84 mm in female (Table 2 and Figure 2).

The Medullary cone (Conus medullaris) was formed by the last eight segments of the spinal cord which extends from S_2 to the end of the last caudal segment. It began with a transverse diameter 3.1 mm in female, and 3.5 mm in male mongoose. The transverse diameter at the end of medullary cone reaches 0.8 mm in both sexes. Figure 3 shows the position of the medullary cone in male mongoose. The values of the medullary cone are recorded in table 2.

Table1: Length, in Millimeters and Index, in Percentage of the Cervical, Thoracic, Lumbar, Sacral and Caudal Regions of the Spinal Cord in Male and Female Mongooses (*Significant at p<0.05)

Region/Values	Mean length (mm)		Indices (%)	
	Male	Female	Male	Female
Cervical	66.24±1.78	58.22 ± 2.57*	22.66±0.31	23.81±0.05*
Thoracic	119.6±2.81	99.43±3.67*	40.93±0.73	40.68±0.47
Lumbar	77.2±3.11	64.18±2.34*	26.40±0.27	26.26±0.34
Sacral	17.3±2.29	15.69±1.21	5.90±0.56	6.41±0.22
Caudal	12.04±1.95	6.96±1.23*	4.10±0.52	2.83±0.38*
Total	292.38±11.47	244.48±10.83*	100	100

Table 2: Length, in Millimeter and Number of Segments of the Enlargements and Medullary Cone of the Spinal Cord in Male and Female Mongoose (*Significant at p<0.05)

Values / Sex	Male	Female
Cervical Enlargement Length	42.2±1.58	36.15±1.79*
Number of Segments in Cervical Enlargement	5	5
Lumbar Enlargement Length	37.6±2.42	41.3±0.84*
Number of Segments in Lumbar Enlargement	4	5
Medullary Cone Length	23.1±0.55	22.75±0.71
Number of Segments in Medullary Cone	8	8

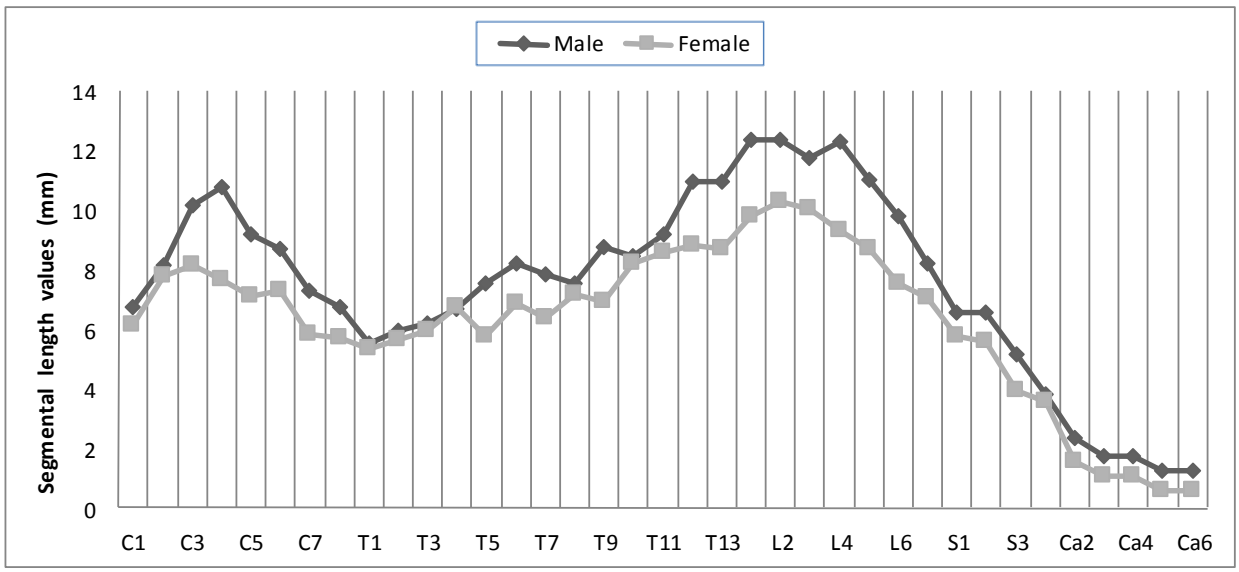

Figure 1: A Diagram Showing the Length of Spinal Cord Segments in both Sexes of Mongoose

Figure 2: Showing the Position of the Cervical (a) and Lumbar (b) Enlargements in Female Mongoose

The angulation of the spinal nerves from C_1 to S_3 was shown in Figure 4 and Figure 5. According to our study, there were three alternate increasing and decreasing spinal nerve angulation regions and there was no significant difference in this value both two sexes .According to the data there was an increase in the degree of angulation from C_1 to C_4. Between C_4 to C_6 the degree of the angulation gradually decreased and the most degree of angulation of the spinal nerves , was recorded in C_4 in both sexes. Also, the most degree of the angulation was recorded in T_7 -T_8 and L_1 - L_2 in thoracic and lumbar region, respectively.

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Figure 3: The Position of Medullary Cone (a) and Termination of the Spinal Cord (b) in Male Mongoose

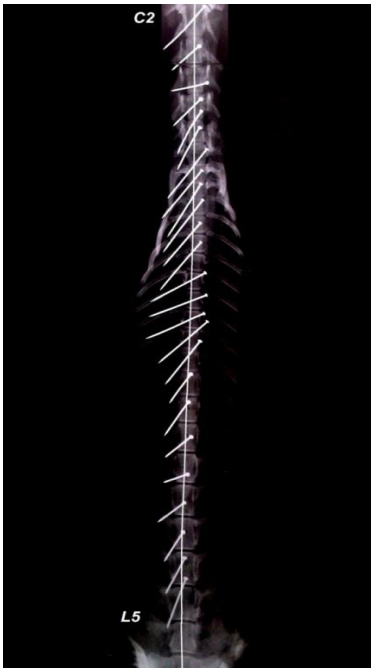

Figure 4: Photograph from Radiogram, Showing the Longitudinal Wire and Needles Through the Middle Spinal Nerve Trunk for Measuring the Angulation of Spinal Nerves Different Regions of Spinal Cord of Male Mongoose

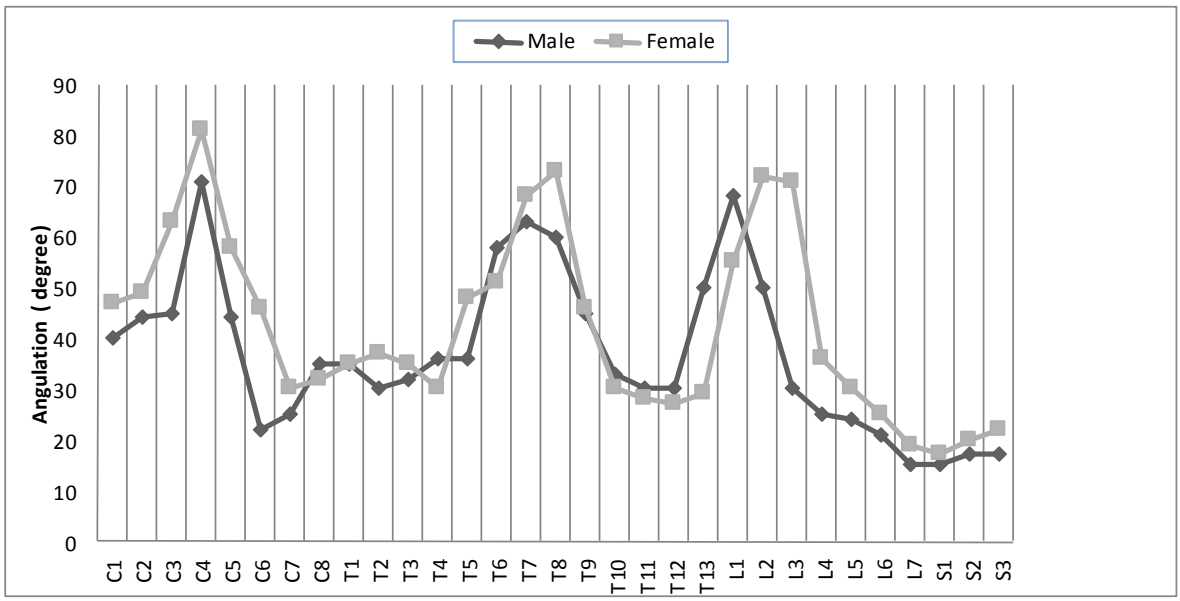

Figure 5: A Diagram Showing Angulation of Spinal Nerves in Male and Female Mongoose

The present study reported that the average length of the spinal cord of mongoose was about 292.38±11.47 mm. and 244.48 ±10.83 mm. in male and female mongoose respectively, and like the other domestic animals, its beginning was on the level with the foramen magnum.

In the relationship between the spinal cord regions' length, the indices of the cervical, thoracic, lumbar and sacrocaudal regions are recorded in Table 1. Moreover, the indices of the cervical, thoracic, lumbar and sacrocaudal regions are reported to be 18.47%, 35.26%, 34.17% and 12.02% in rabbit (Santos *et al.,* 1999), 22.40%, 49.32%, 24.07% and 3.68% in cougar , 21.97%, 50.83%, 11.20% and 15.97% in anteater %,28.02%, 35.34%, 19.68% and 6.93% in deer (Lima *et al.,* 2010) and 31% , 42.3% , 19.5% and 5.48% in sheep (Goller, 1958).

The present results are in accordance with what Thomas and Combs (1962) mentioned in cat and Abu-zaid (1982) mentioned in buffalo as they defined the spinal cord segment as that part that lied between the rostral most rootlets attachment of the spinal nerve to the rostral most rootlets of the next nerve.

Concerning the length of the spinal cord segments in the different regions, the present work revealed that the longest segments were at C_3, T_{12}, L_2, S1 and Ca_1 in different regions. Farag *et al.,* (2012) mentioned C_2, T_{12}, L_2 and S_2 as the longest segments in the rabbit. This work recorded the longest segment along the whole length of the spinal cord was at L_2. A similar result to what was reported in rabbit (Farag *et al.,* 2012). In other animals, the longest segment was at C_3 in goat (Sharma *et al.,* 1937), buffalo (Abu-zaid, 1982) donkey (Mansour, 1980) and sheep (Ghazi *et al.,* 1993), C_5 in camel (Mansour, 1983), T_{13} or L_1 in cat (Thomas, 1962) and at mid-thoracic in the human (Donaldson *et al.,* 1903).

The spinal cord ends between S2 and S3 vertebra in mongoose, S1 in cat (Eldridge, 1984), S3 and S4 in deer (Lima *et al.,* 2010), at the level of the second sacral vertebra in horse, cattle (Deem *et al.,* 2004) and sheep (Rao, 1990), at the cranial portion of the seventh lumbar vertebra in dogs (Getty *et al.,* 1986), at L_5 or L_6 in pig, at S3 in buffalos (Rao, 1976) and impalas (Rao *et al.,* 1993), at the caudal end of S2 in rabbit (Farag *et al.,* 2012), and between L1 and L2 in human (Williams *et al.,* 1995).

The cervical enlargement was between $C_3 – C_7$ in mongoose. In deer, this thickening includes segment $C_4 – T_1$ (Lima *et al.,* 2010), while in rabbit, was between $C_5–T_1$ (Farag *et al.,* 2012). It is formed between $C_7 – C_8$ in pig (Dellmann and McClure, 1975), $C_6 – T_1$ in the dog (Miller *et al.,* 1964), between $C_6 – T_2$ in buffalo (Abu-zaid, 1982) and camel (Mansour, 1983) and $C_5–T_2$ in Indian sheep (Rao,1990) and donkey (Mansour,1980). Moreover, this dilatation correspond to C_5-T_2in sheep (Rao, 1990) and$C_6 – C_8$ in cat (Thomas, 1962).

The lumbar enlargement in mongoose, extended from L_3, cranially to the L_6 (Figure 1). In rabbit, the lumbar enlargement was formed between $L_4 – S_3$ (Farag *et al.,* 2012). In the donkey, it is found between $L_2 – S_1$ (Mansour, 1980), between $L_6 – S_1$ in camel (Mansour, 1983), between the last three lumbar and first two sacral in buffalo (Abu-zaid, 1982), between $L_4 – S_1$ in sheep as mentioned by Rao (1990), between $L_6 – L_7$ in the pig, between $L_5 – L_7$ in the cat (Thomas, 1962), and between $L_4 – S_1$ in the dog (Dellmann and McClure, 1975). In the deer, this enlargement of the spinal cord was found between L_3-L_6 (Lima *et al.,* 2010).

The present work showed that in mongoose the two enlargements represent a large portion of the spinal cord. This study revealed that the cervical enlargement is longer and more voluminous than the lumbar one in male mongoose. However in female mongoose, the controversial opinion is more believable. In rabbit, the lumbar enlargement is longer than the cervical one (Farag *et al.,* 2012), while the studies of Thomas (1962) in cat, Abu-zaid (1982) in buffalo and Mansour (1983) in camel showed that the cervical enlargement was longer than the lumbar one.

The present study showed that the index of length of medullary cone was 8.51±0.87 % in both sexes. The reported lengths of the medullary cone are 29.94 mm. in rabbit (Farag *et al.,* 2012) and

88.5 mm in sheep (Santos *et al.*,1999). Moreover the medullary cone lengths measured in deer was 46.26 mm. with a mean length index of 7.53% (Lima *et al.*, 2010).

According to our studies, it could be concluded that the general topographic and morphometric characteristics of spinal cord of male and female mongooses are similar to each other, and the most significant difference is in termination of their spinal cords. Therefore comparative study on the termination of spinal cord between male and female in other animals (especially carnivores) seems necessary. Morphometric studies on the regions and segments of the spinal cord of male and female mongoose and studies on the other carnivores and animals have been consistent. Despite the smaller size of the spinal cord, lumbar enlargement in females was also longer than males. It seems that this difference is due to the massive muscles of the hind limb in females. Moreover, the angulations of the spinal nerves in male and female mongooses were not significantly different.

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REFERENCES

Abd El-ghany NAAN (1995). Some anatomical studies on the spinal cord of the goat with special references to its meninges and vascularization .PH.D Thesis, (Anatomy) Faculty of Veterinary Medicine, Cairo University.

Abu-Zaid SMS (1982). Some gross anatomical studies on the prenatal and postnatal morphological features on the spinal cord of the water buffalo (*Bos Bubalis* L.). PH.D Thesis, (Anatomy). Faculty of Veterinary Medicine, Cairo University.

Carvalho – barros RA, Prada ILS, Silva Z, Riberio AR and Silva DCO (2003). Constituição do plexolombar do macacoCebusapella. *Brazilian Journal of Veterinary Research and Animal* **5** 373 - 81.

Deem SL, Noss AJ, Villarroel R , Uhart MM and Karesh WB (2004). Disease survey of free-ranging Grey Brocket Deer *(Mazama gouazoubira)* in the Gran Chaco, Bolivia. *Journal of Wildlife Diseases* **40** 92-8.

Dellmann HD and McClure RC (1975). Central Nervous System of Domestic Animals in *"Sisson-Grossman" Anatomy of Domestic Animals.* 5th edition **Vol.2** p302. (W.B. Saunders Philadelphia, London, Toronto), 156.

Donaldson HH and Davis DJ (1903). A description of charts showing areas of the cross sections of the human spinal cord at the level of each spinal nerve. *Journal of Comparative Neurology* **13** 19 - 40.

Dyce KM, Sack WO and Wensing CJG (2010). *Textbook of Veterinary Anatomy*. (Philadelphia, Pa; London: Saunders Company) 279 – 90.

Farag FM, Elayat MA , Wally YR and Elkarmoty AF (2012). Morphometric Studies on the Spinal Cord Segments of the Domestic Rabbit *(Oryctolagus cuniculus) Journal of Veterinary Anatomy* **2** 33 – 47.

Fettuccia DC and Simoes-Lopes PC (2004). Morfologia da coluna vertebral do botocinza, Sotaliaguianensis *(Cetacea, Delphinidae). Biotemas*. **17**(2) 125-148. (In Spanish with English abstract).

Getty R (1986). *Sisson and Grossman's the Anatomy of the Domestic Animals*. (Philadelphia, Saunders Company) **Vol 1** 255– 66.

Ghazi SR and Gholami S (1993). A study of the length of the spinal cord at vertebral levels during pre-and postnatal development of sheep. *Journal of Applied Animal Research* **4** 61 – 66.

Ghazi SR and Gholami S (1997). Study on the Developmental changes in angulation of spinal nerves, the Length of the Dorsal Roots and Spinal Nerves in Sheep. *Anatomia, Histologia, Embryologia* **26** 211-15.

Goller VH (1958). Topographic and segmental erfeinbau des ruckenmakes des schafes *(Ovis arise). Anatomischer Anzeiger* **105** 26 – 88 (In Spanish with English abstract).

Lima FC, Santos ALQ, Lima BC, Vieira LG and Hirano LQL (2010). Topographic anatomy of the spinal cord: vertebromedullary relationships in *Mazama gouazoubira*. *Acta Scientiarum Biological Sciences* **32** 89-194.

Machado GV, Lesau GG and Birck AJ (2003). Topografia do cone medular no lobo marinho *(Arctocephalusaustralis Zimmermann*). *Arquivos de CiênciasVeterinárias e Zoologia da Unipar*, **6** 11 -14. (In Spanish with English abstract).

Mansour AAK (1980). Some morphological features of the spinal cord in donkey . M.V.SC thesis (anatomy), Faculty of Veterinary Medicine, Assuit University .

Mansour AAK (1983). Some anatomical features of the systema nervosum centrale of *Camelus dromedarius*. PH.D thesis, (Anatomy) Faculty of Veterinary Medicine, Assuit University.

Miller ME , Christensen GC and Evans HE (1964). *Anatomy of the Dog*, 1st edition. (W.B. Saunders Comp. Philadelphia, London, Toronto) 589 – 598.

Nowak RM (1999). Carnivora; Family Herpestidae. In: *Walker's Mammals of the World*, 6th edition **Vol. 1**. (The John Hopkins University Press, Baltimore, London) 766–786.

Rao GS (1976). Study of spinal cord segments in the Indian Buffalo. *Journal of the Anatomical Society of India* **16** 43-50.

Rao GS (1990). Anatomical studies on ovine spinal cord. *Anatomischer Anzeiger* **171** 261-64.

Rao GS, Kalt DJ , KochM and Mojok AA (1993). Anatomical studies on the spinal cord segments of the Impala *(Aepyceros melampus)*. *Anatomia, Histologia, Embryologia* **22** 273- 78.

Santos AL, Lima EMM and Santana MI (1999). Length of the spinal cord and Topography of medullary cone in rabbits. *Bioscience Journal* **15** 45-62.

Sharma DN, Singh Y and Dhinger LD (1973). Anatomical studies on the spinal cord segments of Goat (Capra hircus).Haryana Agriculture University. *Journal of Research* **3** 87 - 92.

Shil SK, Das BC, Uddin M, Rahman ML and Quasem MA (2012). Anatomy of digestive and respiratory system of Indian grey mongoose *(Herpestes edwardsii). University Journal of Zoology, Rajshahi University*. **31** 83-84.

Thomas CE and Combs CM (1962). The spinal cord segments. Anatomy Gross structure in the adult Cat. *American Journal of Anatomy* **110** 37- 47.

Thulin CG, Simberloff D, Barun A., Pascal M and Islam MA (2006). Genetic divergence in the small Indian mongoose *(Herpestes auropunctatus)*, a widely distributed invasive species. *Molecular Ecology* **15** 3947– 56.

Williams PL, Bannister LH and Berry MM (1995). *Gray's Anatomy*. 38th edition. (London: Churchill Livingston) 1516-17.