Original article

Origin and distribution of the femoral nerve in fetuses of zebu-crossed bovines

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Abstract

In this study the femoral nerve origin and distribution was assessed through the dissection of 30 fetuses of zebu-crossed bovines, 20 males and 10 females. These animals samples fixation in 10% formaldehyde aqueous medium occurred either by subcutaneous, intra-muscle, and intra-cavity injections in different sites, or by immersion of the mentioned pieces in vessels containing the same medium. The femoral nerve originated from the forth (L4), fifth (L5), and sixth (L6) spinal lumbar ventral branches in 14 animals (46.7%), from L4 and L5 in 13 samples (43.3%), and L5 and L6 in three cases (10%). In the course of its way, on both antimeres the mentioned nerve was branched to the greater psoas (100%), iliac (100%), pectinal (56.7%), femoral quadriceps (100%), muscles, and gave off saphena nerve, which gave branches for the pectinal (43.3%) and sartorius (100%) muscles and continued distally along the saphena artery to spread on the medial face of the knee and leg medial articulation skin. Statistically, there was no significant difference between the muscle branch frequencies given by the femoral nerve to the right and left antimeres. The obtained results related to the femoral nerve origin and distribution in fetuses of zebu-crossed bovines generally presented common characteristics with the ruminant corresponding data found in the literature, and this information is important as the basis for clinical or surgical approaches involving the studied structures.

Keywords: peripheral nerve system, lumbar-sacral plexus, spinal nerves.

1 Introduction

The brachial and lumbar-sacral plexus originate the nerves that are branched to the thoracic and pelvic limbs structures, respectively. Lumbar-sacral plexus is consisted of the last lumbar nerves and of the two first sacral nerves (DYCE, SACK and WENSING, 2004).

Regarding the anatomic-surgical importance of domestic animal spinal nerves, mainly those formed from the respective plexus, the subject of this work is the study of the femoral nerve, which is considered an important component of the lumbar-sacral plexus and has considerable relevance to animal posture and locomotion.

According to the studies on the femoral nerve formation by Schwarze and Schroder (1970), Ghoshal (1986), Godinho, Cardoso and Nascimento (1987), and Dyce, Sack and Wensing (2004) for ruminants and Konig, Liebich and Cerveny (2004) for bovines, this nerve is formed from the forth (L4), fifth (L5), and sixth (L6) spinal lumbar ventral branches. Furthermore, in ovines this nerve is originated from L5 and L6 and, in caprines from L4 and L5 (GHOSHAL, 1986) whilst in bovines, according to Sisson and Grossman (1972), the femoral nerve is formed mainly from L4 and L5 and usually gets contributions from L3 and L6.

Regarding the muscle groups innervated by the femoral nerve, Sisson and Grossman (1972) and Konig, Liebich and Cerveny (2004) who studied bovines and Schwarze and Schroder (1970), Ghoshal (1986), Godinho, Cardoso and Nascimento (1987) and Dyce, Sack and Wensing (2004) who studied ruminants, stated that the mentioned nerve is branched to the pelvic limb muscles, and close to the pubic bone it emits the saphena nerve which also gives branches to the thigh muscles and is distributed to the leg medial face skin.

A femoral nerve dysfunction, although unusual, brings serious consequences once the femoral quadriceps muscle palsy prevents knee articulation to fix making this limb unable to support body weight (MOLENAAR, 2004). Dyce, Sack and Wensing (2004) stressed that femoral nerve injury is sometimes identified in newborn fetuses that were delivered through a strong traction of the pelvic limbs while

Konig, Liebich and Cerveny (2004) mentioned that pelvic fractures can, in the same way, be the cause of femoral palsy.

Several authors studied the lumbar-sacral plexus nerve origin and distribution in different domestic animals species and races. Among them, it was evidenced those working with caprines (LIMA, SILVA, SEVERINO et al., 2008), zebu-crossed bovine fetuses (FERRAZ and PRADA, 1998; CAMPOS, SILVA, SEVERINO et al., 2003; FERRAZ, LOPES, MELO et al., 2006; MIRANDA, SILVA, SEVERINO et al., 2007), mocós (SANTOS, ALBUQUERQUE, SILVA et al., 2006), pigs (CHAGAS, DRUMMOND, SILVA et al., 2006), and carnivores (GUIMARÃES, MACHADO, SANTOS et al., 2005; ROCHA and MASSONE, 2006). However, the anatomical nature information related to the femoral nerve in fetuses of zebu-crossed bovines is still unusual.

Thus, the aim of this study was to assess the femoral nerve origin and distribution in fetuses of zebu-crossed bovines.

2 Material and methods

For this research it was used 30 fetuses of zebu-crossed bovines, 20 males and 10 females, aged nearly three to six months, which were obtained from a slaughterhouse in the city of Uberlândia, Minas Gerais, Brazil.

The pieces were kept frozen after its obtention. The frozen samples were then thawed in water bath for at least 24 hours. For the injection of blood vessels staining solution, a thoracic portion of the descending aorta artery was individualized and received a canule compatible to its diameter by means of a vertical incision at the ninth intercostals space level of the left antimere. It was injected with Neoprene Latex "450" at 50% (Du Pont of Brazil-Chemical Industries) and a specific staining pigment (Globo S. Dyes and Pigments).

These animals samples fixation in 10% formaldehyde aqueous medium occurred through subcutaneous, intramuscular, and intra-cavity injection in different places as well as through an immersion in a vessel containing the same solution for 48 hours before the beginning of the dissection.

Next, a horizontal incision at the ventral-median line from the xiphoid cartilage of the sternum bone to the cranial ridge of the pelvic symphysis was made for the right and left femoral nerve origin visualization. From this point, other four vertical incisions were made, two in each antimere, until the dorsal median line was reached. The internal organs, the abdominal descendent aorta artery, and the caudal cava vein were cranially moved. Following, the pelvic symphysis was disarticulated into longitudinal section. After removing part of the adipose tissue and the smaller psoas muscle was moved away, the lumbar spinal nerve ventral branches of both antimeres that originated the right and left femoral nerves it could be visualized. Finally, the muscle branches distribution of the femoral nerves in their respective antimeres at the thighs and legs cranial-medial region was assessed. Magnifying lens with 10× increase was used to facilitate the branches visualization when necessary.

The results were recorded by schematic designs and photographs of the femoral nerves origin and distribution in both antimeres. The description of results was reported according to International Committee on Veterinary Gross Anatomical Nomenclature (2005).

For the statistical assay related to the right and left femoral nerve origin, it was chosen to work with data in descriptive form and simple percentage terms. Aiming to verify the existence of significant differences between the frequencies of the femoral nerve branches designated to the right and left antimere muscles, the Wilcoxon test was applied. Using the Kruskal-Wallis test, it was observed the possible existence of significant differences between the frequencies of branches given to the same antimere muscle. The significance level of the statistical assay was 5% (AYRES, AYRES JÚNIOR, AYRES et al., 2005).

3 Results

After assessing 30 fetuses of zebu-crossed bovines, it was found that all animals (100%) presented six lumbar vertebrae. The femoral nerves are constituents from lumbar-sacral plexus and gave off L4, L5 and L6 in 14 animals (46.7%), L4 and L5 in 13 samples (43.3%) and L5 and L6 in only three cases (10%).

This referred nerve presented symmetry related to its origin in all animals (100%), that is, in both antimeres the nerve roots originating it were coincident in numbers.

The anatomical dissection of the pieces enabled the identification of several contributions to the femoral nerve formation, and it also enabled to verify the differentiated proportions between them. Thus, most conspicuous contribution to the nerve formation was demonstrated by the L5 ventral branch in 86.7% of cases and by the L6 in 10% of the animals. The L5 and L6 ventral branches were the most conspicuous and contributed equally to the mentioned nerve formation in one case only (3.3%).

Less contribution to the femoral nerve formation occurred in 76.7% of the cases involving the L4 ventral branch, L6 in 10% of animals, and L5 in only one sample (3.3%). Ventral branches of L4 and L6 were the least conspicuous on the referred nerve formation in 6.7% of cases while in one animal (3.3%) the L4 and L5 branches presented less contribution to the femoral nerve formation.

With regard to its distribution, it was detected that the femoral nerve was spread through the greater psoas (100%), iliac (100%), pectinal (56.7%), and femoral quadriceps (100%) muscles, and emitted the saphena nerve, which gave branches to the pectinal (43.3%) and sartorius (100%) muscles and continued distally along the saphena artery and vein to divide into the medial face skin of the knee and leg of both antimeres (Figure 2 and 3). Peculiar aspects of muscle branches distribution in each of the samples was also evidenced (Table 2).

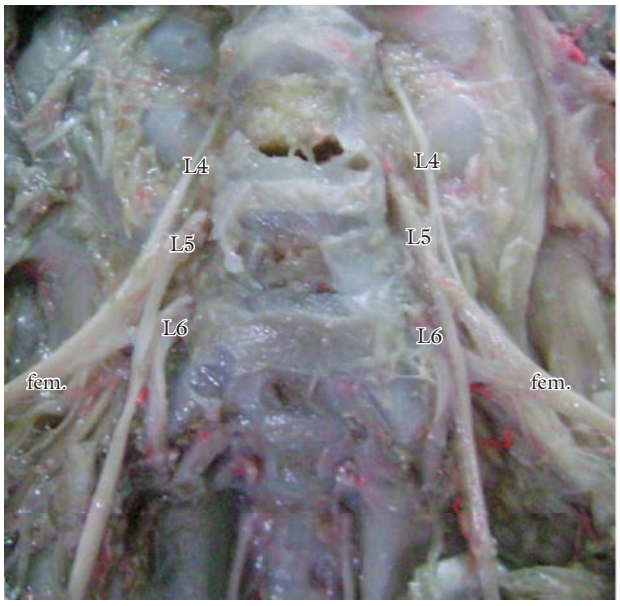
Through the Wilcoxon test application, it was not verified significant differences ($p > 0.05$) between the muscle branches frequency of the femoral nerve given off to the right and left antimeres. However, using the Kruskal-Wallis test it was detected significant differences ($p < 0.05$) between the frequency of the femoral nerve given branches to the same antimere muscle, and it could be observed in both antimeres a greater frequency of given branches to the femoral straight muscle compared to the other muscles (Table 2).

3.1 Discussion

Godinho, Cardoso and Nascimento (1987) stated that the lumbar vertebrae number in domestic species is variable

influencing the lumbar spinal nerve quantity. However, in the fetuses of zebu-crossed bovines of the present research this variation was not identified since all samples presented six lumbar vertebrae.

According to the studies of Schwarze and Schroder (1970), Ghoshal (1986), Godinho, Cardoso and Nascimento (1987), and Dyce, Sack and Wensing (2004) for ruminants, Konig, Liebich and Cerveny (2004) for bovines, and Schwarze and Schroder (1970) and Evans and Delahunta (2001) for carnivores, the femoral nerve origins from the forth (L4), fifth (L5), and sixth lumbar spinal nerves (L6). It should be stressed that the fetuses of zebu-crossed bovines femoral nerves here studied presented several origins (Figure 1),



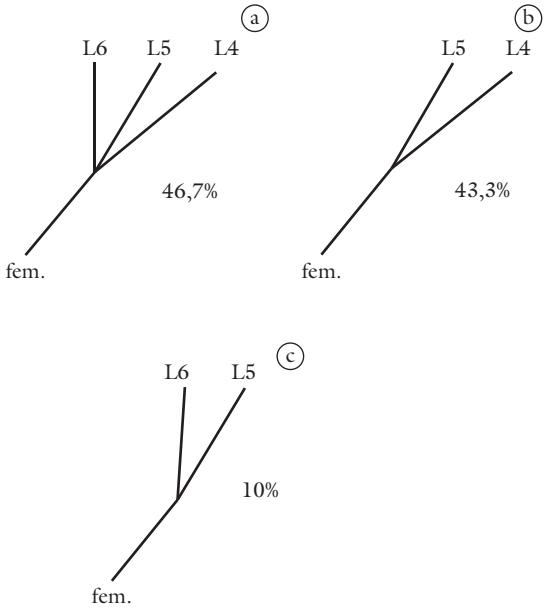


Figure 1. Lumbar spinal nerves (L4 to L6) ventral branches ventral face photography showing the most common femoral nerve origin (fem.) and unilateral schematic design of this nerve origin in three fetuses of zebu-crossed bovines (A, B, C) with its respective occurrence percentages.

however, it was found in the present investigation that this nerve originated from L4, L5, and L6 in 14 animals (46.7%) in accordance with the findings of above mentioned authors.

In addition, in the present study it was observed that the femoral nerve originated from L4 and L5 in 13 samples (43.3%) in accordance with the results of Sisson and Grossman (1972) for bovines and Ghoshal (1986) for caprines. Still, according to Sisson and Grossman (1972), this nerve normally receives L3 and L6 contribution, but such condition was not observed in the fetuses of zebu-crossed bovines regarding the L3 contribution.

Ghoshal (1986) stated that the ovine femoral nerve is normally formed by L5 and L6 ventral branches; however in this study about fetuses of zebu-crossed bovines this fact was found in only 10% of the investigated samples (Figure 1).

The referred nerve presented symmetry related to its origin in all animals (100%), that is, in both antimeres the

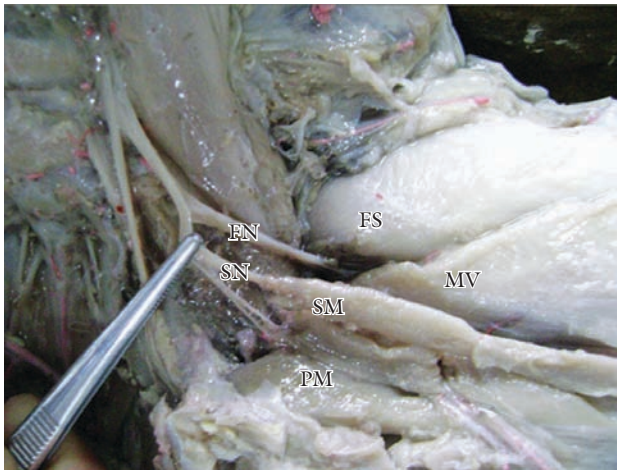


Figure 2. Photography showing the left femoral nerve (FN) ventral face emitting the saphena nerve (SN) and piercing into the femoral quadriceps muscle between the Femoral Straight (FS) and Medial Vast (MV) muscles; (SM) Sartorius muscle; and (PC) Pectinal muscle.

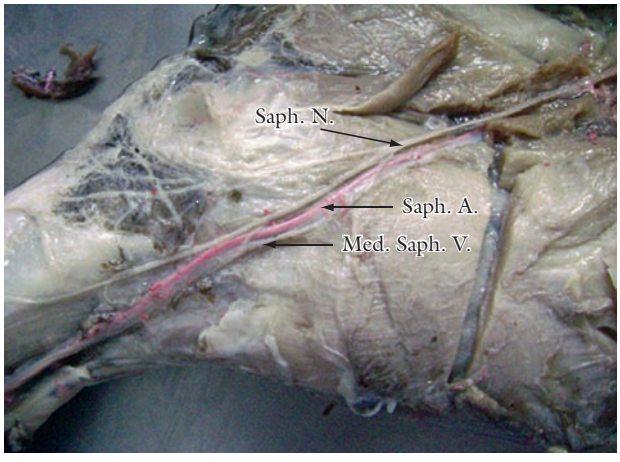


Figure 3. Pelvic limb medial face photography showing saphena nerve (Saph. N.) spreading to the medial surface skin of knee and leg and its relation to the saphena artery (Saph. A.) and medial saphena vein (Med. Saph.V.).

nerve root that originated it was coincident in number, which was not in accordance to Barros (2002) reports that in *Cebus apella* the femoral nerves presented a symmetry related to its origin. Moreover, Lacerda, Moura, Miglino et al. (2006) stressed that on mócos a direct origin of the femoral nerve occurred from the L6 ventral branch, however, in 100% of the samples of the present investigation this nerve was found to be constituted by two or more spinal nerves, which confirmed its multisegmentar nerve characteristic (MACHADO, 2002).

With regard to great or less participation of the spinal nerve ventral branch in the femoral nerve formation (Table 1), it was observed that in reviewed literature this specific information is scarce. There could be found only general citations related to the branches that constitute the referred nerve without mentioning the different proportions between them. However, Ghoshal (1986) mentioned that ruminants have the femoral nerve formed by L5 ventral branch with often contributions, in a variable way, from L4 and L6. Such a description can be observed in 86.7% of the samples in this study, in which the most conspicuous participation on this nerve formation was demonstrated by the L5 ventral branch.

Regarding the muscle branches distribution of the femoral nerve to the greater psoas and iliac muscles, it was shown in the present study in accordance to reports by Ghoshal (1986) for ruminants and Konig, Liebich and Cerveny (2004) for bovines (Figure 2 and 4).

Along the femoral nerve way near the pubic bone cranial branch, this nerve emitted the saphena nerve in all samples (100%) of the present investigation corroborating the Sisson and Grossman (1972) and Konig, Liebich and Cerveny (2004) findings for bovines, the Schwarze and Schroder (1970), Ghoshal (1986), Godinho, Cardoso and Nascimento (1987) and Dyce, Sack and Wensing (2004) findings for ruminants and Evans and Delahunta (2001) findings for carnivores (Figure 2 and 4).

Schwarze and Schroder (1970) and Godinho, Cardoso and Nascimento (1987) researching ruminants and Konig, Liebich and Cerveny (2004) researching bovines emphasized that the innervation of the pectinal muscles is provided by the saphena nerve branches, a fact that was found in 43.3% of this present investigation animals. However, in 56.7% of the fetuses of zebu-crossed bovines assessed, the pectinal muscle branches emerged directly from the femoral nerve before the saphena nerve emission (Figure 4), disagreeing with the above mentioned author reports.

As established by Sisson and Grossman (1972) and Konig, Liebich and Cerveny (2004) for bovines, Schwarze and Schroder (1970), Ghoshal (1986) and Godinho, Cardoso and Nascimento (1987) for ruminants, Evans and Delahunta (2001) for carnivores, and accordingly for fetuses of zebu-crossed bovines of the present research, it was evidenced that the sartorius muscle was provided by the left and right saphena nerves in 100% of the samples (Figure 2 and 4).

According to Schwarze and Schroder (1970), Ghoshal (1986), Godinho, Cardoso and Nascimento (1987) and Dyce, Sack and Wensing (2004) information for ruminants, Sisson and Grossman (1972) and Konig, Liebich and Cerveny (2004) for bovines, and Evans and Delahunta (2001) for carnivores, the femoral nerve after the saphena nerve emition ends in the femoral quadriceps muscle providing its four heads (straight femoral, vast medial, vast lateral, and vast intermediate). The findings of this research are in accordance with these authors reports since this result was found in 100% of zebu-crossed bovine fetuses (Figure 2 and 4).

The saphena nerve route continued distally along the saphena artery and the saphena medial vein, and it was distributed through the medial face of the knee articulation skin and of leg in all studied animals (Figure 3), corroborating to Ghoshal (1986), Godinho, Cardoso and Nascimento (1987) and Dyce, Sack and Wensing (2004) notes.

The adductor muscle innervations reported by Ghoshal (1986) and the gracil muscle innervations described by Schwarz and Schroder (1970) and Konig, Liebich and Cerveny (2004) were not identified in the present investigation thus stressing the muscle diversity supplied by the femoral nerve branches.

Statistically, significant differences between the muscle branches frequency of the femoral nerve given to the left

Table 1. Femoral nerve origin from lumbar spinal nerves ventral branches in fetuses of zebu-crossed bovines, right (RA) and left (LA) antimeres. Uberlândia-MG, 2009.

Ventral branches	Frequency	
	RA	LA
L4	90%	90%
L5	100%	100%
L6	56.7%	56.7%

Table 2. Relative frequency (%) of muscle branches number originated from the femoral nerve to the right (D) and left (E) antimeres muscles in fetuses of zebu-crossed bovines. Uberlândia-MG, 2009.

Muscles	Branches number (%)											
	1		2		3		4		5		6	
	D	E	D	E	D	E	D	E	D	E	D	E
Greater psoas	33.3	50	50	33.3	16.7	16.7	-	-	-	-	-	-
Iliac	40	43.3	46.7	36.7	13.3	20	-	-	-	-	-	-
Pectinal	53.3	40	36.7	53.3	10	6.7	-	-	-	-	-	-
Sartorius	40	33.3	50	56.7	10	6.7	-	-	-	3.3	-	-
Straight femoral	10	3.3	16.7	16.7	43.3	40	20	23.3	10	10	-	6.7
Vast medial	16.7	13.3	56.6	53.3	26.7	33.3	-	-	-	-	-	-
Vast lateral	33.3	26.7	60	56.6	6.7	16.7	-	-	-	-	-	-
Vast intermediate	33.3	23.3	50	50	16.7	20	-	6.7	-	-	-	-

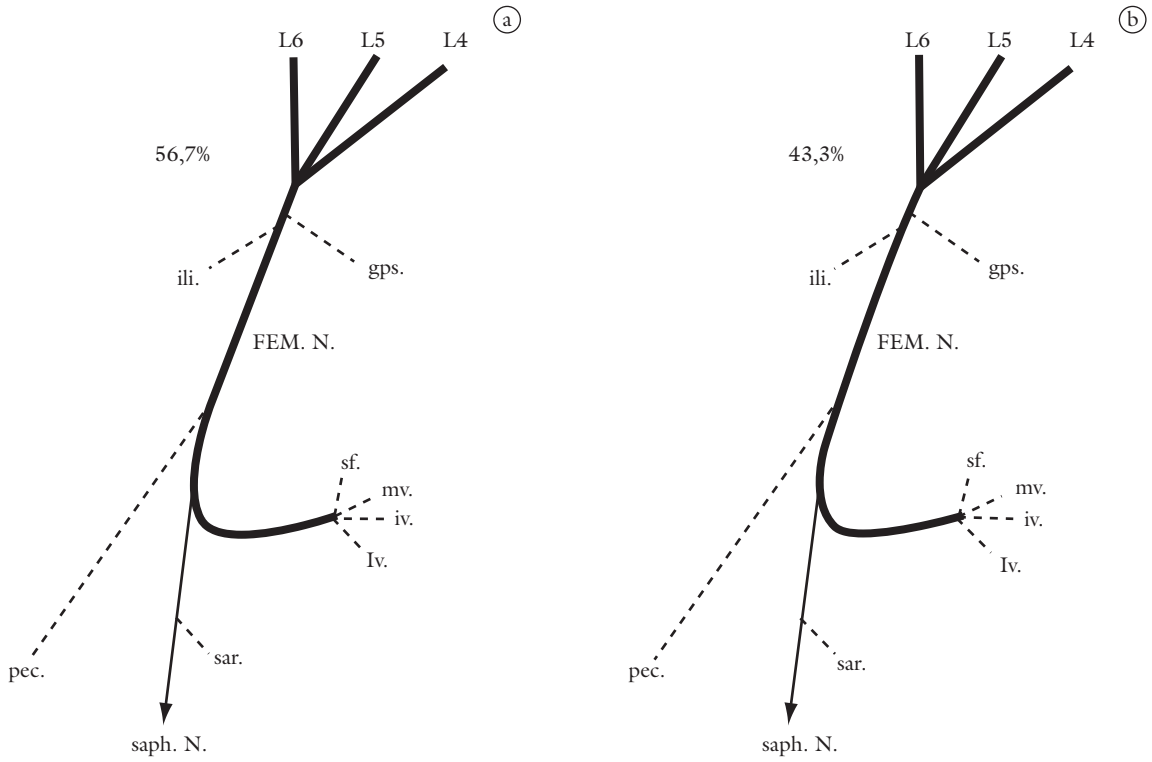


Figure 4. Unilateral schematic design of the femoral nerve (FEM. N.) distribution in two fetuses of zebu-crossed bovine (A, B) with their respective occurrence percentages; (L4 to L6) ventral branches of lumbar spinal nerves; (gps.) greater psoas muscle; (ili.) iliac muscle; (pec.) pectinal muscle; (sf.) femoral straight muscle; (mv.) medial vast muscle; (iv) intermediate vast muscle; (lv.) lateral vast muscle; (sar.) sartorius muscle; and (saph. N.) saphena nerve.

and right antimeres were not evidenced, however, it was observed a greater frequency of the delivered branches to the straight femoral muscle than to other muscles in both antimeres (Table 2). Nevertheless, specific information about muscle the branches frequency of the referred nerve was not reported in the literature making it difficult to discuss these results.

Regarding age range all tratadist report adult animals. Campos, Silva, Severino et al. (2003) and Ferraz, Lopes, Melo et al. (2006) also used fetuses due to the facility of obtaining handling this material compared to adult animals. Ferraz, Lopes, Melo et al. (2006) performed an anatomic study of an intra-pelvic portion of the ischiatic nerve in fetuses of zebu-crossed bovines and mentioned that it is very probable that the ischiatic nerve presents, in adults, similar origin and sintopy to those found in fetuses, keeping the right proportions between the nervous system structures and adjacent tissues. It is believed that this pattern can also be observed regarding the femoral nerve origin and distribution, the subject of the present investigation.

4 Conclusion

The femoral nerve in fetuses of zebu-crossed bovines originated from the L4 to L6 ventral branches and presented symmetry regarding to its origin in all samples.

The referred nerve was distributed to the greater psoas, iliac, femoral quadriceps muscles, and emitted the saphena nerve which gave branches to the pectinal and sartorius muscles and spread in the medial face skin of the knee articulation and leg.

The obtained results related to the femoral nerve origin and distribution in fetuses of zebu-crossed bovines presented common characteristics with corresponding data found in the literature about ruminants, and such important information can provide the basis for clinical or surgical approaches involving the studied structures.

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