DOI: https://doi.org/10.52973/rcfcv-e32102 Revista Cientifica, FCV-LUZ / Vol. XXXII, rcfcv-e32102, 1 - 7

Distribution of the Sciatic nerve in hind limb of Hasmer sheep breed: An anatomical study

Distribución del nervio ciático en la extremidad posterior de la raza de oveja Hasmer: un estudio anatómico

Hulya Balkaya

Department of Anatomy, Faculty of Veterinary Medicine, Ataturk University. Erzurum, Turkey
Email: hulya.balkaya@atauni.edu.tr

ABSTRACT

In order to determine the anatomical arrangement of the branches of the sciatic nerve (SN), in Hasmer sheep breed (HSB), five animals were used for this purpose. After opening the body cavities of the cadavers, they were fixed in 10 % formaldehyde solution. The branches of the SN were dissected separately and photographed. In HSB, it was observed that SN passed through the foramen ischiadicum majus together with its branch, caudal gluteal nerve. At the level of the caudoproximal part of the femur, SN gave off its first prominent branch in hind limb, the common root of the rami musculares. After branching the common root of the rami musculares, SN coursed ventrally; and approximately in the middle of the thigh, it was divided into three nerves: caudal sural cutaneous nerve, tibial nerve, and common peroneal nerve. This anatomical study in the HSB will make a demonstrative contribution to understanding the distribution of SN in hind limb, and support further anatomical and surgical studies in this area.

Key words: Hasmer sheep; sciatic nerve; nerve distribution; anatomy

RESUMEN

Con el objetivo de determinar la disposición anatómica de las ramas del nervio ciático (NC), en la raza ovina Hasmer (HSB), se utilizaron cinco animales para este propósito. Después de abrir las cavidades corporales de los cadáveres, se fijaron en una solución de formaldehído al 10 %. Las ramas del NC se disecaron por separado y se fotografiaron. En la HSB se observó que el NC atravesó el foramen ischiadicum majus junto con su rama, nervio glúteo caudal. A nivel de la parte caudoproximal del fémur, el NC desprendió su primera rama prominente en la extremidad trasera, la raíz común de las ramas musculares. Después de ramificar la raíz común de las ramas musculares, NC cursaba ventralmente; y aproximadamente en la mitad del muslo, estaba dividido en tres nervios: nervio cutáneo sural caudal, nervio tibial y nervio peroneo común. Este estudio anatómico en la HSB hará una contribución demostrativa para comprender la distribución del NC en las extremidades traseras y respaldará más estudios anatómicos y quirúrgicos en esta área.

Palabras clave: Oveja Hasmer; nervio ciático; distribución nerviosa; anatomía

Received: 03/11/2021 Accepted: 15/11/2021 Published: 09/03/2022

INTRODUCTION

In Anatolian husbandry, sheep (*Ovis aries*) have been a significant element for almost 10,000 years (yr) from the Neolithic time, and currently, it is still important in Turkey's national economy [1]. In addition, ancient Central Anatolia played a significant role in the sheep taming process [23].

In 1986, detailed studies were launched in order to improve the sheep meat production in Turkey. Some of these studies are still in process, such as pure breeding and crossbreeding of British, German, and French mutton sheep breeds with Turkish indigenous breeds [8].

Hasmer sheep breed (HSB) was developed as a result of crossbreeding studies at Bahri Dagdas International Agricultural Research Institute, between the yr of 1989 and 2000, in order to create the new meat type sheep in Turkey. HSB contains 31.25 % Hampshire Down, 31.25 % German Black Head, and 37.50 % Merino genotypes [2]. HSB name was created from the first syllables of the pure genotype names (based on Turkish pronunciation) [21]. According to the statement written in the Turkish official newspaper, HSB type is approved as official indigenous animal breed of Turkey.

In experimental studies, sheep is a large animal model which is suitable for nerve regeneration examinations before administration to humans [4]. These animals have similar body size and peripheral nerve size to humans and the rate of nerve regeneration in the two species is similar [14, 15]. Also, sheep nerves are histomorphologically similar to those of humans, in terms of fasciculation [20].

The pelvic viscera and the pelvic limb are innervated by nerves of the lumbosacral plexus [16]. The nerves originating from lumbosacral plexus of mammals are cranial gluteal nerve, caudal gluteal nerve, caudal femoral cutaneous nerve, sciatic nerve, pudendal nerve, and caudal rectal nerves [5, 18]. The SN is originated from sacral plexus and it passes through foramen ischiadicum majus, from which the cranial and caudal gluteal nerves arise in mixed breed sheep [22]. The SN divided into tibial nerve and common peroneal nerve at the end of its course [5].

The nervous web from which the SN arises together with the cranial and caudal gluteal nerves can be exposed to particular risks including getting injured in fractures of the bone or by compression when the mare is giving birth. Paralysis of the common peroneal nerve, which is one of the branches of the SN, leads to overextension of the hock and flexion of the digits. In contrast, any damage to the tibial nerve, which is another branch of the SN, leads to overflexion of the hock and overextension of the digits [6].

Studies based on HSB are generally used for animal husbandry and zootechnical purposes. No studies about the anatomy of the nervous system of this sheep was observed in literature reviews. The majority of the carcass used as meat is constituted by the muscles of the hind limb and gluteal region in HSB, as in most other butchery animal species. These regions are mostly innervated by SN. Additionally, SN and its terminal branches are considerable landmarks for the regional anesthesia of hind limb. The aim of this study was to investigate the anatomical structure of branches of the SN in hind limb and to reveal the course pattern of these branches and their innervation areas in HSB. The results of this study are believed to make a contribution to future surgical and morphological studies in this area and to be improved further with the morphometric studies.

MATERIALS AND METHODS

In the present study, a total of 5 female HSB were used. For anaesthesia, 0.05 miligrams (mg)/ kilograms (kg) of xylazine, followed by 2 $mg \cdot kg^{-1}$ of ketamine were injected intravenously. Sulcus jugularis of the animals was dissected, and the arteria carotis communis was revealed and drained of blood. Then, an incision was made from the pubis to the processus xiphoideus along the linea alba. The muscles and surrounding tissues were dissected, and symphysis pelvis was cut with a costatom (MVM, Liston OT217, Turkey) and the pelvic cavity was opened. The internal organs of the abdominal cavity and pelvic cavity were removed, and the cadavers were fixed in 10 % formalin solution. The 5 sets of pelvic limbs were dissected carefully. At the end of the dissection, SN and its branches that were dispersing in the hind limb were revealed separately and photographed (Iphone 6 plus camera, Apple, USA). The anatomical terms used in this study were based on the Nomina Anatomica Veterinaria [17].

RESULTS AND DISCUSSION

The innervation of muscles in the hind limb was mainly provided by SN in HSB. In the current study, it was observed that SN passed through the foramen ischiadicum majus together with its branch, caudal gluteal nerve (FIG. 1). The caudal gluteal nerve split into muscular branches, for innervation of musculus *gluteus superficialis* and musculus *semitendinosus*, at the caudal and dorsal gluteal region, after exiting from the foramen ischiadicum majus (FIG. 1). At the level of the caudoproximal part of the femur, SN gave off its first prominent branch in hind limb, the common root of the rami musculares. This nerve trunk headed caudally and after a short distance, it emitted six nerve branches for musculus *adductor*, musculus *semimembranosus*, and musculus *semitendinosus* (FIG. 1). Distribution of rami musculares was located in caudal part of the thigh, between the musculus *semitendinosus* and musculus *semimembranosus*, in HSB (FIG. 1).

After branching the common root of the rami musculares, the SN coursed ventrally parallel to the caudoventral margin of musculus *quadriceps femoris*, this course took place among the musculus *semimembranosus*, musculus *adductor*, and musculus *gluteobiceps*; and approximately in the middle of the

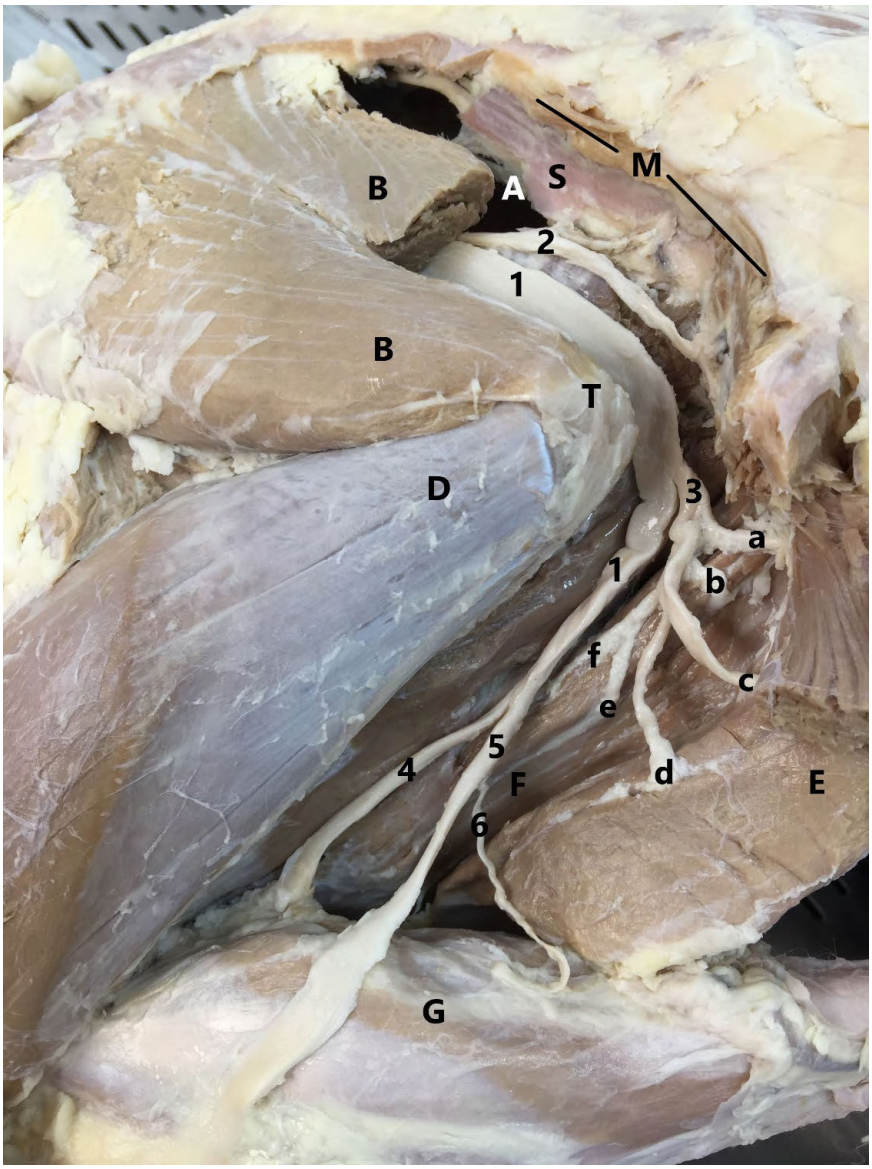

FIGURE 1. Sciatic nerve and its main branches (lateral view of left pelvic limb). 1: Sciatic nerve (SN). 2: Caudal gluteal nerve. 3: Common root of the rami musculares. 4: Tibial nerve. 5: Common peroneal nerve. 6: Caudal sural cutaneous nerve. a, b, c, d, e, f: Rami musculares. A: Foramen ischiadicum majus. B: Musculus *gluteus medius*. D: Musculus *quadriceps femoris* (*vastus lateralis*). E: Musculus *semitendinosus.* F: Musculus *semimembranosus*. G: Musculus *gastrocnemius*. S: Ligamentum *sacrotuberale latum.* M: Musculus *gluteobiceps*

thigh, it was divided into three nerves: tibial nerve, common peroneal nerve, and caudal sural cutaneous nerve. The thinnest and the most caudal nerve of these branches was caudal sural cutaneous nerve. This nerve was proceeding caudally and innervating the caudolateral side of the tarsus and the fascia and skin of the caudal portion of the crus (FIG. 1).

One of the last branches of the SN in the middle of the thigh was the common peroneal nerve in HB (FIG. 1; FIG. 2). After coursing through, the proximal and lateral of the crus with its broad and plain band-like shape, at the level of the condylus lateralis of the tibia and near the origin of the musculus *soleus*, musculus *extensor digitorum lateralis*, and musculus *peroneus longus*, the common peroneal nerve is divided into three branches: the branch for articulatio genu, superficial peroneal nerve, and deep peroneal nerve (FIG. 2). While the nerve branch for articulatio genu went to the femorotibial joint and aponeurosis of musculus *gluteobiceps*, superficial peroneal nerve and deep peroneal nerve proceeded between musculus *peroneus tertius* and musculus *peroneus longus*.

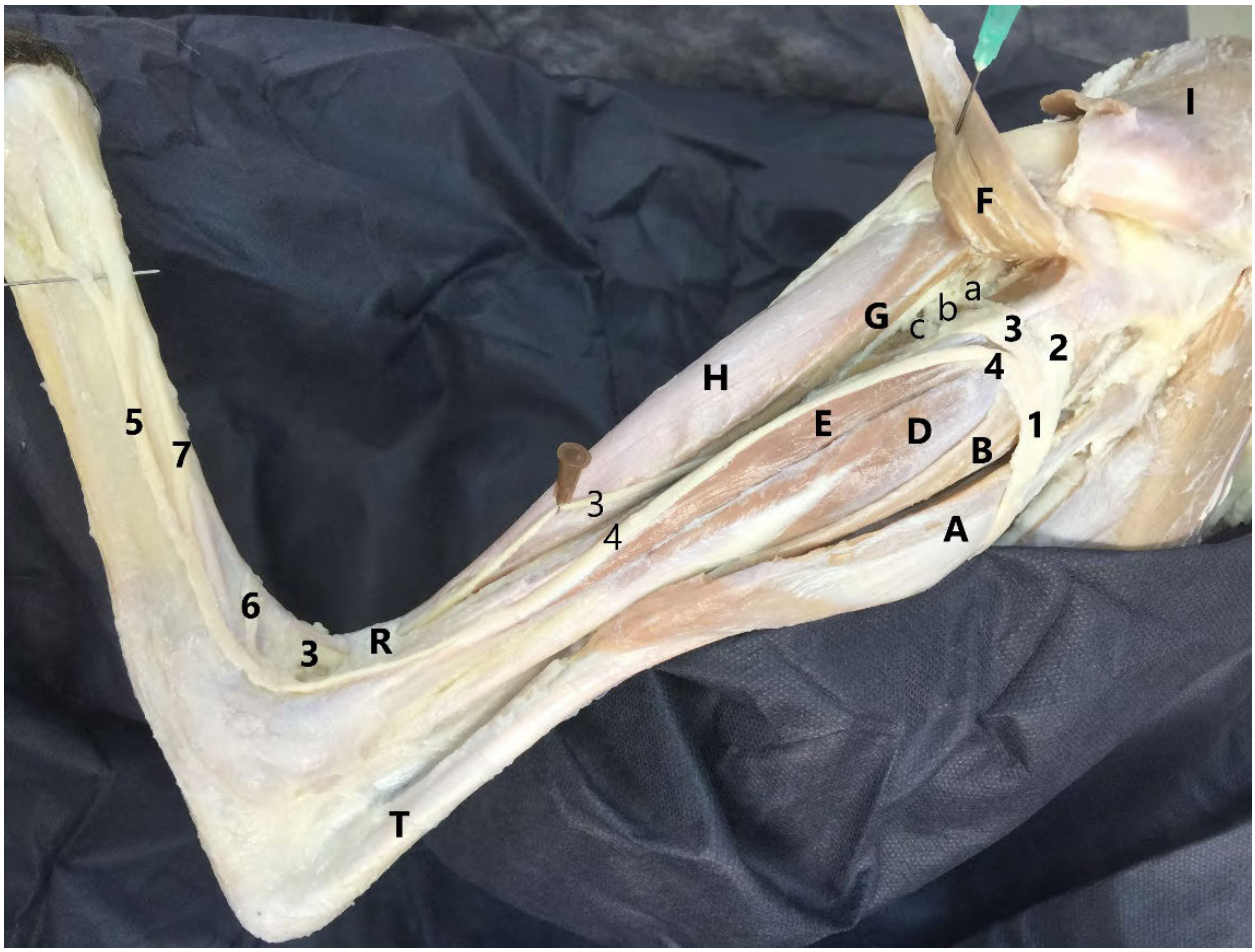

FIGURE 2. Common peroneal nerve (lateral view of left pelvic limb). 1: Common peroneal nerve. 2: Nerve branch for articulatio genu. 3: Deep peroneal nerve. 4: Superficial peroneal nerve. 5: Common dorsal digital nerve IV. 6: Common dorsal digital nerve II. 7: Common dorsal digital nerve III. a, b, c: Muscular branches of deep peroneal nerve. A: Musculus *gastrocnemius*. B: Musculus *soleus*. D: Musculus *extensor digitorum lateralis*. E: Musculus *peroneus longus*. F: Musculus *peroneus tertius*. G: Musculus *extensor digitorum longus*. H: Musculus *tibialis cranialis*. I: Musculus *biceps femoris*. T: Tendo calcaneus communis. R: Retinaculum extensorium proximale

Deep peroneal nerve ramified into three branches among the musculus *peroneus tertius*, musculus *peroneus longus*, and musculus *extensor digitorum longus* and distributed into these muscles and the caudal part of the musculus *tibialis cranialis* (FIG. 2). After this ramification, deep peroneal nerve coursed distally between the musculus *peroneus longus* and musculus *extensor digitorum longus*. At the end of this course deep peroneal nerve passed through retinaculum extensorium proximale and travelled towards the dorsal components of the pedis (FIG. 2).

In HSB, it was observed that near the origin of the musculus *peroneus longus* and musculus *extensor digitorum lateralis*, in the proximolateral part of the crus, one of the three branches of common peroneal nerve was the superficial peroneal nerve (FIG. 2). This nerve ramified into two branches just after its origin. These two branches of the superficial peroneal nerve innervated musculus *extensor digitorum lateralis* and musculus *peroneus longus*. After this ramification, superficial peroneal nerve directed distally and travelled between musculus *extensor digitorum longus* and musculus *peroneus longus*. At the end of this course, this nerve passed to the lateral side of the retinaculum extensorium proximale and at this point it branched common dorsal digital nerve II (FIG. 2). After this ramification, it emitted common dorsal digital nerve III (FIG. 2), to the dorsal side of the metatarsal region. At the end of this course, superficial peroneal nerve proceeded as common dorsal digital nerve IV (FIG. 2) on the dorsolateral component of the pedis.

One of the three terminal branches of SN was the tibial nerve which originated almost at the middle level of the thigh (FIG. 1; FIG. 3). In HB, this nerve originated from the cranial edge of the SN. It extended ventromedially, and after reaching the popliteal area, it emitted two branches between the proximal parts of the caput laterale and caput mediale of the musculus

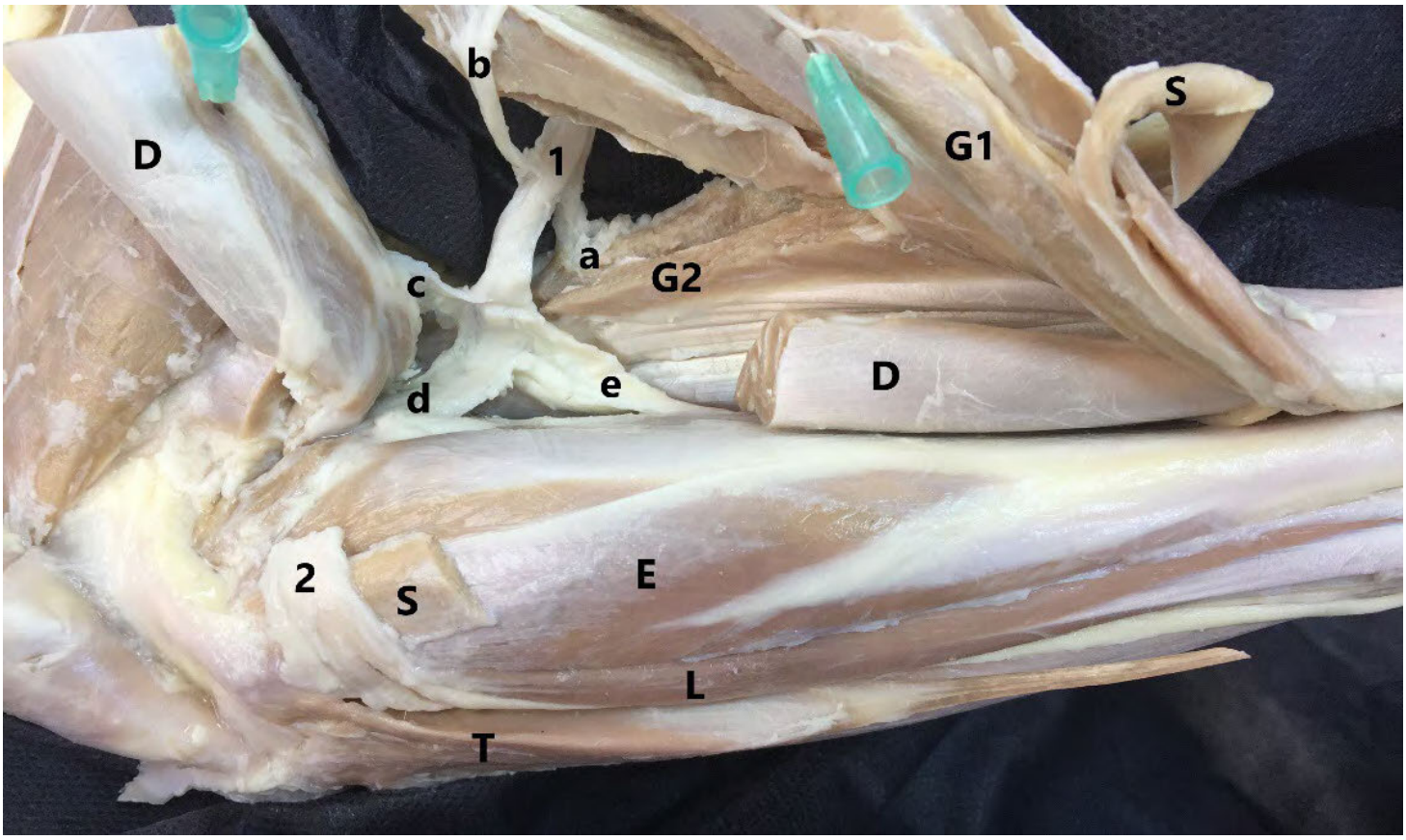

FIGURE 3. Tibial nerve (lateral view of left pelvic limb). 1, e: Tibial nerve. 2:& Common peroneal nerve (cut). a, b, c, d: Muscular branches of tibial nerve. G1: Musculus *gastrocnemius caput laterale*. G2: Musculus *gastrocnemius* caput mediale. D: Musculus *flexor digitorum superficialis*. E: Musculus *extensor digitorum lateralis*. S: Musculus *soleus* (cut). L: Musculus *peroneus longus*. T: Musculus *peroneus tertius*

gastrocnemius, and innervated these muscles (FIG. 3). After this ramification, tibial nerve coursed a short distance, between the two heads of the musculus *gastrocnemius*, and branched again into two nerves which were short and flat band in shape (FIG. 3). These branches were innervating musculus *popliteus*, musculus *tibialis caudalis*, and musculus *flexor digitorum superficialis* in the caudoproximal area of the crus. After this ramification, tibial nerve was coursing caudally, as a wide flat band shape, and travelled between tendo calcaneus communis and caudal edge of the crus. At the end of this course, tibial nerve bifurcated into lateral plantar nerve and medial plantar nerve at the craniomedial face of the tuber calcanei. Lateral plantar nerve, after a short course, passed between talus and calcaneus and innervated tarsal joint, tendon of musculus *flexor digitorum profundus*, and lateral component of the metatarsal area. While the lateral plantar nerve proceeded laterally, medial plantar nerve ran at the plantar region of the pedis coursing collateral to the tendon of musculus *flexor digitorum superficialis*, and innervated the digital parts of the foot.

The SN proceeds from its origin and goes through the foramen ischiadicum majus, giving rise to the cranial gluteal nerve and caudal gluteal nerve in mixed breed sheep. In HSB examined in this study, SN passed through the foramen ischiadicum majus together with its branch, caudal gluteal nerve in contrast to the findings of Vasconcelos *et al*. [22]. However, Erden [7] reported that caudal gluteal nerve originated from the first and second sacral spinal nerves and the last lumbar spinal nerve in Angora goats (*Capra hircus*) and Akkaraman sheep.

In sheep, it was indicated that rami musculares were different in size and released by the SN to supply the musculus *gluteus medius*, musculus *gluteobiceps*, musculus *gluteus profundus*, musculus *gemelli*, musculus *obturatorius externus*, musculus *quadratus femoris*, musculus *semitendinosus*, musculus *semimembranosus*, and musculus *adductor* [12]. In the current study, contrary to Ghoshal and Getty's [12] findings, it was found that the rami musculares were a thick common root which was separated from the SN. This nerve trunk emitted six nerve branches for musculus adductor, musculus *semimembranosus*, and musculus *semitendinosus*.

In the present study, it was observed that the SN gave off its terminal branches at the middle level of the thigh; these branches were tibial nerve, common peroneal nerve, and caudal sural cutaneous nerve, from cranial to caudal. However, Godinho *et al*. [13], De Lima *et al*. [3], and Vasconcelos *et al*. [22]

reported that the tibial nerve and common peroneal nerve were the terminal branches of the SN, originating distally near the trochanter majus of femur.

In sheep, Ghoshal and Getty [12] indicated that the SN apparently divided into common peroneal nerve and tibial nerve usually at the 1 centimeter (cm) distal to the origin of the caudal sural cutaneous nerve, near the middle of the thigh. Caudal sural cutaneous nerve distributed in the fascia and skin of the lateral aspect of the tarsus; and in the majority of the cases, this nerve arose directly from the SN. In this study, in contrast with Ghoshal and Getty's [12] findings, caudal sural cutaneous nerve was one of the three terminal branches of the SN in HSB, although some researchers indicated that this nerve may also be derived from the peroneal nerve or tibial nerve [9 - 11]. Similar to the Ghoshal and Getty's [12] findings, caudal sural cutaneous nerve was innervating the caudolateral side of tarsus and the fascia and the skin of the caudal portion of the crus in this study.

Popesko [19] illustrated that common peroneal nerve bifurcated between musculus *peroneus longus* and musculus *extensor digitorum lateralis* in sheep. Also Erden [7] displayed that common peroneal nerve divided into superficial peroneal nerve and deep peroneal nerve at the level of the sulcus extensorius of tibia in Akkaraman sheep and Angora goat. This researcher also reported that the common peroneal nerve continued as common dorsal digital nerve III in both animal species. But, in HSB it was observed that the common peroneal nerve bifurcated into superficial peroneal nerve and deep peroneal nerve near the origin of the musculus *extensor digitorum lateralis* and musculus *peroneus tertius* at the level of the proximal part of the tibia. The superficial peroneal nerve proceeded as common dorsal digital nerve IV on the dorsolateral component of the pedis.

It was reported that tibial nerve was the thickest nerve among the terminal branches of the SN [5]. Likewise, in HSB examined in this study, the tibial nerve was the thickest nerve among the terminal branches of the SN. Some researchers noticed that the tibial nerve run between the musculus *gastrocnemius* caput laterale and musculus *gastrocnemius* caput mediale to reach and supply the caudal muscles of the crus [5, 6, 18]. They also reported that it bifurcated into lateral plantar nerve and medial plantar nerve at the level of the point of the hock. Similar to the findings of the previous studies [5, 6, 18], it was found that tibial nerve ramified into its branches inside the muscles of the caudoproximal area of the crus and innervated this area. At the end of this ramification, tibial nerve bifurcated into lateral plantar nerve and medial plantar nerve at the craniomedial face of the tuber calcanei

CONCLUSIONS

In conclusion, this study demonstrated the anatomical structure of the SN in hind limb of HSB. The present study will help to understanding the anatomical variety of ramification patterns of peripheral nerves among different species. Additionally, these findings will contribute to the future understanding of the branching patterns of the SN in other species. The present study explain the distribution of SN through the hind limb of HSB and supply specific anatomical data about the innervation of this body part of these animals. These findings are also expected to contribute to the knowledge about regional anesthesia applications of the hind limb and treatment of peripheral nerve injury in these regions.

ACKNOWLEDGEMENTS

This study has not received any funding support. There was no contribution of other colleagues or institutions. All procedures were carried out in exact accordance with the principles of Ethical Committee of Animal Experiments. The author declare no conflict of interest for this study.

BIBLIOGRAPHIC REFERENCES

[1] ARBUCKLE, B.S; OZTAN, A; GULCUR, S. The evolution of sheep and goat husbandry in central Anatolia. **Anthropozool.** 44: 129-157. 2009.

[2] ANATAN, T; KAN, M; KIRBAŞ, M; AKAY, N; YILMAZ, O. Adult live weight estimates of Hasmer and Hasak sheep with their some body measurements. **Balkan Agriculture Congress.** Edirne, 10/08-10. Turkey. 238 pp. 2014.

[3] DE LIMA, E.M.M; SILVA, F.O.C; SEVERINO, R.S; DRUMMOND, S.S; CAMPOS, D.B; SANTANA, M.I.S; DE MORAES, D.D.A. Origin and distribution of the ischiatic nerves in goats of the Saanen breed. **Cien. Rural.** 38: 372-377. 2008.

[4] DIOGO, C.C; CAMASSA, J.A; PEREIRA, J.E; COSTA, L.M; FILIPE, V; COUTO, P.A; GEUNA, S; MAURICIO, A.C; VAREJÃO, A.S. The use of sheep as a model for studying peripheral nerve regeneration following nerve injury: Review of the literature. **Neurol. Res.** 39: 926–939. 2017.

[5] DURSUN, N. Nervi Spinales. In: **Veteriner Anatomi III**. 5th Ed. Medisan Press, Ankara. Pp 90-148. 2000.

[6] DYCE, K.M; SACK, W.O; WENSING, C.J.G. Nervi Spinales. In: **Text Book of Veterinary Anatomy**. 4th Ed. Saunders Elsevier, Missouri. Pp 320-327. 2010.

[7] ERDEN, H. Akkaraman koyunu ve Ankara kecisinin plexus lumbosacralis'i uzerinde karsılastirmali makroanatomik ve subgros calısmalar. **S.U. Vet. Fak. Derg.** 8: 45-50. 1992.

[8] ERTUGRUL, M; ELICIN, A; CENGIZ, F; DELLAL, G. Akkaraman, Border Leicester x Akkaraman (F1) Dorset Down x Akkaraman (F1) ve Ile de France x Akkaraman (F1) Melezi Erkek Kuzuların Besi Gucu ve Karkas Ozellikleri. Ankara Univ. Ziraat Fak. Yayınları No: 1143. 208 pp. 1989.

[9] GHOSHAL, N.G. Crus and Pes of the Domestic Animals (Bovidae, Ovidae, Capridae, Suidae, Equidae). In: A Comparative Morphological Study of the Somatic Innervation of the Antebrachium and Manus. ProQuest Dissertations Publishing of Iowa State University. PhD Thesis. 274 pp. 1966.

[10] GHOSHAL, N.G; GETTY, R. Innervation of leg and foot in the ox (*Bos taurus*), sheep (*Ovis aries*) and goat (*Capra hircus*). **Indian J. Anim. Hlth.** 6: 59-73. 1967.

[11] GHOSHAL, N.G; GETTY, R. A comparative morphological study of the somatic innervation of the crus and pes of the domestic animals (*Bos taurus*, *Ovis aries*, *Capra hircus*, *Sus scrofa domesticus*, *Equus caballus*). **Iowa State J. Sci.** 42: 297-310. 1968

[12] GHOSHAL, N.G; GETTY, R. The lumbosacral plexus (*plexus lumbosacralis*) of the sheep (*Ovis aries*). **N. Z. Vet. J.** Palmerston North. 19: 85-90. 1971.

[13] GODINHO, H.P; CARDOSO, F.M; NASCIMENTO, J.F. Nervios espinales. In: **Anatomia dos ruminantes domésticos.** Universidade Federal de Minas Gerais, Belo Horizonte. 438 pp. 1987.

[14] JEANS, L; GILCHRIST, T; HEALY, D. Peripheral nerve repair by means of a flexible biodegradable glass fibre wrap: A comparison with microsurgical epineurial repair. **J. Plast. Reconstr. Aesthetic. Surg.** 60: 1302-1308. 2007.

[15] LAWSON, G; GLASBY, M. A comparison of immediate and delayed nerve repair using autologous freeze-thawed muscle grafts in a large animal model: The simple injury. **J. Hand. Surg.** 20: 663-700. 1995.

[16] MILLER, M.E. The Vessels And Nerves Of The Pelvic Limb. In: **Guide to the dissection of the dog**. 3rd Ed. Edwards Brothers Inc., New York. Pp 222-256. 1952.

[17] INTERNATİONAL COMMİTTEE ON VETERİNARY GROSS ANATOMİCAL NOMENCLATURE. Myologia, Systema Nervosum. In: **Nomina Anatomica Veterinaria.** 6th Ed. International Committee on Veterinary Gross Anatomical Nomenclature Publishing. Hanover, Ghent, Columbia, Rio de Janeiro. 178 pp. 2017.

[18] PASQUINI, C; SPURGEON, T; PASQUINI, S. Nerves Of Pelvic Limb. In: **Anatomy of Domestic Animals.** 7th Ed. Sudz Publishing, Texas. Pp 437-451. 1995.

[19] POPESKO, P. Koyun (*Ovis aries*). In: **Evcil hayvanlarin Topografik Anatomi Atlasi.** Ayyildiz, A (Ed.). Nobel Tip Kitapevleri, Istanbul. Pp 81-87. 2010.

[20] STRASBERG, S.R; MACKINNON, S.E; GENDEN, E.M; BAIN, J.R; PURCELL, C.M; HUNTER, D.A; HAY, J.B. Long-segment nerve allograft regeneration in the sheep model: Experimental study and review of the literature. **J. Reconstr. Microsurg.** 12: 529-537. 1996.

[21] TEKIN, M.E; GURKAN, M; KARABULUT, O; DUZGUN, H. Performance Testing Studies and the Selection of Hasmer, Hasak, Hasiv and Linmer Crossbreed Sheep Types: II. Pre-Weaning Growth. **Turk. J. Vet. Anim. Sci.** 29: 59-65. 2005.

[22] VASCONCELOS, B.G; SANTOS, M.C.D; SANTOS, A.C; VIANA, D.C; HONORATO, A.G.O; PEREIRA, C.C.H; BORELLI, V; SILVA, F.O.C. Origin and distribution of the ischiatic nerve in mixed-breed sheep. **Braz. J. Vet. Res. Anim. Sci.** 51: 102-110. 2014.

[23] ZEDER, M.A. Domestication and early agriculture in the Mediterranean Basin: origins, diffusion, and impact. **Proc. Natl. Acad. Sci. U.S.A.** 105: 11597-11604. 2008.