

The dissemination of pelvic limb nerves originating from the lumbosacral plexus in the porcupine (*Hystrix cristata*)

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ABSTRACT: In this study the nerves originating from the plexus lumbosacrales of porcupines (*Hystrix cristata*) were investigated. Four porcupines (two males and two females) were used. The plexus lumbosacrales of animals were appropriately dissected and dissemination of pelvic limb nerves originating from the plexus lumbosacrales was examined. The nerves originated from the plexus lumbosacrales of porcupines (*Hystrix cristata*): iliohypogastric nerve from T15, ilioinguinal nerve (on the left side of only one animal) genitofemoral and lateral femoral cutaneous nerves from T15 and L1, the femoral and obturator nerves from T15, L1, L2 and L3. The femoral nerve divided into two as the common dorsal digital nerve I and II after it branched into motor and skin nerves. The cranial gluteal nerve originated from L3 and L4 in males and from only L3 in females. The caudal gluteal nerve and the caudal femoral cutaneous and sciatic nerves originated from the common root which was formed by the union of L3, L4 and S1 in one animal, and by the union of L3, L4, S1 and S2 in the three other animals. The sciatic nerve divided into the tibial and fibular nerve. The fibular nerve divided into two as the common dorsal digital nerve III and IV, and extended after branching in one direction to extensor muscles. The tibial nerve divided into the common palmares digital nerve I, II, III and IV, and extended after branching into the cutaneous surae caudales nerve and rami muscle distales. The cutaneous surae caudales nerve divided into the common palmar and dorsal digital nerve V. The pudendal and caudal rectal nerves originated from S2 in three animals and from S1 in the remaining animal. In the point of origin from the branches of spinal nerves originating from the plexus lumbosacrales, and also in the absence of the ilioinguinal nerve (on left side abroad of only one animal), originating from T15 and L1 of the genitofemoral and lateral femoral cutaneous nerves, from T15 of the iliohypogastric nerve, the studied porcupines differed from rodentia and other mammals

Keywords: lumbosacral plexus; dissemination; pelvic limb's nerves; posterior legs; porcupines (*Hystrix cristata*)

List of abbreviations

M = musculus, T = thoracal, L = lumbal, S = sacral, Ca = caudal

The porcupine is a member of the Hystricidae family, a little group of Rodentia (Karol, 1963; Weichert, 1970; Kuru, 1987; Demirsoy, 1992).

The nerves that spread into the posterior legs originating from the plexus lumbosacrales have been studied in a variety of mammals including the dog (Miller et al., 1964; Getty, 1975), the rabbit (Barone et al., 1973; McLaughlin and Chiasson, 1987), and the rat (Green, 1968; Chiasson, 1980; Schmalbruch, 1986; Asato et al., 2000). In the

porcupines (*Hystrix cristata*), the brachial plexus (Aydin, 2003), the nerves originating from the brachial plexus (Aydin, 2004), the morphology of circulus arteriosus cerebri (Aydin et al., 2005), and the spinal nerves that constitute the plexus lumbosacrales (Aydin et al., 2009) have been studied. However, to the author's knowledge this is the first study on the nerves originating from the plexus lumbosacrales of porcupines (*Hystrix cristata*). The purpose of this study was to document the nerves

that spread to the posterior legs, and which originate from the plexus lumbosacrales of the porcupines (*Hystrix cristata*).

MATERIAL AND METHODS

Four porcupines (two males and two females) which had been caught by hunters were used. The abdominal cavity was opened by an incision along the linea alba and the dissection of muscles. The symphysis pelvis of the os coxae was cut with a costatom, and the pelvic cavity was opened. The organs of the cavum abdominis and pelvis were removed without the nerves originating from the plexus lumbosacrales quadratus lumborum muscle, and the psoas minor and major muscles were dissected carefully. Afterwards, the ventral part of the corpus of the lumbar and sacral vertebra from the last thoracic vertebra to the end of sacrum was cleared completely. The supply of the nerve branches originating from the plexus lumbosacrales in both the posterior legs was examined and photographed. For the terminology, the Nomina Anatomica Veterinaria was used (World Association of Veterinary Anatomists, 1994).

RESULTS

The iliohypogastric nerve originated from the ventral ramus of T15. After emerging between the

psoas major and minor muscles, it divided into three as the medial, intermedius and lateral ramus at the medial side of the abdominal wall. The medial and intermedius ramus supplied the abdominal muscles and periton, while the lateral ramus was spread over the paralumbal fossa, craniolateral part of the femur and the ventral abdominal wall.

The genitofemoral nerve originated from the ventral ramus of T15 and L1 with the lateral femoral cutaneous nerve. After emerging between the lumbar muscles, it extended subperitoneally and in a caudo-ventral direction toward the anulus inguinalis abdominalis. Its motor fibers supplied the internus obliquus abdominis and cramester muscles while the sensitive fibers supplied the testicular fascia, funiculus spermaticus and praeputium in males, the mammae in females, and the skin of the medial side of femoral region in both sexes.

The lateral femoral cutaneous nerve arose from the lumbosacral plexus with the genitofemoral nerve. It was spread over the skin of the femoral region and the craniomedial side of the knee joint.

The femoral nerve originated from the ventral ramus of L2 and L3 mostly with contributions from T15 and L1. It was the thickest nerve of the lumbosacral plexus. After emerging between the psoas major and minor muscles, it reached the spatium femorale with a caudo-ventral course where lay its motor branches. Lower down, the saphenous nerve arose. It divided into two as the common dorsal digital nerves I and II after branching to supply the skin and fascia (Figure 1).

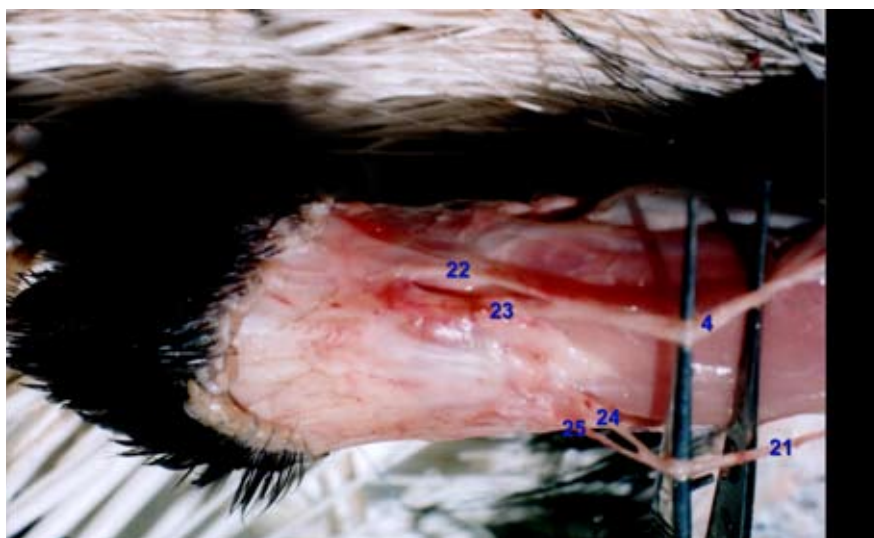


Figure 1. The branches of nerve which extend to the dorsum of the digitis. 4 = femoral nerve; 21 = superficial peroneal fibular nerve; 22 = digital dorsal commun I nerve; 23 = digital dorsal commun II nerve; 24 = digital dorsal commun III nerve; 25 = digital dorsal commun IV nerve

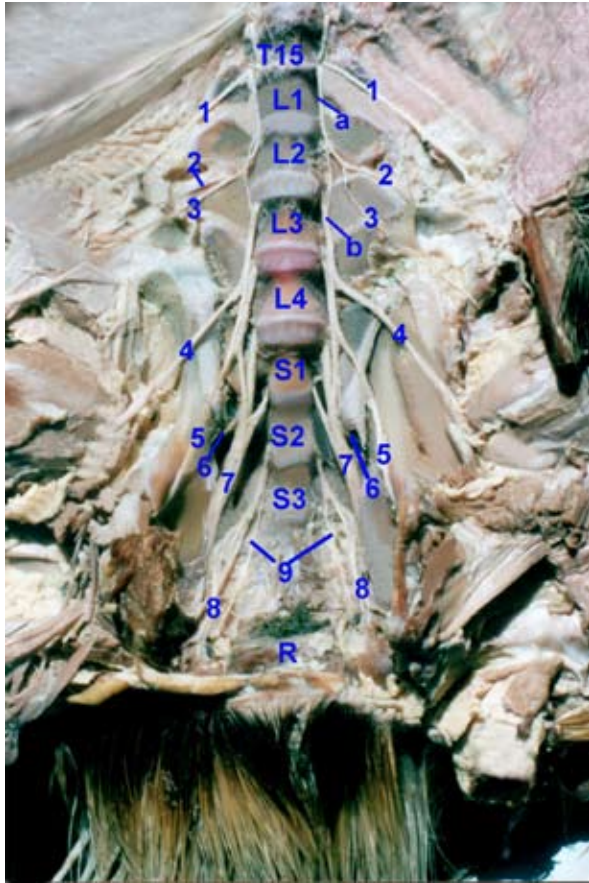


Figure 2. View from the cavum abdominal and pelvis of the plexus lumbosacralis in female porcupines. a = branch from T15 to L1; b = branch from L1 to L2; 1 = iliohypogastric nerve; 2 = lateral cutaneous femoral nerve; 3 = genitofemoral nerve; 4 = femoral nerve; 5 = obturatorial nerve; 6 = cranial gluteal nerve; 7 = the common root which was formed by the union of L3, L4, S1 and S2; 8 = pudendal nerve; 9 = caudal rectal nerve; R = rectum

The obturator nerve had a similar origin to the femoral nerve. After leaving the pelvic cavity through the foramen obturatorum, it supplied the adductor, pectineus, gracialis, obturator internus and externus muscles.

The cranial gluteal nerve originated from the ventral ramus of L3 and L4 in males and from only L3 in females. After leaving the pelvic cavity through the incisura ischiadica major, it supplied the gluteal muscles.

The caudal gluteal nerve, along with the caudal femoral cutaneous and sciatic nerves, originated from the common root which was formed by the union of the entire ventral ramus of L4 and S1 and some slender branches coming from L3 and S2. The caudal gluteal nerve is a motor nerve arising



Figure 3. View of the nerves originating from the common root which was formed by the union of L3, L4, S1 and S2 in the gluteal region. 10 = caudal gluteal nerve; 11 = superficial perineal nerve; 12 = profund perineal nerve; 13 = caudal cutaneous femoral nerve; 14 = ischiadic nerve; 15 = peroneus fibular nerve; 16 = tibial nerve; 17 = proximal ramus musculare

from the caudal portion of this common root. It supplied the gluteal superficial muscle, the caudal portion of the proximal part of the gluteofemoral muscle, cranial part of the biceps femoris and the vertebral head of semitendinosus.

The caudal femoral cutaneous nerve arose from the common root which was formed by the union of L3, L4, S1 and S2, from the caudal portion of the caudal gluteal nerve. This mixed nerve supplied the biceps femoris and semitendinosus muscle, and after passing between these muscles, supplied the skin over the tuber ischiadicum and the caudal portion of the femur.

The rectal caudal nerve supplied up to the end of the rectum, the sphincter muscles of the anus and the skin of the anal regions.



Figure 4. View of the nerves which branched from the caudal cutaneous surae nerve. 18 = caudal cutaneous surae nerve; 21 = superficial peroneus fibular nerve; 24 = digital dorsal commun III nerve; 25 = digital dorsal commun IV nerve; 26 = digital dorsal commun V nerve; 27 = digital palmar commun V nerve

The pudendal nerve arose from S2 in three animals and from S1 and S2, along with the caudal rectal nerve, in one animal. It extended toward the caudal pelvic aperture where it divided into the superficial and profund perineal nerves. These branches in turn, were supplying the skin and muscles of the anal and perianal regions (Figure 2).

The common root continued as the sciatic nerve after branching into the caudal femoral cutaneous nerve. The sciatic nerve branched to give the proximal muscular ramus between the gluteofemoral, biceps femoris and adductores muscles. This branch extended to the skin after supplying the caudal portion of the biceps femoris muscle, semitendinosus and semimembranosus muscle. The sciatic nerve was divided into the tibial and common fibular nerves (Figure 3).

The tibial nerve first branched to give the cutaneous surae caudal nerve, after diverging from the sciatic nerve. This nerve extended until the tarsal joint level, giving slender branches to skin in this region and divided into the digitalis dorsalis and palmaris communis nerve V (Figure 4).

After this branch, it supplied the distal muscular ramus which extended to the flexor muscles between the two heads of the gastrocnemius muscle (Figure 5). Its continuation supplied the muscles on the palmar surface of the metatarsus and diverged into the digitalis palmaris communis nerves I, II, III, IV (Figure 6).

The common fibular nerve passed over the gastrocnemius muscle and entered the sulcus between the peroneus longus and extensor digitorum lateralis muscles, then dividing into the superficial fibular ramus and profund fibular ramus nerves. The superficial fibular nerve supplied the skin of the dorsum of the tarsus and metatarsus and formed the digitalis dorsalis communis nerves III and IV (Figure 1). The profund fibular nerve supplied the extensor muscles on the cruris.

DISCUSSION AND CONCLUSION

The formation of the iliohypogastric and the ilioinguinal nerves in various domestic mammals has been reported in the literature as follows: in equidae and ruminants which have six lumbar vertebrae, the iliohypogastric nerve arises from the ventral ramus of L1 and the ilioinguinal nerve arises from the ventral ramus of L2 (Getty, 1975; Tecirlioglu, 1983; Dursun, 2000); in dogs and cats which have seven lumbar vertebrae, there exist two iliohypogastric nerves, cranial and caudal, which arise from the ventral ramus of L1 and L2 and the ilioinguinal nerve which arises from the ventral ramus of L3 (Miller et al., 1964; Getty, 1975; Tecirlioglu, 1983; Dursun, 2000); in rats the iliohypogastric arises from the ventral ramus of T13 and L1 and the ilioinguinal nerve arises from the ventral rami of L1 and

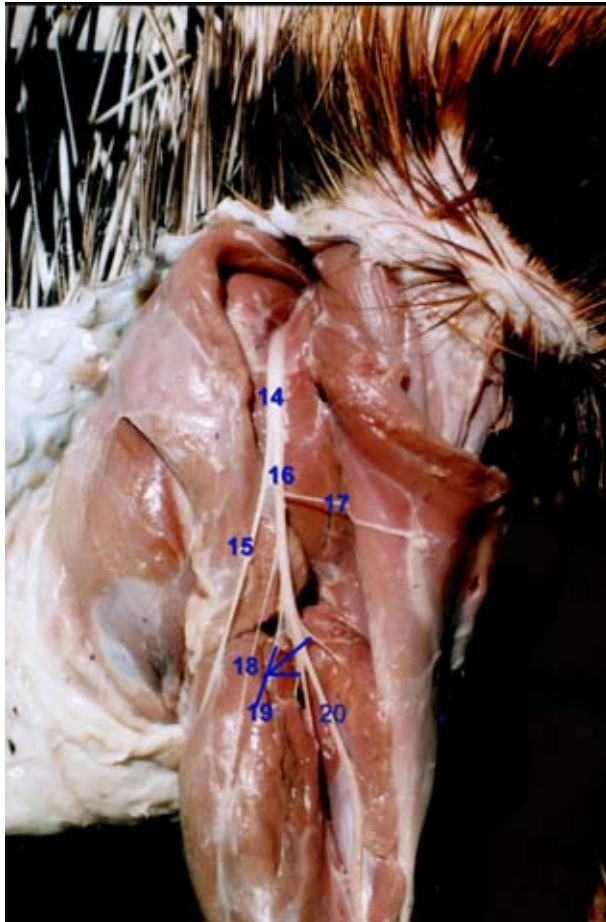


Figure 5. View of branches of the ischiadic nerve. 14 = ischiadic nerve; 15 = peroneous fibular nerve; 16 = tibial nerve; 17 = proximal muscular; 18 = caudal cutaneous surae nerve; 19 = the proximal muscular ramus which extends to flexor muscles; 20 = continuous branching of the tibial nerve

L2 (Green, 1968), in guinea pigs the iliohypogastric arises from the ventral ramus of L4 (Cooper and Schiller, 1975). In all these studies it was reported that these two nerves supply the same regions. This report, however, documents the absence of the ilioinguinal nerve in porcupines, except on the left side of one animal, and an iliohypogastric nerve arising from the ventral ramus of T15 (last thoracic) which is completely different from previous reports.

The formation of the genitofemoral and lateral femoral cutaneous nerves in various domestic mammals was reported in the literature as follows: in sheep, goats (Getty, 1975) and guinea pigs (Cooper and Schiller, 1975) both nerves arise from the ventral ramus of L3 and L4, in rabbits from the ventral ramus of L4 and L5 (McLaughlin and Chiasson, 1987), in dogs the lateral femoral cutaneous nerve

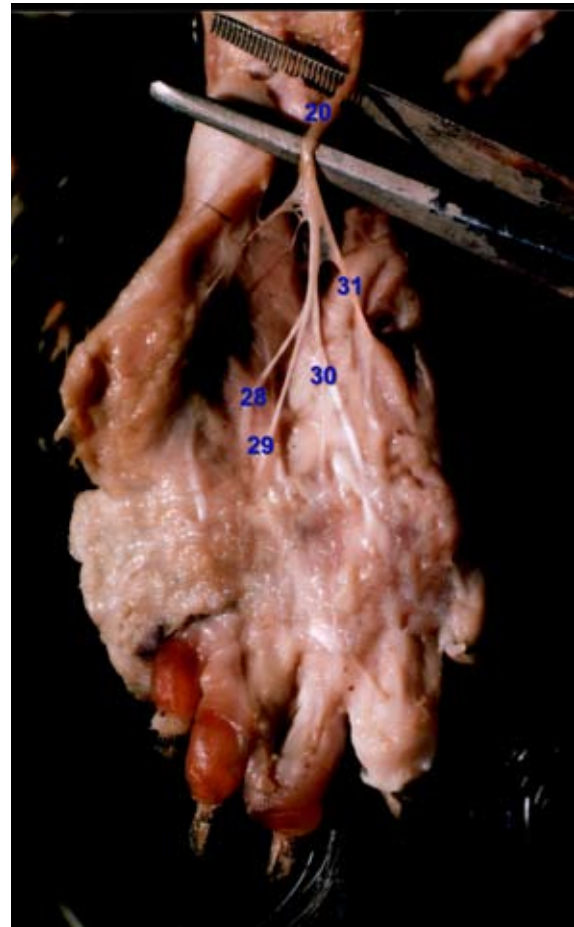


Figure 6. View of the nerves which branched from the tibial nerve at the palmare of digitis. 28 = digital palmar commun IV nerve; 29 = digital palmar commun III nerve; 30 = digital palmar commun II nerve; 31 = digital palmar commun I nerve

arises mostly from the ventral ramus of L4, while occasionally there might be contributions from L3 or L4 (Miller et al., 1964; Getty, 1975), in cats the lateral femoral cutaneous nerve arises from the ventral ramus of L4 and L5 and the genitofemoral nerve arises from the ventral ramus of L3 (Getty, 1975), in equidae the genitofemoral nerve arises from the ventral ramus of L2 and the lateral femoral cutaneous nerve arises from the ventral ramus of L3 (Getty, 1975; Tecirlioglu, 1983). The formation of these nerves in porcupines was similar to that in sheep, goat, guinea pigs and rabbits in terms of common origin, while it was completely different from all others regarding its origin from T15 and L1 spinal nerves.

The formation of the femoral nerve was reported as emerging either from L2, L3, L4 and L5 (Vejsada

and Hnik, 1980) or L2, L3 and L4 (Green, 1968) in rats, from L4 and L5 in guinea pigs (Cooper and Schiller, 1975), mostly from L6 with contributions from L5 and L7 in rabbits (McLaughlin and Chiasson, 1987), from L3, L4, L5 and L6 in dogs (Miller et al., 1964; Getty, 1975), from L5 and L6 in cats (Getty, 1975), mostly from L5 with contributions from L4 and L6 in ruminants (Getty, 1975; Tecirlioglu, 1983; Dursun, 2000), and mostly from L4 and L5 with contributions from L3 and L6 in equidea (Getty, 1975; Tecirlioglu, 1983). In our study we detected that the majority of the fibers came from L2 and L3 with contributions from T15 and L1 which differs from the data reported in the literature. It was also previously reported that the first branch arising from the femoral nerve was to the muscles medial of the femur, its second branch, the saphenous nerve, supplied the skin and muscles of the leg, and its continuation was spread over the skin of the medial part of the leg in rats (Vejsada and Hnik, 1980; Green, 1968), guinea pigs (Cooper and Schiller, 1975), rabbits (McLaughlin and Chiasson, 1987), ruminants and equidea (Getty, 1975; Tecirlioglu, 1983; Dursun, 2000). In porcupines the femoral nerve first branched to give the muscles medial of the femur, similar to what has been reported in the literature. However, its second branch was spread only over the skin similar to the situation in dogs (Miller et al., 1964; Getty, 1975), and it has been reported in the literature that the last branch of the femoral nerve supplies the medial skin of the posterior leg. In porcupines, the last of branch resulted in the common dorsal digital nerves I and II which supplied the dorsum of the digits.

The formation of the obturator nerve was reported in the literature as follows: in rats it was emerging either from L3, L4 and L5 (Vejsada and Hnik, 1980) or L2, L3 and L4 (Green, 1968), in guinea pigs from L5 and L6 (Cooper and Schiller, 1975), in rabbits from L5, L6, L7, S1, S2 and S3 (Chiasson and McLaughlin, 1987) and in dogs from L3, L4, L5 and L6 (Miller et al., 1964; Getty, 1975). The results presented here are consistent with these reports.

Regarding the formation of the cranial and caudal gluteal nerves it was reported that the cranial gluteal nerve arises from L6 and S1 while the caudal gluteal nerve arises from S1 in guinea pigs (Cooper and Schiller, 1975). In rats the cranial gluteal nerve arises from the common root formed by the union of L4, L5, L6 and S1 while the caudal gluteal nerve arises from the peroneal nerve (Green, 1968). In dogs the cranial gluteal nerve arises from L6, L7

and S1 of the lumbosacral plexus while the caudal gluteal nerve arises from L7 of the lumbosacral plexus (Miller et al., 1964), or both nerves were arise from L6, L7 and S1 (Getty, 1975). In cats the cranial gluteal nerve arises from L6 and L7 while the caudal gluteal nerve arises from the caudal portion of the lumbosacral plexus (Getty, 1975). In porcupines, the cranial gluteal nerve arose from L3 in females and from the junction of L3 and L4 in males, while the caudal gluteal nerve was the first branch of the common root which was formed by the union of L3, L4, S1 and S2.

The formation of the caudal femoral cutaneous nerve in guinea pigs was reported as originating from the lumbosacral plexus with the sciatic nerve and then separating from it (Cooper and Schiller, 1975); in dogs it arises mostly from L4 with contributions from L3 and L5 (Miller et al., 1964; Getty, 1975); in cats from S2 and S3 (Getty, 1975); mostly from S2 and S3 with rare contributions from S1 in pigs, while it has been reported as being a branch of the gluteal nerve in equidea (Getty, 1975). In ruminants it has been documented as being a slender branch which originates from the dorsal part of the sciatic nerve (Getty, 1975; Tecirlioglu, 1983). These results are partly similar to those in guinea pigs and ruminants.

With regard to the formation of the pudendal and caudal rectal nerves it has been reported that the pudendal nerve originates from S1, S2, S3 and S4 in rabbits (McLaughlin and Chiasson, 1987), from S2, S3 and S4 in guinea pigs (Cooper and Schiller, 1975), from the pudendal plexus formed by the union of L6, S1, S2, S3, S4, Ca1 and Ca2 of the cranial gluteal nerve in rats (Green, 1968), while in dogs it originates together with the caudal rectal nerve from S1, S2 and S3 before diverging into the superficial and profund perineal nerves (Miller et al., 1964; Getty, 1975). In cats it was reported as originating together with the caudal rectal nerve from S2 and S3 (Getty, 1975), and in ruminants from S3 and S4 before diverging into the superficial and profund perineal nerves (Getty, 1975; Tecirlioglu, 1983). In this study, the pudendal nerve arose from S1 and S2 in one animal while it arose together with the caudal rectal nerve from S2 in three animals. This data differs from all previously reported data in terms of the origin and was similar only to those of the cats and dogs with regard to the common emergence of the two nerves.

In dogs it was reported that the sciatic nerve arises from L6, L7 and S1 (Ueyama, 1978) or from the L6,

L7, S1 and S2 segments of the lumbosacral plexus (Miller et al., 1964; Getty, 1975) before diverging into the tibial and the fibular nerves after giving the cutaneous surae caudal nerve. Studies on rats documented that it arises from L4, L5 and L6 (Green, 1968; Schmalbruch, 1986; Asato et al., 2000), mostly from L6 and S1 with contributions from S2 in guinea pigs (Cooper and Schiller, 1975), from L5, L6, L7, S1, S2 and S3 in rabbits (McLaughlin and Chiasson, 1987), from L5, L6, S1 and S2 in pigs (Getty, 1975), and mostly from the last two lumbar segments with contributions from the first two sacral segments in ruminants (Getty, 1975; Tecirlioglu, 1983). In porcupines the sciatic nerve was formed by the union of the last two lumbar and the first two sacral segments consistent with observations from dogs, ruminants and pigs.

To conclude, this study evaluated the formation of the nerves originating from the lumbosacral plexus in porcupines and reports the following important findings: the ilioinguinal nerve was absent in all but the left side of one animal, the iliohypogastric nerve originated from the last thoracic segment (T15), the femoral nerve terminated by giving the digitalis dorsales communis nerve I and II, the cutaneous surae caudal nerve terminated by giving the digitalis dorsales communis nerve V and digitalis palmares communis nerve V. All these data are different from those previously reported for rodents and other mammals.

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