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Innervation of the muscles of the pelvic limb of the nutria (*Myocastor coypus*) by nerves originating from the lumbosacral plexus

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Abstract

Knowledge about the innervation of the pelvic limb is crucial in veterinary sciences, particularly in anesthesiology, diagnostics, and veterinary surgery, where precise knowledge of the nervous system enables effective treatment and interventions. With the growing interest of veterinarians in studies of the rodent, expanding knowledge of the neuroanatomy of these animals is key to improving veterinary care and treatment efficacy. The aim of our study was to analyze the innervation of the pelvic limb muscles in the nutria (*Myocastor coypus*). Our research demonstrated that these muscles are innervated by motor fibers from nerves such as the femoral nerve, the obturator nerve, the sciatic nerve, and the cranial and caudal gluteal nerves. We also determined the origin of these nerves, indicating that they stem from the ventral roots of the spinal nerves from L3 to S1, knowing that the nutria has six lumbar vertebrae. Conclusions from such analyses can contribute to a deeper understanding of the evolutionary anatomy of the nervous system in various mammal groups and the development of more precise diagnostic and therapeutic methods in veterinary medicine.

Running title: Innervation of the pelvic limb in nutria

Keywords: animal anatomy, nerves, posterior leg

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Introduction

The nutria (*Myocastor coypus*) is a rodent species from the family *Echimyidae* and the subfamily *Echyminae*. It is a semi-aquatic, herbivorous species native to South America: southern Brazil, Chile, Bolivia, Paraguay, Uruguay, and Argentina [1-3]. At the beginning of the last century, this species spread widely and now its geographical range extends far beyond South America, including areas such as the United States, Canada, northern and central Asia, eastern Africa, England, France, the Netherlands, Germany, and Poland [3-8]. The rapid expansion into new and highly diverse climatic environments by *Myocastor coypus* is a testament to the considerable adaptability of these animals [9]. This fact has led to the American nutria being described in the context of uncontrolled population growth and being listed as an invasive alien species of concern to the European Union, subject to rapid eradication efforts [10].

From a biological perspective, *Myocastor coypus* is characterized by a very durable and dense fur cover. An adaptation of the nutria to its semi-aquatic lifestyle is the presence of a membrane connecting four of the five toes on its hind limb, which facilitates efficient movement in the aquatic environment. Additionally, this limb is relatively well-developed in terms of musculature. The nerves supplying it originate from the lumbosacral plexus (*plexus lumbosacralis*), which has been described in several rodent species, including the rat (*Rattus*) [11], red-rumped agouti (*Dasyprocta leporina*) [12], African crested porcupine (*Hystrix cristata*) [13], and the red squirrel (*Sciurus vulgaris*) [14], as well as in the chinchilla (*Chinchilla lanigera*) [15], domestic guinea pig (*Cavia porcellus*) [16], yellow-toothed cavy (*Galea spixii spixii*) [17], and other species less closely related to *Myocastor coypus*, such as the big-eared opossum (*Didelphis aurita*) [18]. The innervation of specific

FIGURE 1 The obturator nerve exits the pelvic cavity and sends its motor fibers to the muscles on the medial side of the thigh

muscles by the nerves of the lumbosacral plexus has also been described in species such as the African crested porcupine (*Hystrix cristata*) [19], house mouse (*Mus musculus*) [20], Cape mole-rat (*Georychus capensis*), cape dune mole-rat (*Bathyergus suillus*), Hottentot golden mole (*Cryptomys hottentotus natalensis*) [21], domestic guinea pig (*Cavia porcellus*) [16], and big-eared opossum (*Didelphis aurita*) [18]. However, to our knowledge, this aspect has never been previously described in the nutria.

The aim of our study was to document and describe the innervation of the pelvic limb muscles by the nerves of the lumbosacral plexus in the nutria (*Myocastor coypus*) and to compare the obtained results with data on other rodent species and mammals exhibiting similar anatomical features.

Materials and methods

The study was conducted on a group of four representatives of *Myocastor coypus*: three male individuals and one female. These were wild animals, and their carcasses were provided by the collections of the Faculty of Biological and Veterinary Sciences at Nicolaus Copernicus University in Toruń. An ethical committee approval was not required, as the material was obtained post-mortem. Before dissection, the specimens were preserved in a 10% solution of formic aldehyde (formaldehyde). Subsequently, using anatomical dissection techniques, the pelvic limb muscles, pelvic girdle, and the nerves supplying these structures were visualized. Additionally, the abdominal and pelvic cavities of the specimens were opened by making incisions through succes-

FIGURE 2 Branches of the sciatic nerve. 1 – sciatic nerve. 2 – muscular branch of the sciatic nerve. 3 – common fibular nerve. 4 – tibial nerve

FIGURE 3 Branches of the sciatic nerve. 1 – sciatic nerve. 2 – common fibular nerve

sive layers of the region, including skin, subcutaneous tissue, fascia, and muscles along the mid-sagittal plane of the body. In the case of the pelvic cavity, the pelvic symphysis was also cut. In both body cavities, organs were carefully removed to avoid damaging the ventral roots of the lumbar and sacral spinal nerves forming the lumbosacral plexus. From the last thoracic vertebra to the sacrum, the area was cleaned to reveal the ventral branches of the spinal nerves extending from the spinal cord.

The innervation of the individual muscles of the pelvic limb in *Myocastor coypus* and the origin of the nerves of the lumbosacral plexus were examined and documented using a Samsung Galaxy A54. Image editing was performed using Adobe Photoshop (25.9.1). The nomenclature of the anatomical structures was standardized according to Nomina Anatomica Veterinaria (2017) [22].

Results

The femoral nerve (*n. femoralis*) originates from the ventral roots of the spinal nerves L3-L4. After passing through the psoas minor muscle (*m. psoas minor*) and the psoas major muscle (*m. psoas major*), it goes to the medial side of the thigh. The muscles innervated by its fibers include the quadriceps femoris muscle (*m. quadriceps femoris*) and the pectineus muscle *(m. pectineus*). Distally, on the medial surface of the thigh, the saphenous nerve (*n. saphenus*) is formed.

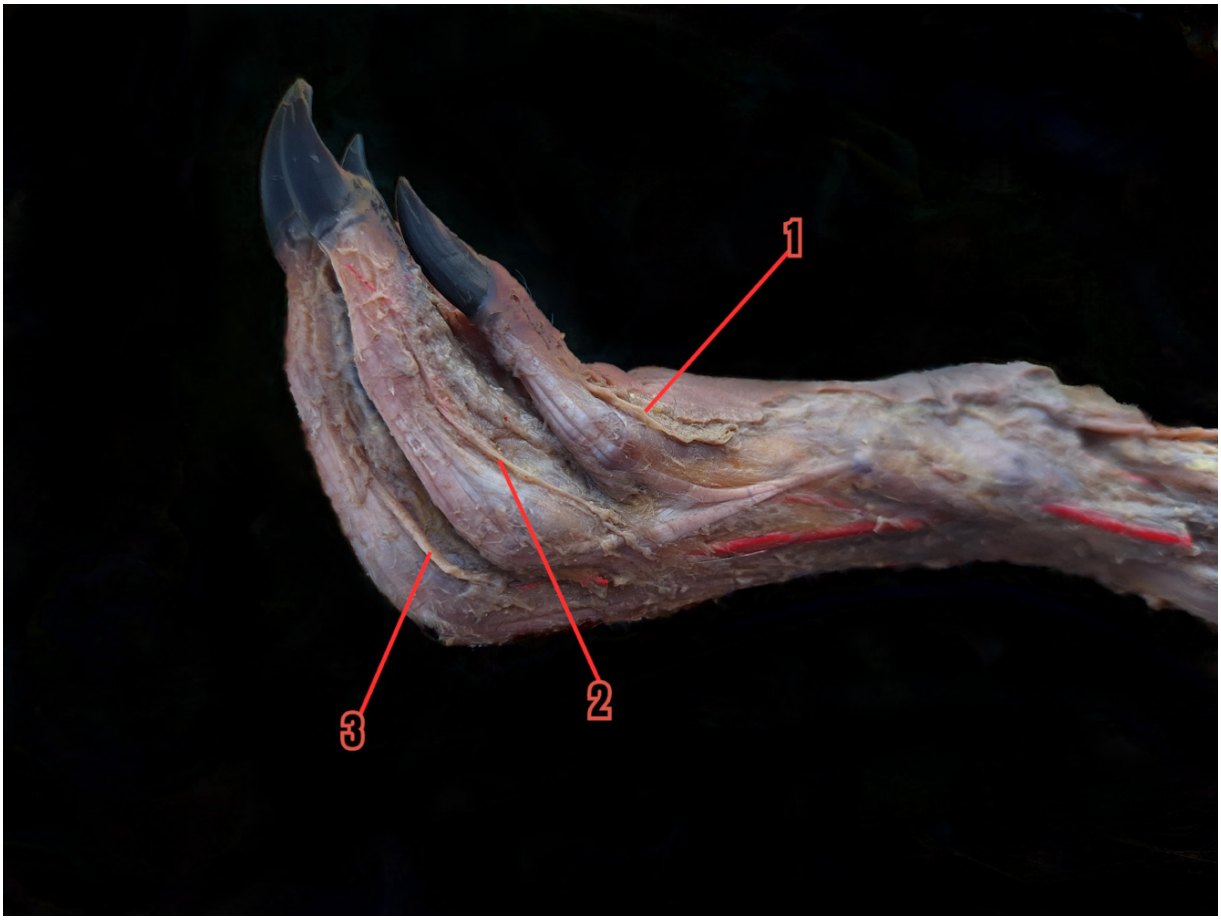

FIGURE 4 Dorsal nerves of the left foot digits. 1 – abaxial dorsal nerve of the 1st finger. 2 – abaxial dorsal nerve of the 2nd finger. 3 – abaxial dorsal nerve of the 3rd finger

The obturator nerve (*n. obturatorius*) is formed from the ventral branches of the lumbar nerves 3-4, sharing the same origin as the femoral nerve. As it heads toward the muscles of the pelvic limb, it passes through the obturator foramen (*foramen obturatum*) along with the same-named blood vessels, thereby exiting the pelvic cavity (**Fig. 1**). After passing through this foramen, its motor fibers reach the adductor muscles, the obturator externus muscle (*m. obturator externus*) as well as the obturator internus muscle (*m. obturator internus*), the pectineus muscle (*m. pectineus*), and the gracillis muscle (*m. gracillis*).

The ventral roots of the spinal nerves L4-L5 form the cranial gluteal nerve (*n. gluteus cranialis*). This nerve provides motor innervation to the gluteal muscles, including the gluteus medius muscle (*m. gluteus medius*) and the gluteus profundus muscle (*m. gluteus profundus*). The caudal gluteal nerve (*n. gluteus caudalis*) is formed by the ventral roots of the spinal nerves L4-S1, and its motor fibers also contribute to the motor innervation of the gluteal region. It exits the pelvic cavity through a common trunk along with the sciatic nerve (*n. ischiadicus*).

The sciatic nerve originates from the ventral roots of the spinal nerves L4, L5, and L6, as well as from the ventral branch of the spinal nerve S1. After exiting the pelvic cavity through the greater sciatic notch (*incisura ischiadica major*), its muscular branch (*ramus muscularis*) (**Fig. 2**) sends motor fibers to the quadratus femoris muscle (*m. quadratus femoris*), biceps femoris muscle (*m. biceps femoris*), caudal crural abductor muscle (*m. abductor cruris caudalis*), semitendinosus muscle (*m. semitendinosus*), semimembranosus muscle (*m. semimembranosus*), and the internal obturator muscle. Then, above the knee joint, the sciatic nerve divides into the common fibular nerve (*n. fibularis communis*) (**Fig. 2**,**3**) and the tibial nerve (*n. tibialis*) (**Fig. 3**).

The common fibular nerve goes to the anterior side of the lower leg. Its fibers innervate the cranial tibial muscle (*m. tibialis cranialis*) the fibularis longus muscle (*m. fibularis longus*), the fibularis brevis muscle (*m. fibularis brevis*), the gastrocnemius muscle (*m. gastrocnemius*), and the extensors of the toe joints. Further along its course, the nerve divides into the superficial fibular nerve (*n. fibularis superficialis*) and the deep fibular nerve (*n. fibularis profundus*), which are involved in the innervation of the dorsal area of the foot and metatarsus (**Fig. 4**).

The tibial nerve is positioned more caudally on the lower leg compared to the common fibular nerve. It runs between the heads of the gastrocne-

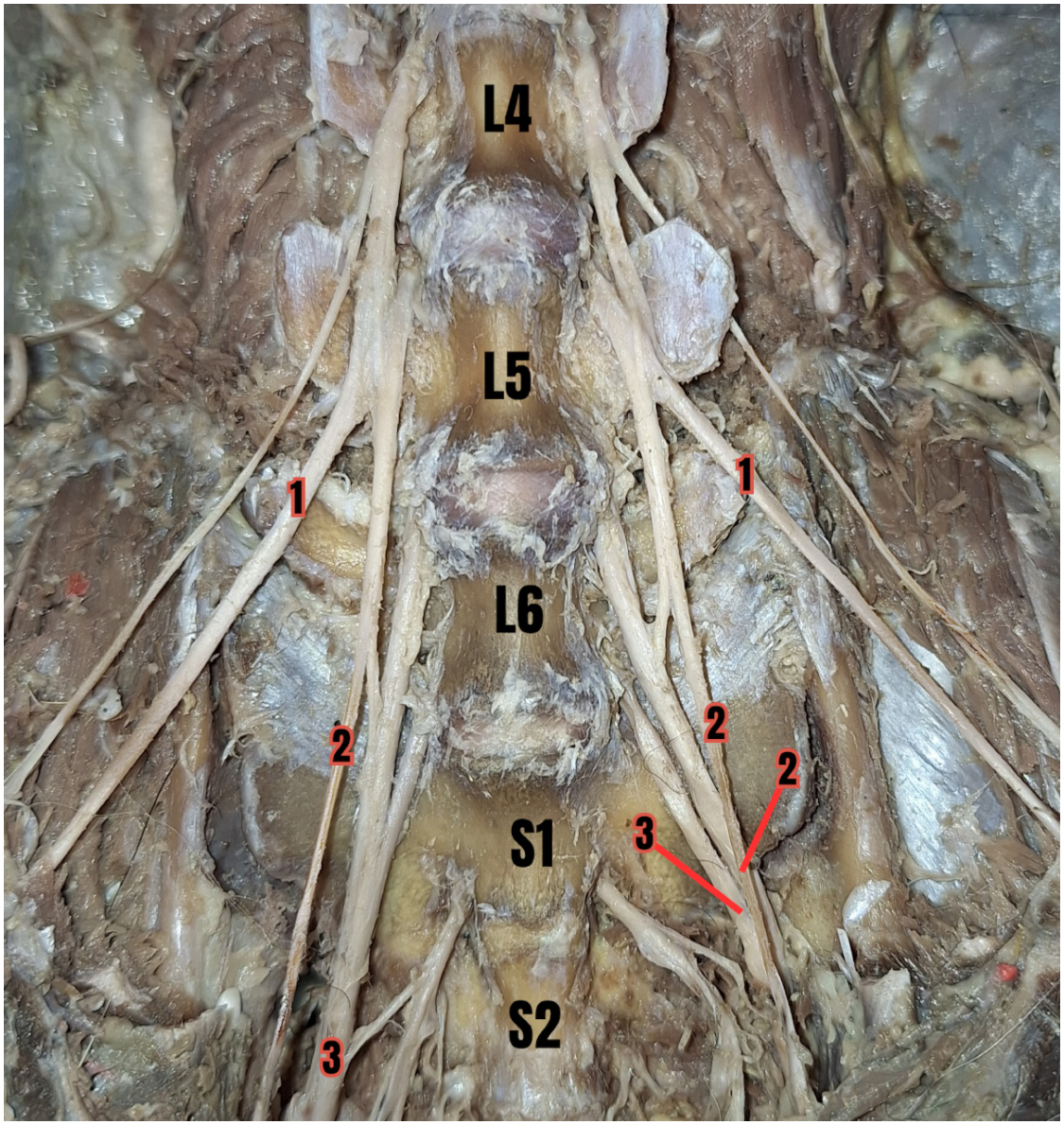

FIGURE 5 Lumbosacral plexus of the nutria; view from the abdominal and pelvic cavities. 1 – femoral nerve. 2 – obturator nerve. 3 – sciatic nerve

mius muscle and sends muscular branches responsible for innervating the semitendinosus muscle, the popliteus muscle (*m. popliteus*), the previously mentioned gastrocnemius muscle, the soleus muscle (*m. soleus*), the superficial digital flexor muscle (*m. flexor digitorum superficialis*), the medial digital flexor muscle (*m. flexor digitorum medialis*), and the lateral digital flexor muscle (*m. flexor digitorum lateralis*). Additionally, this nerve participates in innervating the plantar aspect of the foot and the metatarsus. The origins of the nerves arising from the lumbosacral plexus are shown in **figure 5**.

Discussion

According to the available literature, the nerves that make up the lumbosacral plexus and contribute to the innervation of the pelvic limb muscles originate from the ventral roots of lumbar and sacral spinal nerves in a species-specific manner. In rodents, the femoral nerve and the obturator nerve often originate from a common nerve trunk, which divides into a medial branch, giving rise to the femoral nerve, and a lateral branch, which gives rise to the obturator nerve. This happens in the African crested porcupine, in which these nerves originate from the ventral roots of the L2 and L3 spinal nerves, with Th15 and L1 involved. The femoral nerve here supplies the muscles in the area of the femoral space, and the saphenous nerve branches off from it below, running down the lower leg to the toes. The obturator nerve of this species, on the other hand, supplies muscles such as the pectineus muscle, adductors muscles, gracillis muscle, as well as the external and internal obturators muscles with motor fibers [13,19]. The presence of a trunk giving rise to both mentioned nerves is

also observed in the big-eared opossum, belonging to the order of marsupials, in which they originate from the connection of the ventral roots of L3 and L4. In this case, the femoral nerve innervates the sartorius and quadriceps muscles, while the obturator nerve supplies the pectineus, adductors, gracillis, and internal obturator muscles [18]. Another species characterized by a trunk originating from the ventral roots of spinal nerves, giving rise to both the femoral and obturator nerves, are the red squirrel, in which the roots L4 and L5 are affected, with L6 involvement [14], and chinchilla, in which these nerves arise from the ventral roots of L4 and L5 [15]. In the case of the yellow-toothed cavy, both the femoral and obturator nerves are described as originating from the ventral roots of L5 and L6 [17]. In other species, the ventral roots of spinal nerves separately give rise to the femoral and obturator nerves. For instance, in the domestic guinea pig, the femoral nerve originates from the ventral roots of L5 and L6, with involvement from L4, while the obturator nerve originates from L6 and L7 [16]. The described nerves also originate separately in the case of the rat, where the femoral nerve arises from roots L2-L5, and the obturator nerve from roots L2-L4 [11]. In the case of the red-rumped agouti, the two discussed nerves had different origins in different individuals—some had them originating from L5-L7 (**Tab. 1**), while others from only L5 and L6, or L6 and L7. In the case of the one individual, the researchers have shown that the ventral root of the spinal nerve L4 was also involved in the formation of the femoral nerve [17]. The supplying of muscles with motor fibers by the femoral and obturator nerve in rodents has been described in three species from the family *Bathyergidae*: cape mole-rat, cape dune mole-rat, Hottentot golden mole. In all these animals, the femoral nerve innervates the pectineus and quadriceps femoris muscles, while the obturator nerve supplies the quadratus femoris muscle, the external obturator muscle, the adductors, and the gracilis muscle [21]. In the case of the house mouse, the femoral nerve innervates the pectineus and quadriceps femoris muscles, whereas the obturator nerve provides motor fibers to the adductor muscles, gracillis muscle, semimembranosus muscle, and external obturator muscle [20]. Our research indicates that the branching pattern of the femoral and obturator nerves in the nutria occurs in the same way as in the porcupine, opossum, squirrel, and chinchilla, where they branch off from a common nerve trunk. It is worth noting that the origin of these nerves in the species we studied aligns with their origin only in the opossum, despite the fact that the nutria is a rodent and the opossum is a marsupial. Interestingly, in the nutria, the femoral nerve innervates the same muscles as in the mouse and the mentioned species of blesmoles; the quadriceps femoris and pectineus. On the other hand, the muscles innervated by the obturator nerve in the nutria are the same as those innervated by this nerve in the African crested porcupine.

The thematic literature describes the origin of other nerves that contribute to the innervation of the pelvic limb muscles in selected mammalian species as follows: in the domestic guinea pig, the sciatic nerve arises from the L7, S1, and S2 roots; the referenced literature does not describe separate gluteal nerves but only a small branch supplying the gluteal muscles, branching off from the sciatic nerve [16]. In the African crested porcupine, the cranial gluteal nerve has a different origin depending on sex: in females, it originates only from the L3 root, while in males, it arises from both L3 and L4; however, in both sexes, this nerve innervates only the gluteal muscles. The caudal gluteal nerve shares a common origin with the sciatic nerve; the L4 and S1 roots, with small branches from L3 and S2. Both of these nerves provide motor fibers to the biceps femoris and semitendinosus muscles; in addition, the sciatic nerve innervates the semimembranosus muscle, while the caudal gluteal nerve innervates the superficial gluteal muscle [13]. In the rat, the tibial nerve is described as originating from L4-L6, while the common fibular nerve arises from L4-L5 [11]. In the big-eared opossum, there is a nerve trunk composed of the ventral roots of L4-L6, from which the sciatic nerve and the cranial and caudal gluteal nerves originate. In this marsupial, the biceps femoris muscle receives motor fibers from both the sciatic nerve and the caudal gluteal nerve. Additionally, the sciatic nerve innervates muscles such as the semitendinosus and semimembranosus, while the caudal gluteal nerve innervates the gemelli muscles (*m. gemelli)*, the quadratus femoris, and the gluteus medius. The latter is also innervated by the cranial gluteal nerve, which additionally supplies the superficial gluteal muscle [18]. In the red-rumped agouti, as with the femoral and obturator nerves, the origin of the other nerves we described varies among individuals. The sciatic nerve in this species most commonly arises from the L7, S1, and S2 roots, though in some individuals, L6 and S3 also contribute. The cranial gluteal nerve most often originates from the ventral root of L7, but in some individuals, it arises from L7 and S1, and in others, only from S1. The caudal gluteal nerve, on the other hand, originates from S1 in most cases studied, with a lesser extent from S1 and S2, or only from S2 [17]. In the red squirrel, the ventral roots of the lumbar nerves L6, L7, S1, and S2 combine into a common trunk, which gives rise to the sciatic nerve as well as the cranial and caudal gluteal nerves [14]. In the chinchilla, a similar phenomenon occurs, but the ventral roots forming the nerve trunk originate from L5, L6, and S1 [15]. Regarding the aforementioned species of the blesmoles, the innervation of the pelvic limb muscles by the sciatic nerve is as

TABLE 1 Contribution of the ventral roots of spinal nerves in the formation of nerves supplying the pelvic limb in various species

	FEMORAL NERVE	OBTURATOR NERVE	SCIATIC NERVE	CRANIAL GLUTEAL NERVE	CAUDAL GLUTEAL NERVE
Myocastor coypus	L3-L4	L3-L4	L4-S1	L4-L5	L4-S1
Hystrix cristata [13]	L2-L3 (Th15-L3)	L2-L3 (Th15-L3)	L4-S1 (L3-S2)	L3 L3-L4	L4-S1 (L3-S2)
Didelphis aurita [18]	L3-L4	L3-L4	L4-L6	L4-L6	L4-L6
Dasyprocta leporina [12]	L5-L7 L5-L6 L6-L7	L5-L7 L5-L6 L6-L7	L7-S2 L6-S3	L7 L7-S1 S1	S1 S1-S2 S2
Sciurus vulgaris [14]	L4-L5 (L4-L6)	L4-L5 (L4-L6)	L6-S2	L6-S2	L6-S2
Chinchilla lanigera [15]	L4-L5	L4-L5	L5-S1	L5-S1	L5-S1
Galea spixii spixii [17]	L5-L6	L5-L6	L6-S1	L7	—
Cavia porcellus [16]	L5-L6 (L4-L6)	L6-L7	L7-S2	—	—
Rattus [11]	L2-L5	L2-L4	—	—	—

TABLE 2 Innervation of the pelvic limb muscles of various species by the nerves of the lumbosacral plexus

	FEMORAL NERVE	OBTURATOR NERVE	SCIATIC NERVE	CRANIAL GLUTEAL NERVE	CAUDAL GLUTEAL NERVE
Myocastor coypus	*m. quadriceps femoris, m. pectineus*	*mm. adductores, m. gracillis, m. obturator externus, m. obturator internus, m. pectineus*	*m. quadratus femoris, m. biceps femoris, m. abductor cruris caudalis, m. semitendinosus, m. semimembranosus, m. obturator internus*	*m. gluteus medius, m. gluteus profundus*	—
Hystrix cristata [19]	Muscles at the level of the femoral space	*mm. adductores, m, pectineus, m.gracillis, m. obturator externus, m. obturator internus*	*m. biceps femoris, m. semitendinosus, m. semimembranosus*	m. gluteus medius, m. gluteus profundus, m. gluteus superficialis	m. gluteus superficialis, m. biceps femoris, m. semitendinosus
Didelphis aurita [18]	*m. sartorius, m. quadriceps femoris*	*m. obturator externus, m. pectineus, mm. adductores, m. gracillis*	*m. biceps femoris, m. semitendinosus, m. semimembranosus*	m. gluteus medius, m. gluteus superficialis	m. gluteus medius, m. biceps femoris, mm. gemelli, m. quadratus femoris
Georychus capensis, *Bathyergus suillus*, *Cryptomys hottentotus natalensis* [21]	*m. quadriceps femoris, m. pectineus*	*m. quadratus femoris, m. obturator externus, mm. adductores, m. gracillis*	*m. biceps femoris, m. semitendinosus, m. semimembranosus*	m. gluteus medius, m. gluteus profundus, m. gluteus superficialis	m. gluteus superficialis, m. biceps femoris
Mus musculus [20]	m. quadriceps femoris, m. pectineus	m. gracillis, mm. adductores, m. semimembranosus, m. obturator externus	mm. gemelli, m. obturator internus, m. quadratus femoris	m. gluteus medius, m. gluteus profundus, m. gluteus superficialis, m. sartorius, m. piriformis	m. gluteus superficialis, m. sartorius

follows: it innervates the biceps femoris, semitendinosus, and semimembranosus muscles. The sciatic nerve then branches into the tibial nerve, which innervates muscles located on the caudal side of the lower leg, such as the gastrocnemius or soleus muscles, and the common fibular nerve, which further divides into the superficial and deep peroneal nerves, providing motor fibers to the muscles on the cranial side of the lower leg, such as the cranial tibial muscle or the fibularis longus muscle. In the species of blesmoles described, there are also gluteal nerves: the cranial gluteal nerve, which innervates the superficial, middle, and deep gluteal muscles, and the caudal gluteal nerve, which supplies the superficial gluteal muscle and the cranial part of the biceps femoris muscle [21]. Interestingly, In the house mouse, the sciatic nerve provides motor fibers to the internal obturator muscle, quadratus femoris muscle, and gemelli muscles. In the mouse, the sciatic nerve gives rise to the tibial nerve, which innervates the biceps femoris and semitendinosus muscles, and then descends to the caudal region of the lower leg, where it innervates the muscles located there, such as the gastrocnemius and superficial digital flexor muscles. The sciatic nerve also gives rise to the common fibular nerve, which, like in the aforementioned blesmoles species, divides into the superficial and deep fibular nerves. Both of these branches supply the muscles located on the cranial side of the lower leg, such as the long digital extensor or lateral digital extensor muscles. In the mouse, the superficial gluteal muscle and the sartorius muscle receive motor fibers from both the cranial and caudal gluteal nerves. Additionally, the cranial gluteal nerve innervates the middle gluteal muscle, deep gluteal muscle, and the piriformis muscle (*m. piriformis*) [20]. Our research on the innervation of the pelvic limb in the nutria indicates that the origin of the sciatic nerve differs from all the species we compared (**Tab. 2**). Its origin is most closely related to that in the chinchilla, where it arises from the ventral roots of the spinal nerves L5, L6, and S1, while in the species we studied, it originates from L4, L5, L6, and S1. In the nutria, this nerve innervates muscles such as the semitendinosus, semimembranosus, and biceps femoris, showing similarities to the African crested porcupine, big-eared opossum, and the blesmoles species mentioned in this work. However, in the nutria, the sciatic nerve innervates the quadratus femoris and internal obturator muscles, similar to the house mouse. In all the species mentioned, the sciatic nerve branches into the common fibular and tibial nerves, which provide motor fibers to similar areas in the lower leg. In the case of the origin of the cranial gluteal nerve in the nutria, it presents a similar situation to that of the sciatic nerve, as in none of the described species does it originate from the ventral roots of the spinal nerves L4-L5. The closest similarity in the origin of this nerve compared to the nutria is found in the male porcupine, where it arises from L3-L4. In the nutria, the cranial gluteal nerve innervates the middle and deep gluteal muscles, similar to the porcupine, mouse, and blesmoles; however, in each species, this nerve also innervates other muscles. The caudal gluteal nerve in the nutria shows a similar origin pattern to that of the African crested porcupine, big-eared opossum, red squirrel, and chinchilla, as it branches off from the ventral roots together with the sciatic nerve, originating from L4-S1 in the nutria.

Conclusions

The greatest similarity to the nutria in terms of pelvic limb muscle innervation by the lumbosacral plexus nerves, as well as the origin of these nerves, can be observed in the African crested porcupine, which may be related to the close relationship between the families *Echimyidae* and *Hystricidae*. In the nutria, as in the big-eared opossum, African crested porcupine, red squirrel, chinchilla, and yellow-toothed cavy, both the femoral nerve and the obturator nerve originate from a common nerve trunk. The area innervated by the femoral nerve in the described species is analogous to that in the house mouse, cape mole-rat, cape dune mole-rat, Hottentot golden mole, while the area innervated by the obturator nerve is synonymous with that of the porcupine. The sciatic nerve, as in all other rodent species considered in the study, originates from both the lumbar and sacral spinal cord ventral roots and branches into the common fibular nerve, which extends to the cranial side of the shank, and the tibial nerve, which innervates the muscles of the caudal part of the shank. The cranial gluteal nerve and the caudal gluteal nerve jointly participate in innervating the gluteal region of the nutria. The caudal gluteal nerve, similar to the porcupine, squirrel, opossum, and chinchilla, shares its origin with the sciatic nerve.

Knowledge about the innervation of the pelvic limb muscles in different species is extremely valuable in veterinary medicine, both in anesthesiology and diagnostics, such as in cases of muscle paralysis. This study highlights the significant differences in the origins of certain nerves of the lumbosacral plexus and their innervation of the pelvic limb muscles among rodents, demonstrating that each species should be approached individually during treatment.

Ethical approval
The conducted research is not related to either human or animal use.

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Conflict of interest statement
The authors declare no conflict of interest.

References

1. Cabrera A, Yepes J. Mamiferos sud-americanos. Argentina: Compania Argentina de Editores; 1940. 370 p.
2. Cabrera A. Catalogo de los mammiferos de America del Sur. 2nd ed. Arb gentina: Coni; 1961. 732 p.
3. Baroch J, Hafner M, Brown TL, Mach JJ, Poché RM. Nutria (Myocaster coypus) in Louisiana [Internet]. Lincoln: University of Nebraska; 2002 [cited 2024 Sep 02]. Available from: https://digitalcommons.unl.edu/icwdmother/46/.
4. Aliev FF. Numerical changes and the population structure of the coypu (Myocastor coypus) in different countries. Saugetierkundliche Mitteif lungen. 1966;15:238-42.
5. Van Den Brink FH. A field guide to the mammals of Britain and Europe. Minneapolis: Houghton Mifflin; 1968. 221 p.
6. Corbet GB. The mammals of the Paleoarctic region: a taxonomic review. London: Cornell University Press; 1978. 314 p.
7. Hall ER. The mammals of North America. 2nd ed. New York: John Wiley and Sons; 1981. 717 p.
8. Bar-Ilan A, Marder J. Adaptations to hypercapnic conditions in the nutria (Myocastor coypus) – in vivo and in vitro CO_2 titration curves. Comp Biochem Physiol A. 1983;75:603-8; DOI:10.1016/0300-9629(83)90427-9.
9. Kowalska D, Bielański P, Łapiński S. Nutrie – perspektywy hodowli. Wiadomości Zootechniczne. 2010;1:39-45.
10. Gwiazdowicz DJ. Łowieckie spotkania. 4. Inwazyjne gatunki obce. Koszalin: Bogucki Wydawnictwo Naukowe; 2023. 79 p.
11. Vejsada R, Hník P. Radicular innervation of hindlimb muscles of the rat. Physiol Bohemoslov. 1980;29(5):385-92.
12. Oliveira GB, Araújo Júnior HN, Lopes PMA, Silva Costa H, Oliveira REM, Moura CEB, Paula VV, Oliveira MF. The lumbosacral plexus of the red-rumped agouti (Dasyprocta leporina Linnaeus, 1758) (Rodentia: Caviidae). Semina Ciências Agrárias. 2016;37(6):4085-96; DOI:10.5433/1679-0359.2016v37n6p4085.
13. Aydin A, Dinc G, Yilmaz S. The spinal nerves that constitute the plexus lumbosacrales of porcupines (Hystrix cristata). Vet Med. 2009;54(4):194-7; DOI:10.17221/55/2009-VETMED.
14. Aydin A. The spinal nerves that constitute the plexus lumbosacrales of the red squirrel (Sciurus vulgaris). Vet Med. 2010;55(4):183-6; DOI:10.17221/3021-VETMED.
15. Martinez-Pereira MA, Rickes EM. The spinal nerves that constitute the lumbosacral plexus and their distribution in the chinchilla. J S Afr Vet Assoc. 2011;82(3):150-4; DOI:10.4102/jsava.v82i3.53.
16. Potter GE, Brueck WL. Nervous system of Guinea Pig (Cavia porcellus). Bios. 1958;29(4):185-96; DOI:10.11606/T.10.2012.tde-04072013-120221.
17. Oliveira GB, Albuquerque JFG, Oliveira MF, Rodrigues MN, Sousa RS, Sousa ES, Miglino MA. Source and distribution of the lumbosacral plexus in Spix's yellow-toothed cavy (Galea spixii spixii). Braz J Morphol Sci. 2008;25(1-4):1-34.
18. Senos R, Ribeiro MS, Benedicto HG, Kfoury Júnior JR. Lumbosacral plexus in Brazilian common opossum. Folia Morphol. 2016;75(3):300-5; DOI: 10.5603/FM.a2015.0131.
19. Aydin A. The dissemination of pelvic limb nerves originating from the lumbosacral plexus in the porcupine (Hystrix cristata). Vet Med. 2009;54(7):333-9; DOI:10.17221/55/2009-VETMED.
20. Brannen TA. The hind limb myology of the laboratory mouse (Mus musculus) with comparisons to the other rodent genera [dissertation]. Kanu sas: Kansas State University; 1976.
21. Sahd L, Bennett NC, Kotzé SH. Hind foot drumming: morphological adaptations of the muscles and bones of the hind limb in three African mole-rat species. J Anat 2019; 235(4):811-24; DOI: 10.1111/joa.13028.
22. International Committee on Veterinary Gross Anatomical Nomenclature. Nomina Anatomica Veterinaria. 6th ed. Editorial Committee: Hanover, Germany; Ghent, Belgium; Columbia, MO, USA; Rio de Janeiro, Brazil, 2017. 178 p.