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Gross anatomy of the lumbar plexus of magpie (*Pica pica*) and chukar partridge (*Alectoris chukar*)

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Abstract: In poultry, the nervous system has many differences among species. The intumescentia lumbosacralis is one of the enlargements of the medulla spinalis, and the lumbosacral plexus originates from here. The nerves which are responsible for the innervation of the hind limbs and pelvic region originate in the lumbosacral plexus. The aim of this study was to compare the lumbar plexus (plexus lumbalis) of magpies (*Pica pica*) and chukar partridges (*Alectoris chukar*). In the present study, 20 magpies and 20 chukar partridges were used. The nerves that form the lumbar plexus were dissected separately and photographed in both species. In both studied species, the lumbar plexus was formed by the ventral rami of the second, third, and fourth synsacral spinal nerves at the ventrolateral part of the synsacrum. It was noted that the nervus (n.) cutaneus femoris, n. coxalis cranialis, n. femoralis, n. saphenus, and n. obturatorius originate from this plexus. In conclusion, in both species, the formation of the lumbar plexus and the nerves that originate from this plexus are similar to each other and similar to many winged species. There are also some minimal differences.

Key words: Chukar partridge, lumbar plexus, magpie

1. Introduction

The magpie (*Pica pica*), which belongs to the family Corvidae, is the common name of bird species that comprise Urocissa, Cyanopica, and Cissa [1]. The partridge belongs to the pheasant family (Phasianidae), which includes Alectoris and Perdix. There are many semidomesticated or wild partridge species in the world [2–4].

Birds have a special ability to descend to the earth, to perch on tree branches, to roost, and walk [5,6]. The lumbosacral canal and medulla spinalis act as a balance organ like the semicircular canals in the inner ear. The semicircular canals provide balance in the body during flight, and the lumbosacral canal and legs provide stability while birds are walking [7,8].

The lumbar plexus in birds is formed as a result of the junction of the ventral branches of three lumbar spinal nerves [9,10]. The nerves that originate from the lumbar plexus in mammals are nervus (n.) iliohypogastricus, which is named n. pubicus [11], n. genitofemoralis, n. cutaneus femoris lateralis, n. femoralis, and n. obturatorius [9]. Nervus iliocostalis and n. iliohypogastricus (which is the first lumbal nerve that does not originate from the lumbar plexus) innervate the abdominal muscles [12]. The nerves that originate from the lumbar plexus in domestic birds are n. iliohypogastricus, n. pubicus (n. ilioinguinalis), n. obturatorius, n. cutaneus femoris, n. femoralis, n. gluteus cranialis, and n. cutaneus femoris medialis (n. saphenus) [9,10].

Although numerous studies have been carried out on the lumbar plexus of domestic mammals, studies on the lumbar plexus in birds, especially wild birds, are inadequate. The aim of this study was to compare the lumbar plexuses, and branches of these lumbar plexuses, in magpies (*Pica pica*) and chukar partridges (*Alectoris chukar*) and to research the differences in both species.

2. Materials and methods

This study is in compliance with the principles of scientific research and publication ethics according to the examination made by the Atatürk University Veterinary Faculty, Ethics Subcommittee. In this study, a total of 20 magpies (*Pica pica*) (9 female and 11 male) with mean weights of 330 ± 49 g that were dead or found injured by natural causes in Erzurum Province were used. A total of 20 chukar partridges (*Alectoris chukar*) (13 female and 7 male) with mean weights of 515 ± 62 g that were obtained from Amasya Chukar Partridge Hatchery were used. The injured magpies (*Pica pica*) and chukar partridges (*Alectoris chukar*) were anesthetized intramuscularly

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with 10 mg/kg xylazine as a preanesthetic and 35 mg/kg ketamine as anesthetic [7], respectively. Artery (A.) carotis communis was cut from the neck region of the anesthetized magpies and chukar partridges and blood was drained. Subsequently, the material from which blood had been evacuated was incised from the cloaca to the distal part of the sternum. The organs in the abdominal cavity were taken out in such a way that the nerves composing the lumbosacral plexus were not harmed [8,9]. Next, the species were left in 10% formaldehyde solution for fixation. The nerves composing the lumbar plexus were dissected. The dissected nerves were photographed. The terms in Nomina Anatomica Avium (NAA) were used as the basis for naming of the nerves and surrounding anatomical structures.

3. Results

3.1. Lumbar plexus

The ventral branches of the second, third, and fourth synsacral spinal nerves that compose the lumbar plexus in magpies and chukar partridges integrate with the dorsocranial side of the kidneys on the ventral surface of musculus (m.) iliotrochantericus cranialis at the ventrolateral side of the synsacrum.

In magpies, it was determined that the ventral branch of the second synsacral spinal nerve immediately joined the lumbar plexus and coursed caudoventrally without showing branching. The ventral branch of the third synsacral spinal nerve coursed ventrolaterally and also joined the lumbar plexus without showing branching. It was observed that the ventral branch of the fourth synsacral spinal nerve, also known as the nervus furcalis, immediately exited the canalis vertebralis as two branches. One branch ran down cranially and joined the lumbar plexus, and the other, caudally-directed branch joined the sacral plexus.

The first nerve that composed the lumbar plexus was thinner than the other nerves in chukar partridge, and it divided into two separate branches before it joined the lumbar plexus, immediately after its origin. The thin branch was n. pubicus (n. ilioinguinalis), and it was distributed to the abdominal muscles. The thick branch coursed caudoventrally to join the plexus and constituted the origin of n. cutaneus femoris, which was the first branch coming from the plexus. It was determined that the ventral branch of the third synsacral spinal nerve that joined the plexus was thicker than the ventral branches of the other two nerves composing the plexus. The cranial branch of this nerve root (n. furcalis) also joined the plexus (Figures 1a and 1b).

It was observed that the lumbar plexus in magpies and chukar partridges was located at the ventral part of the os ilium and laterally in the cranial division of the kidneys. The branches of the lumbar plexus were the n. pubicus (n. ilioinguinalis), n. cutaneus femoris, n. coxalis cranialis, n. femoralis, n. cutaneus femoris medialis (n. saphenus), and n. obturatorius.

3.1.1. Nervus pubicus (nervus ilioinguinalis)

Nervus pubicus, found only in the chukar partridge, was a weak nerve originating from the ventral branch of the second synsacral spinal nerve and spreading to the caudal section of musculi abdominis and then proceeding in the caudoventral direction (Figures 1a and 1b).

3.1.2. Nervus cutaneus femoris

The first branch to originate from the lumbar plexus in both the magpie and the chukar partridge was n. cutaneus femoris. After originating as a thick branch, it was directed cranioventrally and proceeded as a single branch in the magpie after the delivery of n. cutaneus femoris lateralis, its first branch.

In the chukar partridge, n. cutaneus femoris divided ventrally and dorsally into two branches. Just after it delivered the n. cutaneus femoris lateralis branch and just before it entered the m. sartorius, the ventral branch innervated the integument of the craniolateral part of the femur, proceeding between the caudal section of m. iliotibialis cranialis and the cranial section of m. iliotibialis lateralis. The dorsal branch innervated the middle section of m. iliotibialis cranialis (Figures 2a and 2b).

3.1.3. Nervus coxalis cranialis

In both examined species, n. coxalis cranialis divided into two branches, one craniolateral and the other caudolateral, just after originating from the dorsal aspect of n. femoralis. Its branches terminated, spreading to m. iliotibialis and m. gluteus medius (Figures 3a and 3b).

3.1.4 Nervus femoralis

It was determined that in both species, n. femoralis was the strongest nerve, running down caudolaterally from the lumbar caudolateral to n. coxalis cranialis. In magpies, it divided into two basic branches that coursed caudoventrally, and in the chukar partridge it divided into three basic branches. In the magpie, the first branch divided into two branches that coursed craniolaterally and proceeded in the caudal direction, where it entered the ventromedial aspect of m. iliacus and innervated the lateral section of m. femorotibialis medialis. The second branch divided into two branches and proceeded to the ventral aspect of m. femorotibialis where it was distributed throughout this muscle to provide innervation. In the chukar partridge, the first branch divided into three branches. The second branch proceeded as a single branch in the caudal direction. The third branch coursed caudoventrally, and it divided into two caudal branches, which continued and entered the dorsal aspect of m. ambiens. It innervated m. femorotibialis internus,

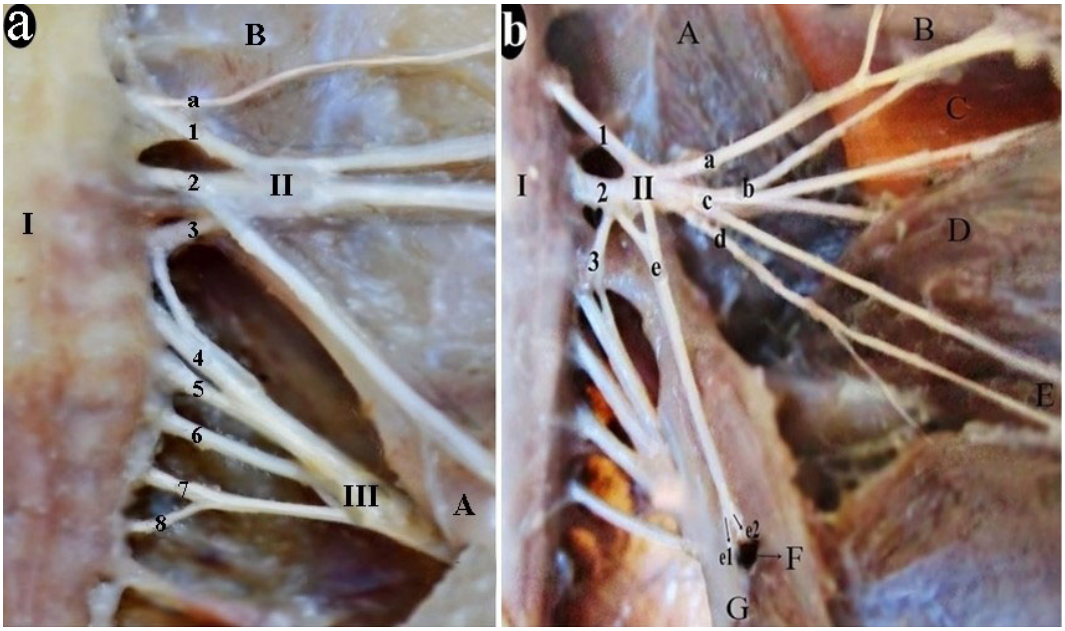

Figure 1. Gross anatomical views of; a: lumbar plexus in the chukar partridge, left ventromedial view; (I); synsacrum, (II); lumbar plexus, (III); sacral plexus, (1–8); ventral branches of 2.–9. synsacral spinal nerves (3); n. furcalis, (a); n. pubicus (n. ilioinguinalis), (A); m. obturatorius internus, (B); m. iliotrochantericus cranialis. b: lumbar plexus in the magpie, left caudoventral view; (I); synsacrum, (II); lumbar plexus, (1–3); ventral branches of 2.–4. synsacral spinal nerves, (3); n. furcalis, (a); n. cutaneus femoris, (b); n. coxalis cranialis, (c); n. femoralis, (d); n. cutaneus femoris medialis (n. saphenus), (e, e2); n. obturatorius, (e1); r. lateralis of n. obturatorius, (A); m. iliotrochantericus cranialis, (B); m. iliotibialis cranialis, (C); m. iliotibialis lateralis, (D); m. femorotibialis medialis, (E); m. ambiens, (F); foramen obturatum, (G); m. obturatorius internus.

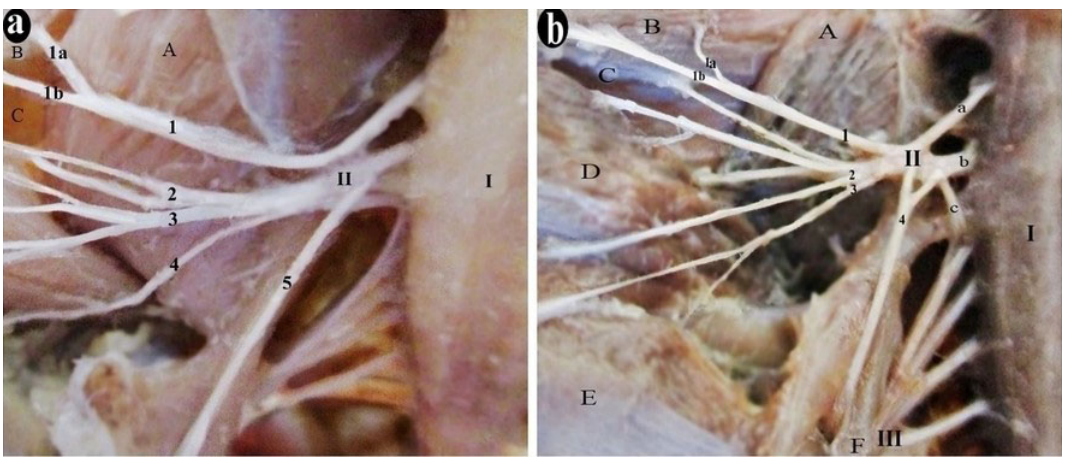

Figure 2. Gross anatomical view of; a: nervus cutaneus femoris and its branches in the chukar partridge, right caudoventral view; (I); synsacrum, (II); lumbar plexus, (1, 1b); n. cutaneus femoris, (1a); n. cutaneus femoris lateralis, (2); n. coxalis cranialis, (3); n. femoralis, (4); n. cutaneus femoris medialis (n. saphenus), (5); n. obturatorius, (A); m. iliotrochantericus cranialis, (B); m. iliotibialis cranialis, (C); m. iliotibialis lateralis. b: n. cutaneus femoris and its branches in the magpie, right caudoventral view; (I); synsacrum, (II); lumbar plexus, (III); sacral plexus, (1, 1b); n. cutaneus femoris, (1a); n. cutaneus femoris lateralis, (2); n. femoralis, (3); n. cutaneus femoris medialis (n. saphenus), (4); n. obturatorius, (a–c); 2.–4. synsacral spinal nerves, (c); n. furcalis (A); m. iliotrochantericus cranialis, (B); m. iliotibialis cranialis, (C); m. iliotibialis lateralis, (D); m. femorotibialis medialis, (E); m. puboischiofemoralis medialis, (F); m. obturatorius internus.

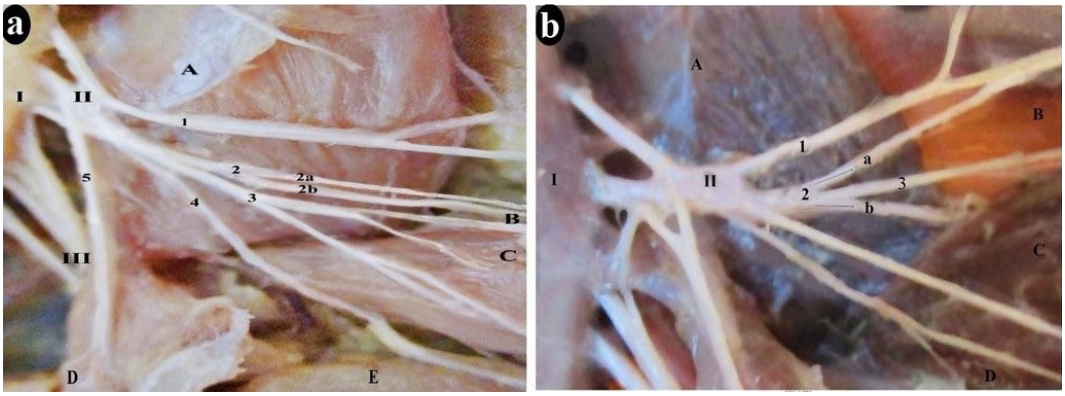

Figure 3. Gross anatomical view of; a: nervus coxalis cranialis and its branches in the chukar partridge, left ventrolateral view; (I); synsacrum, (II); lumbar plexus, (III); sacral plexus, (1); n. cutaneus femoris, (2); n. coxalis cranialis, (2a, 2b); branches of n. coxalis cranialis, (3); n. femoralis, (4); n. cutaneus femoris medialis (n. saphenus), (5); n. obturatorius, (A); m. iliotrochantericus cranialis, (B); m. iliotibialis lateralis, (C); m. femorotibialis medialis, (D); m. obturatorius internus, (E); m. iliotibialis cranialis. b: n. coxalis cranialis and its branches in the magpie, left ventrolateral view; (I); synsacrum, (II); lumbar plexus, (1); n. cutaneus femoris, (2); n. coxalis cranialis, (3); n. femoralis, (a, b); branches of n. coxalis cranialis, (A); m. iliotrochantericus cranialis, (B); m. iliotibialis lateralis, (C); m. femorotibialis medialis, (D); m. puboischiofemoralis medialis.

proceeding with n. saphenus between the cranial border of m. puboischiofemoralis medialis (adductor) and the caudal border of m. femorotibialis medialis (Figures 4a and 4b).

3.1.5. Nervus cutaneus femoris medialis (nervus saphenus)

In both researched species, nervus cutaneus femoris medialis (n. saphenus) originated from the caudal part of the lumbar plexus just before n. obturatorius in the proximal part of the abdominal wall. It was determined that it moved from the proximal to distal side of the abdominal wall near the pecten ossis pubis, in the caudal direction. Then, while proceeding in the ventrolateral direction, it coursed ventrally on m. ambiens. In both studied species, it created n. cutaneus cruralis cranialis in order to innervate the skin in the proximal region of the juncturae genius medial face (Figures 5a and 5b).

3.1.6. Nervus obturatorius

Nervus obturatorius was formed in the magpie through combination of the branch that started from the caudal aspect of the lumbar plexus and the branches that separated from the ventral branches of the second and third synsacral spinal nerves. In the chukar partridge, it was formed through combination of the branch that originated from the caudal aspect of the plexus and the caudal branch of the third synsacral spinal nerve just before it joined to the lumbar plexus.

Nervus obturatorius moved through the foramen obturatum in the caudal direction and proceeded parallel to the os pubis just after originating from the lumbar plexus in both the magpie and the chukar partridge. Before moving through the foramen obturatum, n. obturatorius gave rise to ramus (r.) medialis in order to provide innervation of m. obturatorius internus, which is located around the foramen obturatum. It gave rise to r. lateralis, which is responsible for the innervation of m. obturatorius externus, just after exiting the foramen obturatum. Afterwards, it spread in the m. abductor femoris, proceeding in the ventral direction (Figures 6a and 6b).

4. Discussion

In birds, the cranial branch of n. furcalis was the last branch of the lumbar plexus, and its caudal branch was the first branch of the sacral plexus. It was reported that in white turkeys [13], Japanese quails [11], and rock partridges [14], the lumbar plexus and sacral plexus combined through n. furcalis. In this study, it was determined that they combined through n. furcalis in magpies and chukar partridges, as was similar among birds in the literature.

It was reported that the lumbar plexus was formed by the ventral branch of three spinal nerves in domestic birds [9,10], rock partridges [15], quails [16], and Japanese quails [15]. On the other hand, the lumbar plexus was formed by the ventral rami of four synsacral spinal nerves in ostriches [17]. In magpies and chukar partridges, the lumbar plexus consisted of the ventral rami of three (second, third, and fourth) synsacral spinal nerves, as in sparrowhawk [18].

In some studies, it was reported that n. pubicus (n. ilioinguinalis) started from the lumbar plexus in domestic

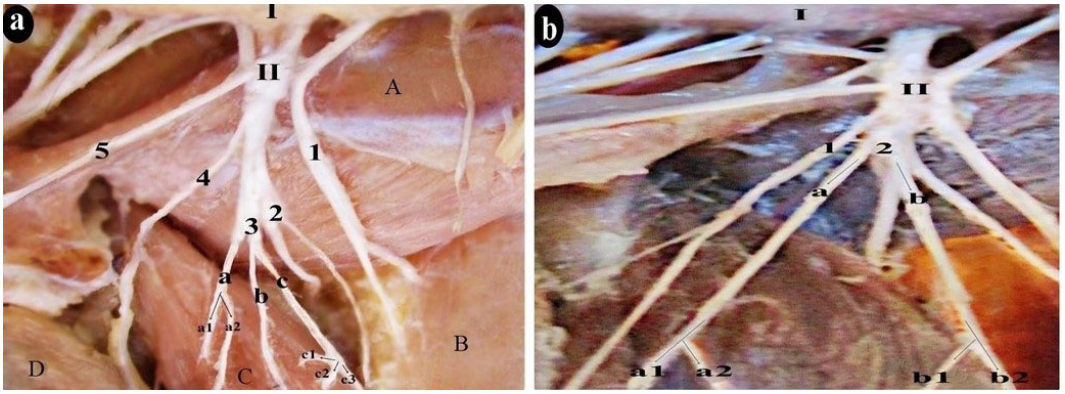

Figure 4. Gross anatomical view of; a: nervus femoralis and its branches in the chukar partridge, left ventrolateral view; (I); synsacrum, (II); lumbar plexus, (1); n. cutaneus femoris, (2); n. coxalis cranialis, (3); n. femoralis, (a–c); branches of n. femoralis, (a1, a2; c1–c3); caudal branches of n. femoralis, (4); n. cutaneus femoris medialis (n. saphenus), (5); n. obturatorius, (A); m. iliotrochantericus cranialis, (B); m. iliotibialis cranialis, (C); m. femorotibialis medialis, (D); m. puboischiofemoralis medialis. b: n. femoralis and its branches in the magpie, left ventromedial view; (I); synsacrum, (II); lumbar plexus, (1); n. cutaneus femoris medialis (n. saphenus), (2); n. femoralis, (a, b); branches of n. femoralis, (a1, a2, b1, b2); caudal branches of n. femoralis.

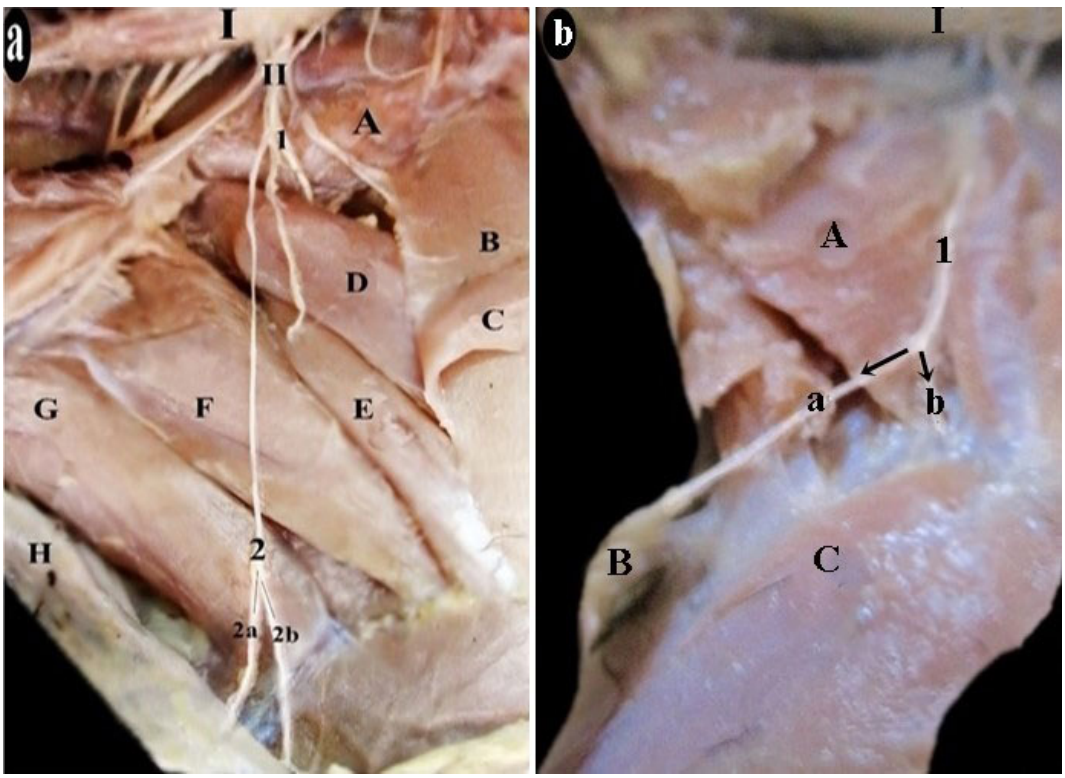

Figure 5. Gross anatomical view of; a: nervus saphenus and n. cutaneus cruralis cranialis in the chukar partridge, left medial view; (I); synsacrum, (II); lumbar plexus, (1); n. femoralis, (2, 2b); n. saphenus, (2a); n. cutaneus cruralis cranialis, (A); m. iliotrochantericus cranialis, (B); m. iliotibialis lateralis, (C); m. ambiens, (D); m. femorotibialis medialis, (E); m. femorotibialis internus, (F); m. puboischiofemoralis medialis, (G); m. biceps femoris, (H); subcutis. b: n. saphenus and n. cutaneus cruralis cranialis in the magpie, left caudoventral view; (I); synsacrum, (1,a); n. cutaneus cruralis cranialis, (b); n. cutaneus femoris medialis (n. saphenus), (A); m. puboischiofemoralis medialis, (B); subcutis, (C); m. iliotibialis lateralis.

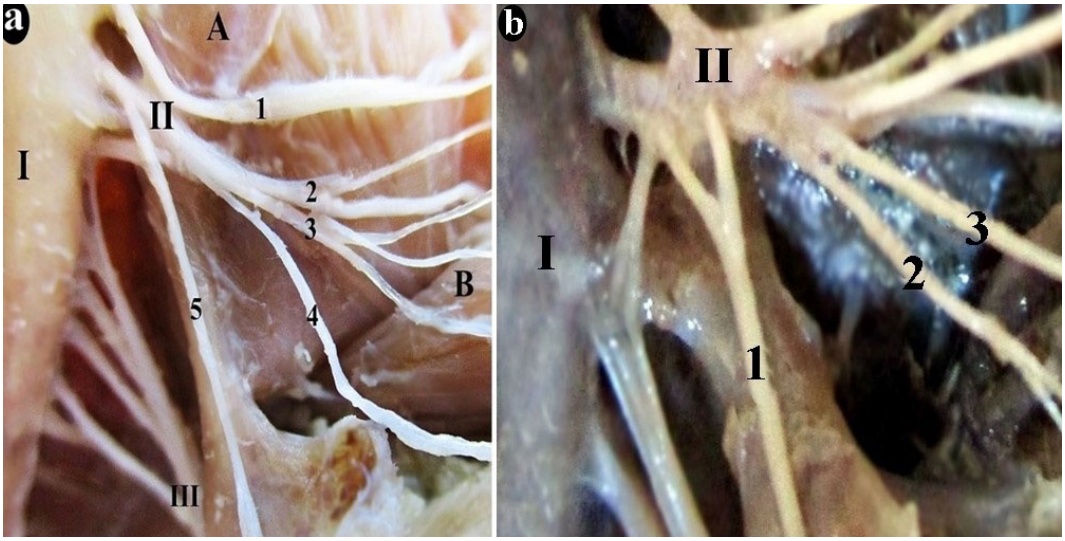

Figure 6. Gross anatomical view of; a: nervus saphenus in the chukar partridge, left caudoventral view; (I); synsacrum, (II); lumbar plexus, (III); sacral plexus, (1); n. cutaneus femoris, (2); n. coxalis cranialis, (3); n. femoralis, (4); n. cutaneus femoris medialis (n. saphenus), (5); n. obturatorius, (A); m. iliotrochantericus cranialis, (B); m. femorotibialis medialis. b: n. saphenus in the magpie, left ventrolateral view; (I); synsacrum, (II); lumbar plexus, (1); n. obturatorius, (2); n. cutaneus femoris medialis (n. saphenus), (3); n. femoralis.

poultry [9,10]. Nervus pubicus (n. ilioinguinalis) was not found in magpies and was a weak nerve originating from the ventral branch of the second synsacral spinal nerve in chukar partridges, as in Japanese quails and rock partridges [15]. Nervus iliocostalis and n. iliohypogastricus (which is the first lumbal nerve that does not originate from the lumbar plexus) innervate the abdominal muscles [12]. It is thought that n. iliocostalis and n. iliohypogastricus innervate the abdominal muscles instead of n. pubicus (n. ilioinguinalis) in magpie.

Nervus cutaneus femoris originates from the lumbar plexus in birds [19]. Balkaya and Özüdoğru [18] reported that this nerve was the first nerve that originated from the lumbar plexus. As Vanden Berge [20] observed, this nerve gave rise to a branch named n. cutaneous femoris lateralis in hawks [21]. Similar to the literature [20], the current study determined that n. cutaneus femoris gave rise to n. cutaneus femoris lateralis, originating as a thick root from the lumbar plexus.

Fitzgerald [16] named n. coxalis cranialis as n. lumbalis. It was reported that n. coxalis cranialis was delivered by the second and third synsacral spinal nerves after they joined the lumbar plexus in ostriches [17] and quails [16]. In some studies [22,23], it was found that n. gluteus cranialis separated from the lumbar plexus and dispersed in m. gluteus medius and profundus. Balkaya and Özüdoğru [18] reported that n. coxalis cranialis innervated m. iliotibialis lateralis. It was determined in both species in the current study that n. coxalis cranialis separated into two terminal craniolateral and caudolateral branches after originating from the lumbar plexus, and the branches dispersed to m. iliotibialis lateralis and m.gluteus medius.

Can and Özdemir [11] reported that n. femoralis divided into three branches in Japanese quails and five branches in rock partridges [14], Balkaya and Özüdoğru [18] reported that it divided into three branches in sparrowhawk, and El-Mahdy et al. [17] reported that it divided into six branches in ostriches. On the other hand, it was found that n. femoralis separated from n. coxalis cranialis and gave rise to two main branches in pigeons [21]. In some studies, n. femoralis was the strongest branch that began from the lumbar plexus in domestic birds, similar to the current findings [9,10,19]. In the present study, n. femoralis divided into two main branches in magpies and three main branches in chukar partridges. Some of the data from these studies were found to be similar to the current findings, but some anatomical differences were also found.

Nervus saphenus was named n. cutaneus femoris medialis in the NAA. Unlike the findings in this study, El-Mahdy et al. [17] reported that n. saphenus separated from n. femoralis. Similar to the results in Balkaya and Özüdoğru [18], in this study, n. saphenus was found to originate from the caudal side of the lumbar plexus in magpies and chukar partridges. Furthermore, Dursun [9] and Nickel et

al. [10] reported that n. saphenus was responsible for the innervation of the skin on the femur's medial surface and articulation genou, and that it separated from the lumbar plexus in domestic birds.

Baumel et al. [24] reported that n. obturatorius consisted of a combination of the second and third roots of the lumbar plexus in pigeons. Martin et al. [25] reported that this nerve took part in the proximal, medial part of the femur. It was reported that in birds, n. obturatorius travelled from the foramen obturatum, located in the caudoventral side of the acetabulum, with tendons of m. obturatorius medialis [19,20]. Similar to the sparrowhawk [18], n. obturatorius consisted of a combination of branches that started from the lumbar plexus and branches that separated from the ventral branches of the second and third synsacral spinal nerve in magpies. In chukar partridges it consisted of a combination of the branch that originated from the caudal side of the plexus and the branch given back from the third synsacral spinal nerve before it joined the plexus.

In this study, the anatomic distribution and nerve structure of the lumbar plexus of magpie (*Pica pica*) and chukar partridge (*Alectoris chukar*) species were determined. There were many similarities and few differences between them. For example, the lumbar plexus in both species was formed by ventral branches of three (2nd to 4th) synsacral spinal nerves. Nervus ilioinguinalis was detected only in chukar partridge. Nervus femoralis was divided into two main branches in magpie and three main branches in chukar partridge. Nervus obturatorius was formed by three nerve branches in the magpie and was formed by two nerve branches in chukar partridge. The lumbar plexus in magpies and chukar partridges shared anatomical similarities with other bird species. It is thought that this research will contribute to future scientific studies on this subject.

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