

Formation of the plexus sacralis in pheasants (*Phasianus colchicus mongolicus*) and macroanatomic investigation of the nerves originating from the plexus sacralis*

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Abstract: The purpose of this study was to investigate the formation of the plexus sacralis in the Kyrgyz pheasant (*Phasianus colchicus mongolicus*) and the origin of the nerves emerging from the plexus sacralis. Five adult male Kyrgyz pheasants were used that had been hunted in their natural habitat near the town of Tokmok in the Chuy region of Kyrgyzstan. The plexus sacralis was found to be formed in the lumbar region by the ventral strands of sacral nerves 1 to 5, originating in the spinal cord. The plexus is composed of the truncus cranialis, which consists of the ventral strands of the first 3 nerves united in the fossa renalis region, the truncus medianus formed by the ventral strand of the 4th nerve alone, and the truncus caudalis formed by the strand of the 5th ventral nerve alone. These 3 trunci are united to form the nervus ischiadicus at the entrance to the foramen ischiadicum. After passing through the foramen ischiadicum, the nerve separates into 5 strands as follows: the 1st strand forms the joint root of n. tibialis and n. peroneus, the 2nd strand forms the n. coxalis caudalis, the 3rd and 5th strands form the rr. musculares, and the 4th strand forms the n. cutaneus femoris caudalis.

Key words: Pheasant, plexus sacralis, Marek's disease, anatomy

1. Introduction

In the zoological system, pheasants belong to the phylum Chordata, class Aves, order Galliformes, family Phasianidae, subfamily Phasianinae, genus *Phasianus*, and species *colchicus* (1). Pheasants originate in the east, but they have successfully adapted to the climate in European countries and on the American continent as high up as Canada. According to historic documents, pheasants were introduced in Europe at around 1300 BC (2). Male and female individuals are easily distinguishable, with the male pheasants sporting a colorful plumage and long tail feathers (1). The Kyrgyz pheasant, an important game bird of the wildlife in Kyrgyzstan, which was first described and named by Brandt (1844, *Phasianus colchicus mongolicus*), is an important pheasant subspecies (3). These birds, also known as the Mongolian pheasant, feature neck rings of a more pronounced copper tone. However, the neck ring is not fully closed. This characteristic distinguishes them from other ringed pheasants (4).

In the literature, some researchers describe the plexus sacralis as being formed by the ventral strands of the 1st to 5th sacral spinal nerves (5–8), while others include

the ventral branches of the 6th sacral nerve (9–11). The number of roots forming the plexus varies from 5 to 7 (6,7,12). The first root of the plexus, the n. bigeminus, appears together with the last root of the plexus lumbalis, while the plexus' last root, the n. furcalis, appears together with the first root of the plexus pudendus (5–8,11,12). Sometimes, the n. bigeminus and n. furcalis may not be visible at all (8,11).

The roots forming the plexus sacralis generally unite to form 3 nerve trunks. The first 3 roots are strongly joined to the truncus cranialis. The 4th root continues alone as the truncus medianus. The 5th and 6th roots unite with the truncus caudalis (6,7,11). Serbest et al. (12) reported that in chicken, the 1st and 2nd branches of the plexus sacralis form the truncus cranialis, the 3rd branch alone forms the truncus medianus, and the 4th and 5th branches form the truncus caudalis. From the truncus cranialis emerges the n. tibialis and from the truncus medianus emerges the n. fibularis, while the truncus caudalis provides the tail nerves in the thigh region (7).

In the available literature, no anatomic study about the Kyrgyz pheasant, and in particular about its nervous

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system, could be found. This lack of data was the main reason for undertaking this study, which focused on the n. ischiadicus and its origin in the plexus sacralis, as this nerve is considered an important diagnostic criterion for Marek's disease in poultry due to its change of color and its increase in diameter (13,14).

The formation of the plexus and the branches emerging from it were examined with the purpose of aiding operative intervention in these animals and of contributing information about local animal populations to the international scientific community.

2. Materials and methods

In this study, 5 adult male Kyrgyz pheasants (*Phasianus colchicus mongolicus*) were used that had been hunted in their natural habitat near the town of Tokmok in the Chuy region of Kyrgyzstan. The birds were bought from hunters. The birds were cut open from the cloaca to the cartilago xiphoidea, the internal organs were removed, and the carcasses were immersed for 72 h in a 10% formaldehyde solution (13,15). Next, the plexus sacralis and the nerve branches emerging from it were dissected and pictures were taken. The thickness of the n. ischiadicus was measured with a caliper rule.

The terminology used is based on the 1993 edition of *Nomina Anatomica Avium* (8).

3. Results

Due to the synsacrum formation, assignment of last thoracic, lumbar, and sacral vertebrae and correct determination of the numbers of the nerves that emerged from intervertebral foramen in dissected pheasants were done, vertebral bodies to which ribs are attached were considered vertebrae thoracicae, and the nerves emerging from the spinal foramen were numbered accordingly.

1. The plexus sacralis is located caudal to the plexus lumbalis and cranial to the plexus pudendus (Figure 1).

2. It is formed in the fossa renalis region by the rami ventralis of sacral spinal nerves 1 to 5 (Figures 1 and 2).

3. The ramus ventralis (n. bigeminus) of the 1st sacral spinal nerve, which contributes to the plexus sacralis formation, emerges from the 1st sacral intervertebral foramen and leaves the canalis vertebralis immediately dorsal to the articulatio coxae (Figure 1).

4. The plexus sacralis is conjunct to the plexus lumbalis via the n. bigeminus.

5. In a caudolateral movement immediately after its point of origin, the n. bigeminus is united with the ramus ventralis of the 2nd sacral spinal nerve (Figure 1).

6. The ventral branch of the sacral spinal nerve leaves the canalis vertebralis through the 2nd intervertebral foramen cranial to the fossa renalis, and after a short extension, it unites with the 1st sacral spinal nerve; in a

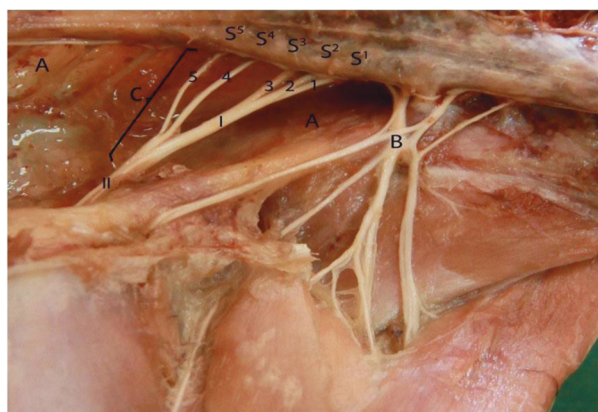


Figure 1. Dorsal view of the plexus sacralis and plexus lumbalis. S: Vertebra sacralis, 1: n. bigeminus, 2: sacral spinal nerve, 3: sacral spinal nerve, 4: sacral spinal nerve, 5: sacral spinal nerve, I: truncus cranialis, II: n. ischiadicus, A: fossa renalis, B: plexus lumbalis, C: plexus sacralis.

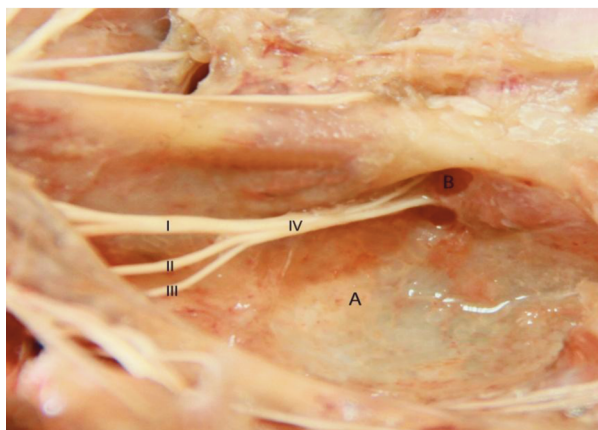


Figure 2. Formation of the nervus ischiadicus. I: Truncus cranialis, II: truncus medianus, III: truncus caudalis, IV: n. ischiadicus, A: fossa renalis, B: foramen ischiadicum.

caudoventral movement, this joint root unites with the ventral branch of the 3rd sacral spinal nerve in the fossa renalis (Figure 1).

7. The ventral branch of the sacral spinal nerve leaves the canalis vertebralis through the 3rd intervertebral foramen in the fossa renalis region; after a caudolateral movement, it unites with the trunk formed by the ventral roots of the 1st and 2nd sacral spinal nerve, forming the truncus cranialis (Figures 1 and 2).

8. The ventral branch of the sacral spinal nerve emerges from the canalis vertebralis at a point conforming to the middle of the fossa renalis and forms the truncus medianus without the inclusion of any other nerves (Figures 1 and 2).

9. The truncus cranialis and the truncus medianus form a joint root in the fossa renalis (Figures 1 and 2).

10. The ventral branch of the 5th sacral spinal nerve leaves the canalis vertebralis caudal to the fossa renalis and forms the truncus caudalis without the inclusion of any other nerves (Figures 1 and 2).

11. The truncus caudalis extends ventrally through the fossa renalis and then unites with the joint root of the truncus cranialis and the truncus medianus to form the n. ischiadicus at the height of the entrance to the foramen ischiadicum (Figures 1–3).

12. The arithmetic average of the n. ischiadicus in the pelvic cavity is 1.04 mm.

13. After the formation of the n. ischiadicus, it extends in a caudolateral direction, and together with the a. ischiadicum and v. ischiadicum, it leaves the pelvic cavity through the foramen ischiadicum (Figures 2 and 3).

14. Immediately after passing through the foramen ischiadicum, the n. ischiadicus separates into 5 branches (Figure 3).

15. The 1st and thickest branch in the cranial position is the common root of both the n. tibialis and n. peroneus. This root extends for up to one-third of the femur length in a perineum layer (Figure 3).

16. The 2nd branch is the n. coxalis caudalis, the 3rd and 5th branches are the rr. musculares, and the 4th branch is the n. cutaneus femoris caudalis (Figures 3 and 4).

17. The n. cutaneus femoralis caudalis passes between the m. flexor cruris lateralis pars pelvica and m. flexor cruris medialis and finally spreads out into the skin on the caudal side of the thigh. (Figure 4).

18. Most nerves mentioned here extend in the vicinity of regional arteries and together with the arteries penetrate the muscle tissue, while also sending out small branches to the arteries.

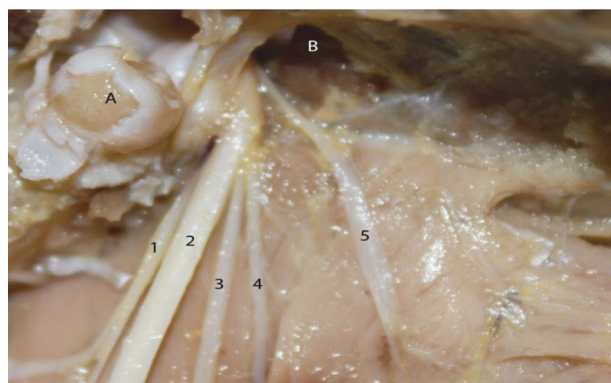


Figure 3. Separation of the nervus ischiadicus into 5 branches. A: Caput femoris, B: foramen ischiadicum, 1: n. coxalis caudalis, 2: common root of n. tibialis and n. peroneus, 3: rr. musculares, 4: n. cutaneus femoris caudalis, 5: rr. musculares.



Figure 4. The branches of n. ischiadicus. I: N. ischiadicus; 1: common root of n. tibialis and n. peroneus; 2, 2', 2'', 2''': n. coxalis caudalis; 3: n. cutaneus femoris caudalis; 4: rr. musculares, A: m. iliofibularis, B: m. flexor cruris lateralis pars pelvica.

4. Discussion

It has been reported that in birds a distinction between the thoracic, lumbar, sacral, and first few caudal spinal nerves is not possible and that all of these nerves emerge through the intervertebral foramina in the synsacrum region (10,11). In this study, the last thoracal vertebra could easily be distinguished. It was difficult, however, to distinguish between the lumbar and sacral vertebrae due to their fusion, and consequently, it proved difficult to assign the spinal nerves to their respective vertebral foramina.

It has been reported in numerous studies (8–10,12,16), including this one, that the plexus sacralis is formed in the fossa renalis region by the ventral branches of spinal nerves originating in the spinal cord of the synsacrum.

Some researchers (8,12) have stated that the plexus sacralis is formed by the ventral branches of 5 sacral nerves originating in the medulla spinalis, while others (9,10,16) have reported 6 sacral nerves. In this study, we found that the plexus sacralis is formed in the fossa renalis region by the rami ventralis of the 1st to 5th sacral spinal nerves.

In a number of studies (5–8,12), the n. bigeminus is defined as the first branch of the plexus sacralis and is described as emerging together with the last branch of the plexus lumbalis. The findings of this study conform to this view.

In previous studies (5–7,10,12), the n. furcalis was identified as the last branch of the plexus sacralis, emerging together with the first branch of the plexus pudendus, while *Nomina Anatomica Avium* (8) states that the n. furcalis and n. bigeminus may sometimes not be visible. In this study, the n. furcalis could not be found, a result conforming to the statement in *Nomina Anatomica Avium*.

It was reported in the literature (6,7,11) that the first 3 roots originating in the plexus sacralis unite to form

the truncus cranialis, while the 4th root alone forms the truncus medianus and the 5th and 6th together form the truncus caudalis. In this study, however, we came to the same conclusion as Serbest et al. (12), who reported that the truncus cranialis is formed by the first 3 branches while the truncus medianus and the truncus caudalis are formed by the 4th and 5th branch, respectively, without the inclusion of other nerves.

It was reported (11,12) that the n. ischiofemoralis originates from the n. ischiadicus and innervates the m. ischiofemoralis. In this study, however, the n. ischiofemoralis could not be detected.

According to Yılmaz and Dinç (10), the first 4 branches of the plexus sacralis unite to form the n. ischiadicus, while others (8,11) stressed that this nerve is formed by 3 trunci in the inner part of the pelvis. The findings of this study support the second view: the n. ischiadicus is formed in the inner pelvic region by 3 trunci and separates into 5 strands after passing through the foramen ischiadicum.

In some papers (9,10), the 2nd nerve separating from the n. ischiadicus is called n. gluteus caudalis, and in others (8), it is called n. coxalis caudalis. In this study, we followed the rules of *Nomina Anatomica Avium* (8) and opted for n. coxalis caudalis. This nerve separates from the n. ischiadicum at the height of the foramen ischiadicum and continues down to the distal side of the leg.

Some researchers (8,11,12) reported that the rr. musculares emerges from the plexus sacralis. In this study, we found that the 3rd and 5th strands separating from the n. ischiadicus extend to the local muscles as rr. musculares.

It was reported (9,10) that in poultry, the n. cutaneus femoralis caudalis passes between the m. biceps femoris and m. semitendinosus and innervates the skin. In our study, we propose different names in accordance with *Nomina Anatomica Avium* (8): the m. biceps femoris to be named m. iliofibularis and the m. semitendinosus to be named m. flexor cruris lateralis pars pelvica. It was, however, established in this study that the n. cutaneus femoralis caudalis is the 4th nerve separating from the n. ischiadicus; this nerve passes between the m. flexor cruris lateralis pars pelvica and m. flexor cruris medialis and finally radiates into the caudal surface skin of the thigh. We can confirm the finding in the above-mentioned sources that the nerve innervates the skin; we did, however, find a different pathway of the nerve.

In conclusion, it can be stated that the region in which the plexus sacralis of the Kyrgyz pheasant is formed conforms to that in other poultry species. We did, however, find differences in the nerves forming the plexus sacralis and in their branching. These differences may be species-related or variations in the peripheral nerve system. This study is the first work on the plexus sacralis of Kyrgyz pheasants and the results may serve as a basis for further investigations on this subject.

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