



Origin of Lumbosacral Plexus and its Branches in Domestic Turkey (*M. gallopavo*)

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Abstract

The lumbosacral plexus that supplies to the hind limb has been extensively studied in mammals and birds. There is no report on lumbosacral plexus characterization in domestic turkey (*Meleagris gallopavo*), so far. Here, we investigated the nerve roots in domestic turkey, which accumulate to form the lumbosacral plexus and characterize the branches originating from the plexus. The lumbosacral plexus consists of lumbar and sacral plexuses. Three turkeys were dissected for characterization of the plexuses. It was found that lumbar plexus was formed by the union of four ventral roots of the spinal nerves, including the last three lumbar and first sacral spinal nerves. Among four roots, the diameter of the third (last lumbar) root was highest, whereas the least was observed in the last root. We observed four branches of the lumbar plexus, including the obturator, cutaneous femoral, saphenus, and femoral nerve. The five roots of spinal nerves, which contributed to form three trunks, formed the sacral plexus of turkey. The three trunks united medial to the acetabular foramen and formed a compact, cylindrical bundle, the ischiatic nerve. The principal branches of the sacral plexus were the tibial and fibular nerves that together formed the ischiatic nerve. Other branches were the caudal femoral cutaneous nerve and the muscular branches. This study was the first work on the lumbosacral plexus of domestic turkey, and these results may serve as a platform for future research.

Keywords: Domestic turkey, Hind limb, Lumbar plexus, Sacral plexus, Spinal nerves, Birds.

INTRODUCTION

Turkey production is becoming an essential and profitable component of the agricultural industry with rising global demand for its meats (Yakubu *et al.*, 2013; Karki, 2005). Turkeys can adapt to a wide range of climatic conditions (Ogundipe und Dafwang, 1980). Besides, turkey is an excellent insect forager and can be used in insect control for the crop production (Grimes *et al.*, 2007). Turkey is more resistant to disease compared to other poultry species like chicken, duck and quail. The mortality rate of turkey is low compared to other poultry bird as it shows resistance to Marek's and infectious bronchitis (Sampath, 2012). Moreover, turkey has aesthetic value due to its beauty (Ogundipe und Dafwang, 1980). For reasons as mentioned above, turkey rearing is also increasing in Bangladesh. Besides meat production, turkey could be of great interest as many other avian species serve as companion animals as well as models in

biological and biomedical research and as sources of high-quality protein (McLelland, 1990). Because of this increased interest in birds on many different levels, there is also increased interest in avian anatomy and physiology. An understanding of the origin and distribution of the plexus components is essential for clinical practice and surgery. In birds, the mixed nerves that constitute the lumbar, sacral, and pudendal plexuses accomplish the innervation of the pelvic region, hindlimb, and tail (Dursun, 2002). The lumbosacral plexus includes the interconnected lumbar and sacral plexuses. The lumbosacral plexus nerves are vital for the diagnosis of Marek's disease, of which pathologic findings including swelling of peripheral nerves, loss of striated mass, and lethargy. It has been reported that turkey shows resistance to Marek's disease, and lumbosacral plexus nerves are not affected (Aiello und Mays, 1998). Scientists are curious about how these nerves become resistant to Marek's disease virus infection. There are ample of studies on the

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anatomy of the lumbosacral plexus of different avian species including different types of birds such as the chicken (*Gallus gallus domesticus*) (Serbest et al., 1993), the rock partridge (*Alectoris graeca*) (Can und Özdemir, 2012a,b), the Japanese quail (*Coturnix coturnix japonica*) (Can und Özdemir, 2011), the pheasant (*Phasianus colchicus mongolicus*) (Istanbullugil et al., 2013), the pigeon (*Columba livia*) (Balkaya und Özüdođru, 2013), the ostrich (*Struthio camelus*) (El-Mahdy et al., 2010), the sparrowhawk (*Accipiter nisus*) (Balkaya und Özüdođru, 2016a,b), the Eurasian eagle owls (*Bubo bubo*) (Akbulut et al., 2016) and the duck (*Anas platyrhynchos domesticus*) (Hussan et al., 2018). However, there is no report on the lumbosacral plexus of the domestic turkey. This study, therefore, aimed to characterize the origin and distribution of nerves of the lumbosacral plexus in domestic turkey.

MATERIALS AND METHODS

Three domestic turkeys (two male and one female) were used in this study. Turkeys were purchased from a local market near the Faculty of Animal Science and Veterinary Medicine, Patuakhali Science and Technology University, Babugonj, Barisal. All three turkeys were healthy. The live body weights of three turkeys were 5.3 (male), 5.4 (female), and 9.5 (male) kg. Turkeys were anaesthetized intravenously with pentobarbital sodium @ 50mg/kg body weight. Next, turkeys were bled to death by giving incision on the right common carotid artery. An incision was made from cloaca to the xiphoid process and expanded around the sternum. The body cavity was opened and internal organs were removed without damage to the nerves to study the lumbosacral plexus. The turkeys were thoroughly dissected and nerves of the lumbosacral plexus were photographed. The terminology used in this study follows the Nomina Anatomica Avium (Baumel et al., 1993).

RESULTS

The network of nerves that innervated the pelvic limb of turkey was the lumbosacral plexus, consisted of lumbar and sacral plexuses. Importantly, any difference was not observed in the formation and branches of lumbosacral plexus of male and female turkey in this study.

Lumbar plexus

In this study, the lumbar plexus was located on the ventral surface of the preacetabular ilium, in a close association with the cranial division of the kidney. In the turkey, lumbar plexus was formed by the union of four roots of spinal nerves, including the last three lumbar and first sacral spinal nerves

(Figure 1A and B). Among four roots of the lumbar plexus, the third (last lumbar) root was highest in diameter, and the last root (1st sacral origin) was least in diameter, as observed by naked eyes. We observed four branches of the lumbar plexus innervating mostly thigh region. The branches of lumbosacral plexus show differences in origin and distribution, which include obturator, cutaneous femoral, saphenus, and the femoral nerves (Figure 1A, B and C). The obturator nerve originates from the roots of L6 and L7 lumbar spinal nerves (Figure 1A and B), and then move caudolaterally parallel to the ventral border of the ilium and left the pelvis through the obturator foramen (Figure 1A and B). This nerve innervates the obturatorius, ischiofemoralis, and adductor muscle. The cutaneous femoral nerve originates from the roots of L5 and L6 lumbar spinal nerves (Figure 1A and B) and then it moves cranioventrally and supplies the muscle sartorius, iliotibialis cranialis and the skin. It was found that saphenous nerve originates from the caudal root along the caudal border of the lumbar plexus, and then passes caudolaterally and supplies the iliacus muscle (Figure 1B). The femoral nerve was the largest and terminal branch of the lumbar plexus, and is originated from the L6 and L7 lumbar spinal nerves (Figure 1A and B). Immediately after its origin, the femoral nerve was divided into three branches (Figure 1B). The femoral nerve supplies the iliotibialis, femorotibialis, and patellar region of the knee joint.

Sacral plexus

We observed that the sacral plexus of turkey was formed by five roots of the spinal nerves, which contributed to form three trunks (Figure 1A and B) in this study. There were two branches in the first sacral nerve, namely cranial and caudal branch. It was found that cranial branch contributes to the formation of brachial plexus (furcal nerve), whereas the caudal branch contributes to the formation of sacral plexus (Figure 1B). Caudal branch of the first sacral nerve and the ventral branch of the second sacral nerve united and formed the cranial trunk. The middle trunk was formed by ventral rami of the third and fourth sacral spinal nerves, and it merged with the cranial trunk and generated a new root in the cranial part of the caudal renal division. Ventral branch of the fifth sacral spinal nerve, after a short distance from its origin, unites with the other two trunks and form the third trunk. (Figure 1A and B). These three trunks united medial to the acetabular foramen, forming a compact, cylindrical bundle, the ischiatic nerve (Figure 1D). Removal of the epineural sheath of the bundle revealed that the plexus splits into branches within the pelvis. The principal branches of the sacral plexus include the tibial and fibular nerves (Figure 1E and F) that together form the ischiatic nerve. Other branches were: the caudal femoral cutaneous nerve and the muscular branches (Figure 1D).

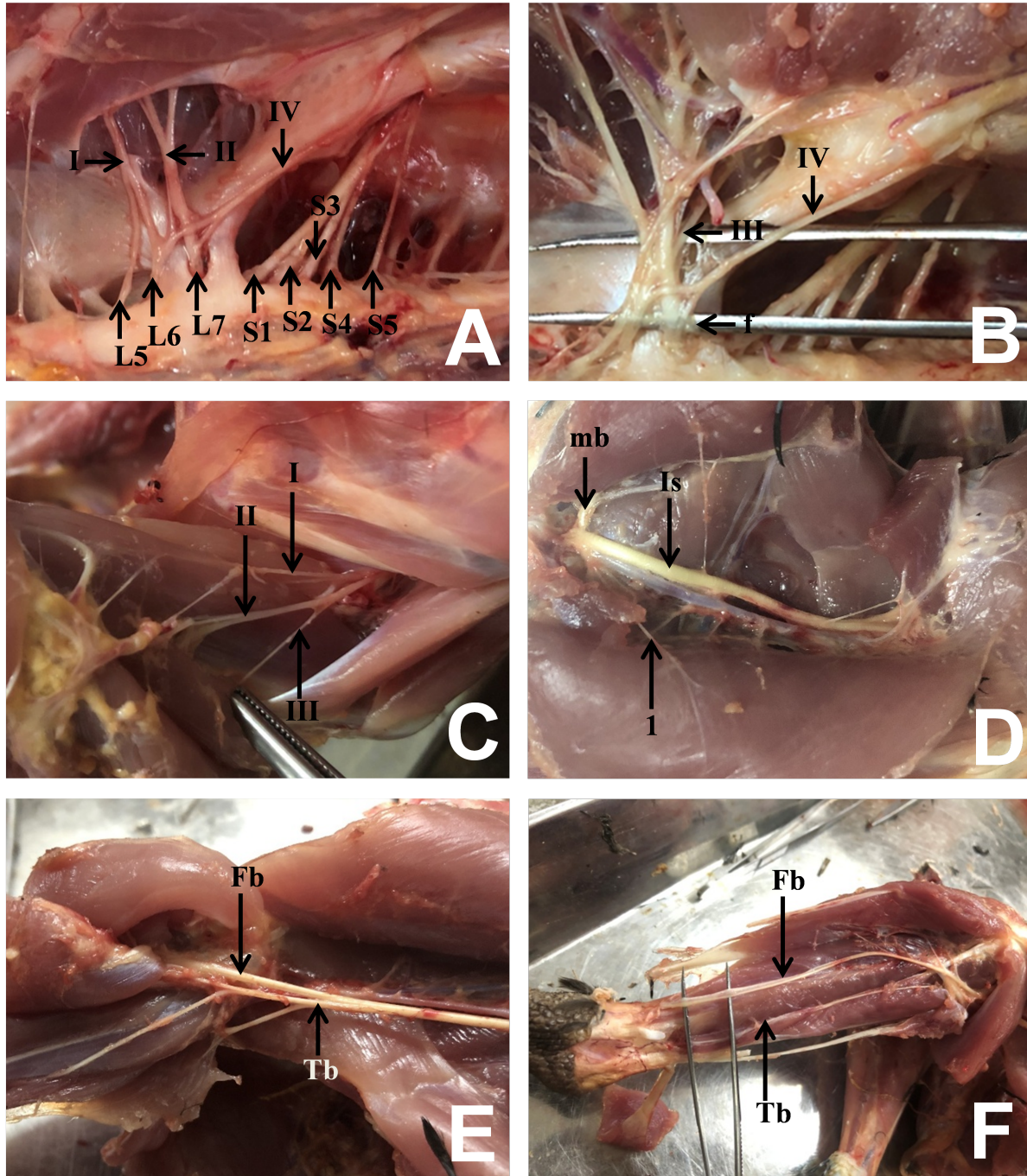


Figure 1: Formation of lumbosacral plexus and its branches in the domestic turkey. **A and B.** Lumbar plexus was formed by the union of the ventral branches of last three lumbar and first sacral spinal nerves; Sacral plexus was formed by the anastomosis of the ventral branches of the five sacral nerves **C.** Branches of lumbar plexus. **D.** Branches of sacral plexus. **E.** Branches of ischiatic nerve. **F** Branches of ischiatic nerve. f= furcal nerve; L5,6,7= lumbar spinal nerve 5, 6, 7; I= Femoral cutaneous nerve, II= Femoral nerve, III= Saphenous nerve, IV= Obturator nerve; S1,2,3,4,5= Sacral spinal nerve 1,2,3,4,5; mb= muscular branch; Is= Ischiatic nerve; I= Caudal femoral cutaneous nerve; Fb= Fibular nerve; Tb= Tibial nerve.

DISCUSSION

We characterized the lumbosacral plexus, which consists of lumbar and sacral plexuses and its branches in do-

mestic turkey during the study. Our findings indicated that the lumbar plexus was formed by the union of four roots of spinal nerves, which included ventral branches of the last three lumbar spinal nerves and first sacral spinal nerve. The findings of

the lumbar plexus formation in turkey are inconsistent with the previous reports in ostrich (El-Mahdy *et al.*, 2010) and Japanese quail (Bentley and Poole, 2009). However, different findings were reported in many avian species such as chicken (Nickel *et al.*, 1977; Dursun, 2002), quail (Fitzgerald, 1969), and rock partridge (Can and Özdemir, 2012a) where the lumbar plexus was formed by the ventral branches of three spinal nerves. We observed that the lumbar plexus gave rise to four large branches including obturator, cutaneous femoral, saphenus, and the femoral nerve that was supplying the thigh in turkey. Similar findings were reported in chicken (Nickel *et al.*, 1977; Dursun, 2002), pigeon (Balkaya and Özüdođru, 2013), and Japanese quail and rock partridge (Can, 2011; Can and Özdemir, 2012a). A previous study in ostrich reported three branches of the lumbar plexus nerves, including the cranial coxal nerve, femoral nerve and obturator nerve (El-Mahdy *et al.*, 2010). However, Can (2011) reported six branches in lumbar plexus including ilioinguinal, cutaneous femoris, femoral, cranial coxal, saphenus and obturator nerves in rock partridges and Japanese quail.

It was observed that the obturator nerve originated from L6 and L7th root of the lumbar spinal nerves and then passed caudolaterally parallel to the ventral border of the ilium and left the pelvis through the obturator foramen, which is similar to the previous studies in domestic fowls (Baumel, 1979; Breazile and Yasuda, 1979; Vanden Berge, 1979). In the ostrich, the nerve extended caudally in the cranial margin of the pubis (El-Mahdy *et al.*, 2010), whereas, Martin *et al.* (1994) reported that this nerve was located medially in the proximal part of the femur. In our observation in the turkey, the cutaneous femoral nerve was located the cranial border of the lumbar plexus and originated from the L5 and L6th lumbar spinal nerve. It then moved cranioventrally and innervated the muscle sartorius, iliotibialis cranialis and the skin. Similar findings were reported in flamingo (Berge, 1976), domestic fowl (Nickel *et al.*, 1977; Dursun, 2002) and ostrich (El-Mahdy *et al.*, 2010). In the present study, the saphenus nerve originated from the caudal root along the caudal border of the lumbar plexus, passed caudolaterally and supplied to the iliacus muscle of turkey, which was in the same line with that of findings domestic birds reported by Dursun (2002) and Nickel *et al.* (1977). In contrast; El-Mahdy *et al.* (2010) reported that the saphenus nerve originated from the femoral nerve in ostrich.

In the turkey, the cranial coxal nerve has not been identified in this preliminary study, which was reported in the duck (Hussan *et al.*, 2018), quail (Fitzgerald, 1969) and ostrich (El-Mahdy *et al.*, 2010). In our findings in the turkey, the femoral nerve was the largest and terminal branch of the lumbar plexus, which is similar as in domestic fowl (Nickel *et al.*, 1977; Dursun, 2002) and ostriches (El-Mahdy *et al.*, 2010). In turkey, the femoral nerve was divided into three branches immediately after its origin. Fitzgerald (1969) and Can (2011) reported that the femoral nerve divided into three branches between the body and thigh in quail and Japanese quail. The ramification of the femoral nerve in the turkey was similar to that reported for quail (Fitzgerald, 1969) and Japanese quail (Can, 2011). Contrary to these reports, Can

(2011) and Can and Özdemir (2012a) stated that the nerve divided into five branches in the rock partridge. El-Mahdy *et al.* (2010) stated that this nerve gave rise to six branches in the ostrich and that is divided into two branches in the pigeon following its origin (Balkaya and Özüdođru, 2013).

It was detected that the sacral plexus of the turkey was formed by ventral branches of synsacral nerves leaving from the canal of synsacrum and this plexus was linked to the lumbar plexus via the furcal nerve (Figure 1A). In our study, no connection was found with that of the pudendal plexus with the bigemini nerve as it was reported in duck (Hussan *et al.*, 2018). In our study, the sacral plexus of turkey was formed by the ventral rami of five synsacral spinal nerves, which contribute to form three trunks. It was reported that the sacral plexus was formed by four ventral rami of synsacral nerves for the quail (Can and Özdemir, 2011), the pigeon (Balkaya and Özüdođru, 2013), the pheasant (Istanbullugil *et al.*, 2013), the chicken (Serbest *et al.*, 1993) and five for the rock partridge (Can and Özdemir, 2012b) and seven for the ostrich (El-Mahdy *et al.*, 2010). In the turkey, the caudal branch of the first sacral nerve and the ventral branch of second sacral nerve united and formed the cranial trunk. The ventral rami of third and fourth sacral spinal nerves united to form the middle trunk. Middle trunk merged with the cranial trunk and generated a new root in the cranial part of the caudal renal fossa. After the short distance from the origin, the ventral branch of the fifth sacral spinal nerve united with the cranial and middle trunk as a third trunk (caudal trunk). A similar finding was reported that ventral branches of synsacral nerves, forming the sacral plexus, formed three trunks: the cranial trunk, the middle trunk and the caudal trunk (Can and Özdemir, 2012b; Balkaya and Özüdođru, 2013); however, there were two trunks in the case of the ostrich, namely the cranial trunk and the caudal trunk (El-Mahdy *et al.*, 2010).

It is stated that five for the ostrich (El-Mahdy *et al.*, 2010), two for the rock partridge (Can and Özdemir, 2012b), the pheasant (Istanbullugil *et al.*, 2013), the quail (Can and Özdemir, 2011), the pigeon (Balkaya and Özüdođru, 2013) and the chicken (Serbest *et al.*, 1993) ventral branches of synsacral nerves participated in the formation of the cranial trunk. It was also reported that the last two ventral branches of synsacral nerves participated in the formation of the caudal trunk (El-Mahdy *et al.*, 2010; Can and Özdemir, 2012b); however, one ventral branch of synsacral nerve participated in the formation of the caudal trunk regarding the pheasant (Istanbullugil *et al.*, 2013). It was also mentioned that the middle trunk was formed by only one ventral branch of the synsacral nerve (Can and Özdemir, 2011; Balkaya and Özüdođru, 2013).

The ischiatic nerve is reported as the thickest nerve leaving from the sacral plexus in poultry, and it is originated from the first four roots of the sacral plexus (Nickel *et al.*, 1977; Martin *et al.*, 1994; Dursun, 2002; El-Mahdy *et al.*, 2010). Some reports state that the ischiadicus nerve is formed by the union of the cranial trunk, the middle trunk and the caudal trunk in the pheasant (Istanbullugil *et al.*, 2013), the chicken (Serbest *et al.*, 1993), the pigeon (Balkaya and Özüdođru, 2013), the rock partridge (Can and Özdemir, 2012b) and the

quail (Can und Özdemir, 2011). In our study, it was determined that firstly, the cranial trunk and the middle unified, and then by uniting of the caudal trunk with these roots. The three trunks united medial to the acetabular foramen and formed a compact, cylindrical bundle, the ischiatic nerve. Removal of the epineural sheath of the bundle revealed that the plexus breaks up into its branches within the pelvis. The principal branches of the sacral plexus were the (1) tibial and (2) fibular nerves that together made up the ischiatic nerve. Other branches were: (3) the caudal femoral cutaneous nerve; (4) the muscular branches. It was stated that four branches originated in the quail (Can und Özdemir, 2011) and the rock partridge (Can und Özdemir, 2012b), respectively, from the sacral plexus cranially to caudally, namely the mutual root of fibular nerve and tibial nerve, the coxal caudal nerve, the cutaneous femoral caudal nerve and the rami musculares, but in the pigeon (Balkaya und Özüdođru, 2013) firstly the coxal caudal nerve, the mutual root of fibular nerve and tibial nerve, the cutaneous femoral caudal nerve and the rami musculares. It was also reported that five branches originated in the pheasant (Istanbullugil et al., 2013) namely the mutual root of fibular nerve and tibial nerve, the coxal caudal nerve, the rami musculares, the cutaneous femoral caudal nerve and finally the second part of the rami musculares. In this study, we explored the morphological structure of the lumbosacral plexus and its branches in the domestic turkey.

It can be concluded that the origin and branching of lumbosacral plexus of indigenous turkey are conformed to that in other avian species. However, we found some differences in the nerves forming the lumbosacral plexus and in their branching. These differences may be species-related or variation in the peripheral nervous system. This study was the first work on the lumbosacral plexus of domestic turkey and results may serve as a basis for further investigation on this topic

References

- Aiello SE, Mays A, 1998. The Merck Veterinary Manual. 8. Auflage. Merck & CO. INC. Whitehouse Station NJ, USA.
- Akbulut Y, Demiraslan Y, Aslan K, Koban A, 2016. The macroanatomy of the sacral plexus and its nerves in eurasian eagle owls (*Bubo bubo*). *Anatomia Histologia Embryologia* 45: 367–372.
- Balkaya H, Özüdođru Z, 2013. Macroanatomic and subgross study on the plexus lumbosacralis and its branches of pigeon (*Columba livia*). *Ataturk University Journal of Veterinary Sciences* 8: 21–33.
- Balkaya H, Özüdođru Z, 2016a. Macroanatomical aspects of the lumbar plexus and its branches in the sparrowhawk. *Anatomia Histologia Embryologia* 45: 67–72.
- Balkaya H, Özüdođru Z, 2016b. Macroanatomical aspects of the sacral plexus and its branches in sparrowhawk. *Journal of Applied Animal Research* 44: 77–82.
- Baumel JJ, 1979. Osteologia. In: Nomina Anatomica Avium (Baumel JJ, King AS, Lucas AM, Breazile JE and Evans HE, eds). London: Academic Press.
- Baumel JJ, King SA, Breazile JE, Evans HE, Vanden Berge JC, 1993. Handbook of Avian Anatomy. Nomina Anatomica Avium. 2. Auflage. Cambridge, MA: Published by the Club.
- Bentley MT, Poole TJ, 2009. Neurovascular anatomy of the embryonic quail hindlimb. *The Anatomical Record* 292: 1559–1568.
- Berge JCV, 1976. M. ilirotibialis medialis and a review of the m. ilirotibialis complex in flamingos. *The Auk: Ornithological Advances* 93: 429–433.
- Breazile JE, Yasuda M, 1979. Systema nervosum peripheriale. In: Nomina Anatomica Avium (Baumel JJ, King AS, Lucas AM, Breazile JE and Evans HE, eds). London: Academic Press.
- Can M, 2011. Bildircin (*coturnix coturnix japonica*) ve kaya kekligi'nin (*alectoris graeca*) plexus lumbosacralis'i uzerinde karsilastirmali, makroskobik ve subgross calismalar. erzurum: Saglik bilimleri enstitusu, anatomi (veteriner) anabilim dali. Dissertation, Doktora Tezi, Ataturk Universitesi.
- Can M, Özdemir D, 2011. Macro-anatomic investigations on the plexus lumbosacrales of japanese quail (*Coturnix coturnix japonica*). *Ataturk University Journal of Veterinary Sciences* 6: 31–45.
- Can M, Özdemir D, 2012a. Macro-anatomic investigations on the plexus lumbales of rock partridge (*Alectoris graeca*). *Ataturk University Journal of Veterinary Sciences* 7: 123–129.
- Can M, Özdemir D, 2012b. Macro-anatomic investigations on the plexus sacralis of rock partridge (*Alectoris graeca*). *Journal of the Faculty of Veterinary Medicine, Kafkas University* 18: 141–146.
- Dursun N, 2002. The anatomy of domestic birds. *Ankara: Medisan*.
- El-Mahdy T, El-Nahla SM, Abbott LC, Hassan SA, 2010. Innervation of the pelvic limb of the adult ostrich (*Struthio camelus*). *Anatomia Histologia Embryologia* 39: 411–425.
- Fitzgerald TC, 1969. The coturnix quail, anatomy and histology : 195–200.
- Grimes J, Beranger J, Bender M, Walters M, 2007. How to raise heritage turkey on pasture. American livestock Breeds conservancy Pittsboro, NC27312 USA. Headquarters, 233 S.Wackes Drive, 11th floor Chicago, Illinois-60606.
- Hussan MT, Islam MS, Alam J, 2018. Macroanatomical structures of the lumbosacral plexus and its branches in the indigenous duck. *Bangladesh Veterinary Journal* 52(1-4): 1–9.

- Istanbullugil FR, Karadağ H, Sefergil Ş, İnce Gezer N, Alpapak H, 2013. Formation of the plexus sacralis in pheasants (*Phasianus colchicus mongolicus*) and macroanatomic investigation of the nerves originating from the plexus sacralis. *Turkish Journal of Veterinary and Animal Sciences* 37: 160–163.
- Karki M, 2005. Growth, efficiency of utilization and economics of different rearing periods of turkeys. *Nepal Agricultural Research Journal* 6: 89–88.
- Martin HD, Kabler R, Sealing L, 1994. The avian coxofemoral joint: a review of regional anatomy and report of an open-reduction technique for repair of a coxofemoral luxation. *Journal of the Association of Avian Veterinarians* 8: 164–172.
- McLelland J, 1990. A Colored Atlas of Avian Anatomy. London, England: Wolfe publishing LTD.
- Nickel R, Schummer A, Seiferle E, 1977. Anatomy of the Domestic Birds. Berlin, Hamburg: Verlag Paul Parey.
- Ogundipe S, Dafwang II, 1980. Turkey production in nigeria. *National Agricultural Extension Research and Liaison Service (NAERLS) Bulletin* 22: 2–22.
- Sampath KT, 2012. Turkey farming: A profitable enterprise. *National Institute of Animal Nutrition and Physiology, Adugodi Bangalore, India* 21: 2.
- Serbest A, Bahadır A, Bahri Y, Yılmaz O, 1993. Tavuklarda plexus sacralis ile bunu oluşturan ramus ventralis' lerin makro-anatomik ve subgros incelenmesi. *Uludag University Journal of the Faculty of Veterinary Medicine* 2: 46–54.
- Vanden Berge JC, 1979. Myologia. In: *Nomina Anatomica Avium* (J. J. Baumel, A. S. King, Lucas. AM, J. E. Breazile and H. E. Evans, eds). London: Academic Press.
- Yakubu A, Abimiku HK, Musa-Azara IS, Idahor KO, Akinsola OM, 2013. Assessment of flock structure, preference in selection and traits of economic importance of domestic turkey (*Meleagris gallopavo*) genetic resources in nasarawa state, nigeria. *Livestock Research for Rural Development* 25(1): 18.