

Course and branch of the celiac artery in the red falcon (*Buteo rufinus*)

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ABSTRACT: The present study was aimed at determining the origin, course and distribution of the celiac artery in eight adult red falcons, using a latex injection and dissection method. The celiac artery was ascertained to originate from the aorta at the level of the last 2–3 costae. The celiac artery was determined to split into two main branches, namely, left branch of the celiac artery and right branch of the celiac artery, in between the proventriculus and gizzard, and in the proximity of the lien. Prior to the indicated bifurcation, the celiac artery was observed to give off an esophageal artery and superior proventricular artery. In seven of the red falcons examined, splenic arteries, varying from two to four in number, were determined to spring from the celiac artery. Both the left and right hepatic arteries were ascertained to stem from the left branch of the celiac artery. The terminal branch of the left branch of the celiac artery, namely, the left gastric artery, was determined to have a fan-like distribution to the left surface of the gaster. The artery of the gall bladder was demonstrated to emanate from the left branch of the celiac artery in all of the red falcons examined, excluding one. The right branch of the celiac artery was determined to ramify into its terminal branches, namely, the right inferior gastric artery, ileocecal artery, pancreaticoduodenal artery, duodenojejunal artery and gastroduodenal artery, in the proximity of the pylorus which constitutes the gastro-duodenal passage.

Keywords: macroanatomy; ramification; celiac artery; long legged buzzard

The *Nomina Anatomica Avium* (Baumel et al., 1993) describes the celiac artery as originating from the aorta, on the right side of the esophagus and at the junction where the glandular stomach joins the esophagus, in birds. In avian species, branches originating from the celiac artery are reported to generally be distributed to the glandular stomach (proventriculus) and muscular stomach (gizzard), liver, pancreas, spleen and small intestines (Doguer and Erencin, 1964; Malinovsky and Novotna, 1977; Baumel et al., 1993; Dursun, 2002). The celiac artery is described as splitting into two branches, namely, the ramus dexter and ramus sinister (Doguer and Erencin, 1964; McLeod et al., 1964; Malinovsky, 1965; Malinovsky and Novotna, 1977; Baumel et al., 1993), and the branch situated on the right side is reported to be larger (Getty, 1975). However studies carried out in the Eurasian eagle owl (Aycan and

Duzler, 2000) and pigeon (Chiasson, 1964), have described a celiac artery which does not bifurcate into two branches, while all existing branches spring directly from the celiac artery. Studies carried out in the chicken, duck, goose and pigeon have shown this artery to split into two branches, but to give off esophageal arteries prior to bifurcation (Aslan and Takci, 1998; Kurtul, 2002; Kurtul and Hazirolu, 2002). In studies conducted in ducks (Nickel et al., 1977) and chickens (Malinovsky and Visnanska, 1975; Kuru, 1996) the celiac artery has been reported to divide into two branches running along the right and left sides, after branching off into the superior proventricular artery and esophageal artery. *Nomina Anatomica Avium* (Baumel et al., 1993) describes the left branch of the celiac artery to give off an inferior proventricular artery, left gastric artery, rami sacci, inferior gastric artery, left

hepatic artery and superior gastroduodenal artery. Furthermore, the right branch of the celiac artery is indicated to give off the following branches: splenic artery, right hepatic artery, ileocecal artery, pancreaticoduodenal artery, duodenojejunal artery, right superior gastric artery, right inferior gastric artery and rami sacci. Malinovsky and Novotna (1977) have investigated the origin of the splenic artery in detail, in a study carried out in chickens. The esophageal artery has been determined not to be a branch of the celiac artery and to stem directly from the aorta in geese. Esophageal arteries are reported to arise from the superior proventricular artery (Malinovsky et al., 1973; Baumel et al., 1993). The artery of the gall bladder, which is sent to the gall bladder, is reported to be a branch of the right hepatic artery (Malinovsky and Visnanska, 1975; Baumel et al., 1993).

Despite the abundance of scientific literature on the ramification of the celiac artery in domestic avian species, such studies are quite limited in wild birds. No such previous study exists in the red falcon. In order to acquire information on the ramification of the celiac artery in wild birds, the present study was carried out in the red falcon. The present study was undertaken to define the anatomy of the celiac artery and its branches, to determine features specific to the red falcon, and to lay out similarities with, and differences from, other domestic avian species.

MATERIAL AND METHODS

Eight adult red falcons, both male and female, which were referred to Erciyes University, Faculty of Veterinary Medicine for treatment, yet had died, constituted the material of this study. The birds used were identified as red falcons (*Buteo rufinus*) and were determined to belong to the *Buteo buteo* sub-group under the family *Falconidae*, in accordance with the taxonomy set forth by Kiziroglu (1989). In order to permit better visualisation of the course and ramification of the celiac artery, latex coloured with red Rotring ink was injected into the vessel through the left ventricle. Examinations were performed by dissection. Findings were photographed using an 8 Mega Pixel digital camera with 5× zoom capacity. Measurements were performed with a 150 mm digital calliper. The nominal descriptions of the blood vessels were according to *Nomina Anatomica Avium* (Baumel et al., 1993).

RESULTS

In the red falcon, the celiac artery was determined to originate from the aorta at the level of the last 2–3 costae and the junction of the esophagus with the stomach (Figures 1/a, 2/a). The celiac artery was ascertained to give off its first branch at an approximate distance of 3 mm from its origin in the birds examined. Throughout its straight course to the lien, the celiac artery was determined to branch off into the esophageal artery, superior proventricular artery, superior gastric artery and a single splenic artery, respectively. In one of the birds examined, the inferior proventricular artery was also determined to stem directly from the celiac artery. The celiac artery was ascertained to terminate at the level of the lower one-third of the lien by splitting into two branches, namely, the right branch of the celiac artery and the left branch of the celiac artery (b and c in Figures 1, 3, and 4).

Esophageal artery (arteria esophagealis). The esophageal artery was determined to arise at an average distance of 6.05 mm from the origin of celiac artery, forming a common trunk with the superior proventricular artery in 6 birds examined (Figures 1/d¹–e, 2/b¹–c), and to originate independently and at an average distance of 3.15 mm from the origin of the celiac artery in two birds. Following its origin, the esophageal artery extended in a craniodorsal direction, and split into small branches which varied from three to five in number and were distributed in the dorsal region of the distal one-third of the esophagus.

Superior proventricular artery (arteria proventricularis dorsalis). In six of the falcons examined, this artery was determined to originate from the celiac artery, forming a common trunk with the esophageal artery (Figures 1/d¹–d, 2/b¹–b). Furthermore, in two of the birds examined, the superior proventricular artery was ascertained to emanate directly from the celiac artery immediately after the origin of the esophageal artery (Figure 4/e). This blood vessel was ascertained to terminate dorsal to the proventriculus by splitting into branches varying from two to three in number. One of these branches was determined to run to the gaster, whereas the remainder was ascertained to distribute in the dorsal region of the proventriculus.

Superior gastric artery (arteria gastrica dorsalis). This artery was determined to originate from the superior proventricular artery (Figures 2/d, 4/f). In all of the falcons examined, a.gastrica dorsalis

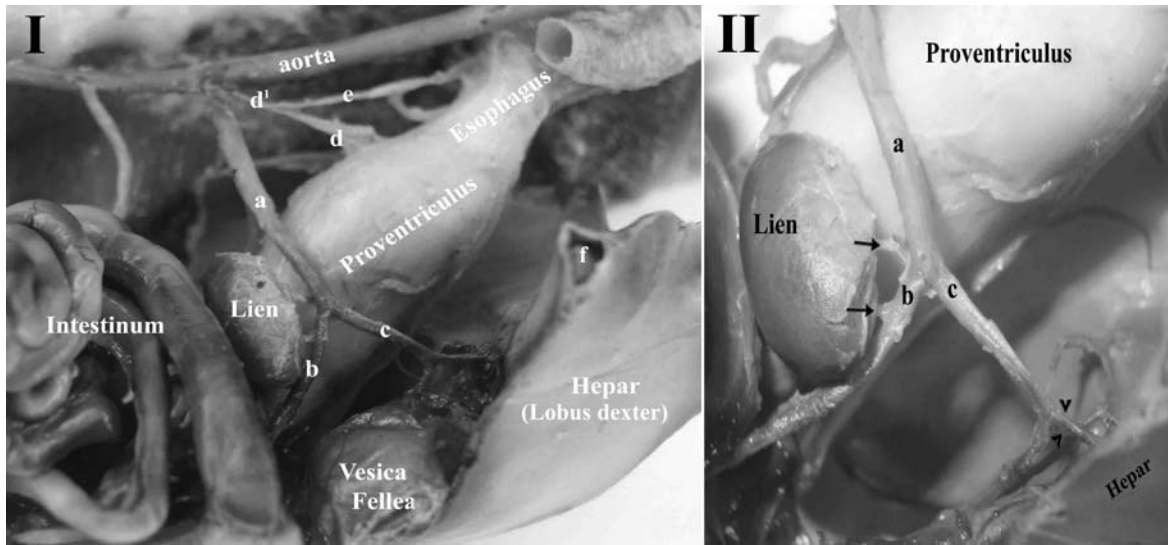


Figure 1. a = arteria celiaca, b = ramus dexter arteriae celiacae, c = ramus sinister arteriae celiacae, d = arteria proventricularis dorsalis, d¹ = common trunk of arteria proventricularis dorsalis and rami esophageales, e = rami esophageales, f = vena cava caudalis; black arrows = arteriae splenicae, black arrowheads = arteria hepatica dextra

was observed to extend to the left side and dorsal border of the gaster, and to give off numerous small branches along its course.

Splenic artery (arteries splenicae). These arteries were demonstrated to stem from the undivided trunk of the celiac artery at the level of the lien. These short arteries, which varied from two to four in number, were determined to distribute directly to the parenchyma of the lien. In one of the

animals examined, one of the splenic arteries was determined to have its origin at the celiac artery, whereas the other had its origin at right branch of the celiac artery (Figure 1/II – black arrows).

Left branch of celiac artery (ramus sinister arteriae celiacae). Following its origin, this blood vessel was determined to extend cranioventrally (Figures 1/c, 2/c, 4/c), and subsequently, ventrally at the level of the junction of the proventriculus with the gaster. Along its course, the left branch of celiac artery was ascertained to send a right hepatic artery to the right lobe of the liver, and subsequently to pass to the left side of the median plane after running a transversal course behind the liver. This branch was demonstrated to send an artery to the gall bladder, and a left hepatic artery to the left lobe of the liver. Following the ramification of these branches, the inferior proventricular artery, inferior gastric artery and finally left gastric artery were determined to spring from the left branch of the celiac artery.

Right hepatic artery (arteria hepatica dextra). This artery was ascertained to emanate from the left branch of the celiac artery and to terminate in the right lobe of liver (lobus hepaticus dexter) (Figures 1/II – black arrowheads, 3/d, 4/d). In one of the falcons examined, this blood vessel was observed to be quite large and to give off two separate branches to the gall bladder.

Artery of gall bladder (arteria vesicae biliaris). This artery was determined to have its origin at the left branch of the celiac artery in six of the birds

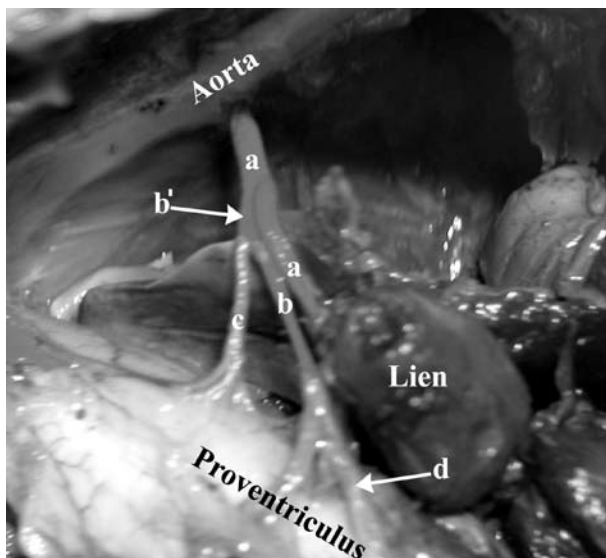


Figure 2. a = arteria celiaca, b = arteria proventricularis dorsalis, b¹ = common trunk of arteria proventricularis dorsalis and rami esophageales, c = arteria esophagealis, d = arteria gastrica dorsalis

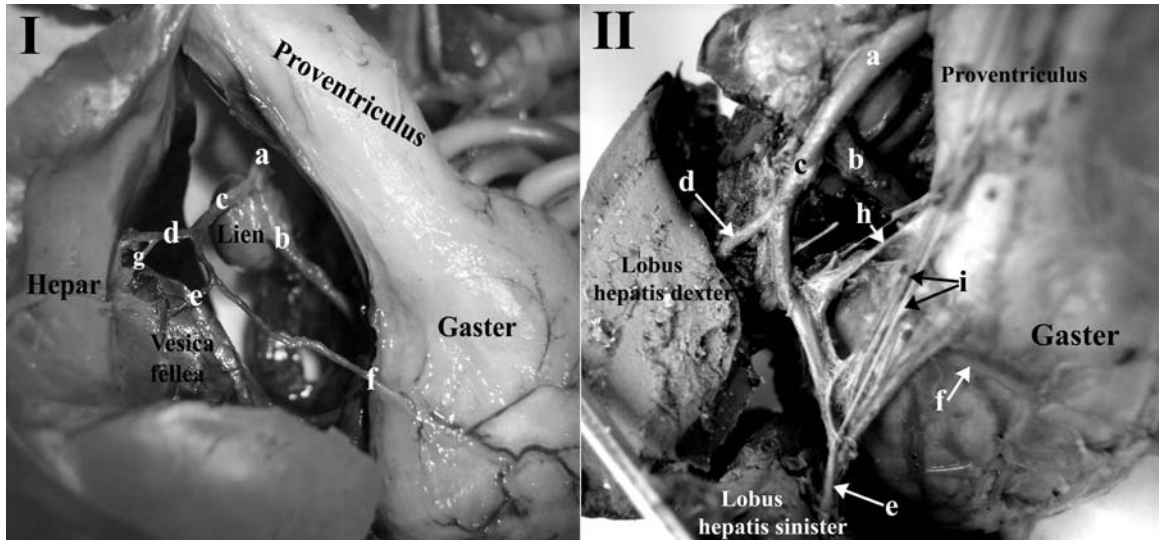


Figure 3. a = arteria celiac, b = ramus dexter arteriae celiacae, c = ramus sinister arteriae celiacae, d = arteria hepatica dextra, e = arteria hepatica sinistra, f = arteria gastrica sinistra, g = arteria vesicae biliaris, h = arteria proventricularis ventralis, i = arteria gastrica ventralis

examined, at the right hepatic artery in one animal (Figure 3/I-g), and at the left hepatic artery in another animal. In one of the six falcons in which the artery of gall bladder originated from the left branch of the celiac artery, the blood vessel was determined to be the first branch, whereas in four of the falcons it was ascertained to be the second branch given off after the right hepatic artery. In one animal, the artery of the gall bladder was demonstrated to stem from the left branch of the celiac artery in the third place, following the ramification of the left hepatic artery and the right hepatic artery.

Left hepatic artery (arteria hepatica sinistra). This artery was determined to arise from the left branch of the celiac artery at the ventrolateral region of the gaster, and to terminate in the left lobe of the liver (Figure 3/e). In seven of the eight falcons examined, the left hepatic artery was observed to be larger than the right hepatic artery, whereas in one material it was determined to be smaller (Figure 3/I). In two of the birds examined, the left hepatic artery was determined to originate as two small branches. In one bird, one of the branches of the left hepatic artery was demonstrated to extend to the porta hepatis.

Inferior proventricular artery (arteria proventricularis ventralis). Having its origin at the ramus sinister celiac artery (Figure 3/h), this blood vessel was observed to distribute as either a single branch or as two branches to the ventral region of the proventriculus. In one of the birds examined, an inferior

proventricular artery was determined to originate from the undivided trunk of the celiac artery.

Inferior gastric artery (arteria gastrica ventralis). This blood vessel was ascertained to originate from r. sinister celiac artery as 2–3 small branches (Figure 3/II-i), to run along to the gaster and to terminate on its ventral border.

Left gastric artery (arteria gastrica sinistra). This blood vessel was determined to be the prolongation of the ramus sinister celiac artery and to constitute its terminal branch (Figures 3/f, 4/white arrowheads). The left gastric artery was ascertained to pass to the left and to extend caudally, and to have a fan-like distribution to the left surface of the gaster.

Right branch of celiac artery (ramus dexter arteriae celiacae). After stemming from the celiac artery, this blood vessel was determined to run along on the right side of the proventriculus in a caudoventral direction (Figures 1/b, 3/b, 4/b). This branch was ascertained to follow a straight course to the junction of the gaster with the duodenum. Prior to reaching the site of the indicated junction, it was determined to give off a right superior gastric artery. At the level of the indicated junction, the right branch of celiac artery was determined to split into its terminal branches which extended in different directions, namely the ileocecal artery, gastroduodenal artery, pancreaticoduodenal artery, duodenojejunal artery and right inferior gastric artery.

Right superior gastric artery (arteria gastrica dextra dorsalis). This blood vessel was determined

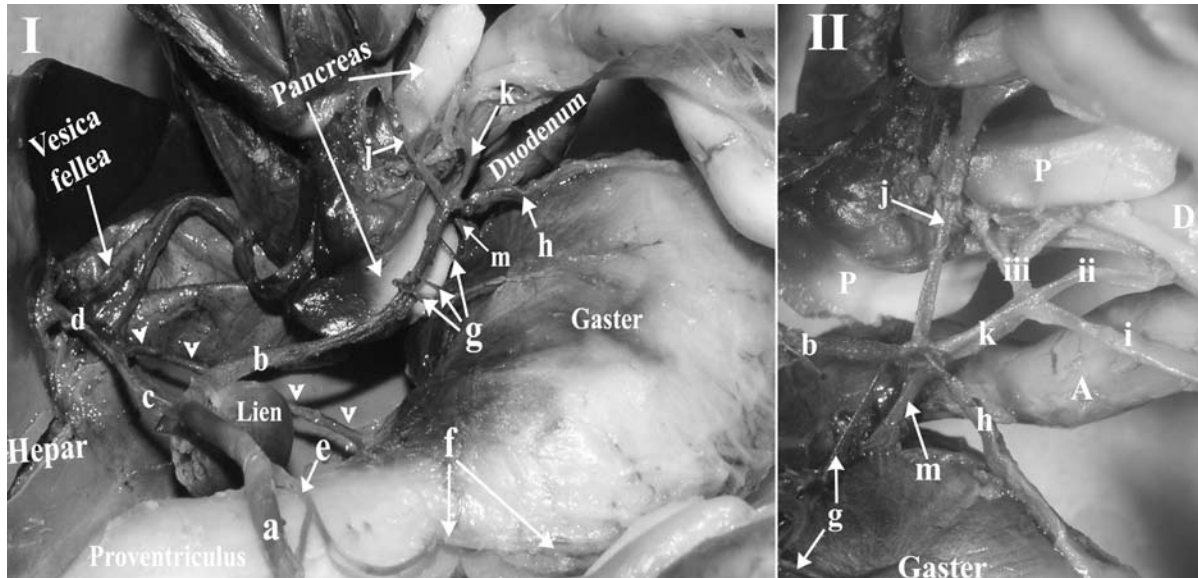


Figure 4. a = arteria celiaca, b = ramus dexter arteriae celiacae, c = ramus sinister arteriae celiacae, d = arteria hepatica dextra, e = arteria proventricularis dorsalis, f = arteria gastrica dorsalis, g = arteria gastrica dextra dorsalis, h = arteria gastrica dextra ventralis, j = arteria ileocecalis, k = arteria pancreaticoduodenalis, m = arteria gastroduodenalis; white arrowheads = arteria gastrica sinistra

to be the first branch stemming from the right branch of celiac artery, and to terminate by distributing to the right surface of the gaster. In one of the materials examined, this artery was demonstrated to spring from the right branch of the celiac artery as three independent branches and to distribute to the right of the gaster (Figure 4/g).

Ileocecal artery (arteria ileocecalis). This artery was determined to originate from the right branch of the celiac artery, and to distribute to only the ileum (Figure 4/j).

Gastroduodenal artery (arteria gastroduodenalis). This blood vessel was determined to be one of the last branches of right branch of the celiac artery (Figure 4/m). The gastroduodenal artery was ascertained to be formed by a single branch and to give off three to four small branches distributing to the proximal region of the duodenum along its course.

Pancreaticoduodenal artery (arteria pancreaticoduodenalis). This artery was determined to stem from the right branch of the celiac artery, to extend caudally and to split into two branches (Figure 4/k). One of the bifurcated branches (Figure 4/II-i) was determined to distribute to the flexura duodeni and pars descendens duodeni of the duodenum. The other branch (Figure 4/II-ii) was ascertained to run along the pars ascendens duodeni. The two bifurcated branches were determined to anastomose with each other at the ansa duodeni. A blood vessel

ramifying from the branch extending to the pars ascendens duodeni was determined to extend to the pancreas, which was situated within the duodenal loop (Figure 4/II-iii).

Duodenojejunal artery (arteria duodenojejunalis). This artery was determined to be one of the last branches originating from the right branch of the celiac artery at the level of the junction of the gaster with the duodenum. Along its course to the jejunum, the indicated blood vessel was ascertained to give off two to four small branches to the duodenum at varying levels.

Right inferior gastric artery (arteria gastrica dextra ventralis). This artery was determined to emanate from the ramus dexter celiac artery, following the ramification of the ileocecal artery (Figure 4/h). The right inferior gastric artery was demonstrated to extend to the ventral region of the gaster, and to terminate by splitting into three or four small branches. In one of the birds examined, the right inferior gastric artery was determined to originate from the duodenojejunal artery.

DISCUSSION

In avian species (Baumel et al., 1993), including the chicken (Malinovsky and Visnanska, 1975; Kuru, 1996; Dursun, 2002), rooster, duck, pigeon (Kurtul,

2002; Kurtul and Haziroglu, 2002), falcon (McLeod et al., 1964), domestic duck (Malinovsky, 1965) and domestic goose (Malinovsky et al., 1973), the celiac artery is reported to originate from the aorta at the level of the junction of the esophagus with the proventriculus. Furthermore, Dursun (2002) has reported the site of origin to be the ventral region of the 5th thoracic vertebra in the chicken. In the present study which was carried out in the red falcon, within the proximity of the site of origin previously reported in the chicken, the celiac artery was determined to stem from the aorta at the dorsal region of the beginning of the proventriculus and at the level of the last 2–3 costae.

In various reports (McLeod et al., 1964; Malinovsky, 1965; Nickel et al., 1977; Kuru, 1996) the first branch to ramify from the celiac artery is reported to be the esophageal artery. Similarly, in two of the red falcons examined in the present study, the esophageal artery was also determined to be the first branch. In six of the red falcons examined, the esophageal artery was ascertained to originate from the celiac artery, forming a common trunk with the superior proventricular artery. Contrary to the above reports, Nomina Anatomica Avium (Baumel et al., 1993) describes the esophageal artery as stemming from the aorta in species of the family *Falconidae*. In the red falcons examined in the present study, the esophageal artery was determined to spring from the celiac artery and not the aorta.

Aycan and Duzler (2000) and Chiasson (1964) have reported that the celiac artery did not bifurcate. In contrast to these studies, in the present study which was carried out in the red falcon, the celiac artery was determined to split into the left branch of the celiac artery and right branch of the celiac artery in between the proventriculus and gaster, in agreement with previous reports of Kurtul (2002), Malinovsky and Novotna (1977), and Pinto et al. (1998). In chickens (Kuru, 1996), the celiac artery was determined to bifurcate after the origin of the superior proventricular artery and cranial to the lien. In the red falcon, the bifurcation of the celiac artery was demonstrated to be localised cranioventral to the lien (at the level of the ventral one-third) and in between the lien and proventriculus.

In various avian species, the splenic artery is known to stem from either the right branch of celiac artery (Doguer and Erencin, 1964; Malinovsky et al., 1973; Baumel et al., 1993; Kuru, 1996; Aslan and Takci, 1998; Dursun, 2002) or directly from

the celiac artery (Chiasson, 1964; Baumel et al., 1993; Aycan and Duzler, 2000). Furthermore, in a study carried out in three different chicken breeds (Malinovsky and Visnanska, 1975) the lien was tabularized to be vascularised by one or more branches arising from the right hepatic artery in 6–15%, left branch of celiac artery in 15%, and superior proventricular artery in 27–57% of the animals examined. In the above investigation, the origin of the splenic artery from the right branch of the celiac artery was observed in 100% of the birds examined, and the rate of the vascularization of the lien by the splenic artery stemming from only the right branch of celiac artery was seen in 69–87% of the chickens examined. In the present study, in one of the red falcons examined, two short branches originating from the celiac artery and the right branch of the celiac artery were determined to extend to the lien. In the remaining seven falcons, the splenic arteries were determined to have their origin at the celiac artery. The number of splenic arteries in chickens has been reported to be two by Kuru (1996) and to vary from two to eight by Malinovsky and Novotna (1977). The number of the indicated arteries has been reported to be two in the Eurasian eagle owl by Aycan and Duzler (2000), and to vary from two to six in the duck by Pinto et al. (1998). Furthermore, the number of splenic arteries has been reported to vary between five and seven in the duck, three and six in the pigeon and four and six in the rooster by Kurtul (2002). In the present study, the number of splenic arteries in the red falcons examined was ascertained to vary from two to four.

The left hepatic artery is reported to be a branch of the inferior gastric artery (Malinovsky and Visnanska, 1975; Kuru, 1996; Dursun, 2002; Kurtul, 2002). In a Eurasian eagle owl (Aycan and Duzler, 2000) the indicated artery has been reported to stem from the celiac artery. Reports exist that indicate the left hepatic artery to arise from the left branch of the celiac artery in domestic avian species (Baumel et al., 1993), ducks (Nickel et al., 1977) and chickens (Malinovsky and Novotna, 1977). In all of the red falcons examined, the left hepatic artery was determined to be a branch ramifying from the left branch of the celiac artery.

In seven of the red falcons examined, the artery of the gall bladder was determined to originate from the left branch of the celiac artery at varying levels and in varying positions. However, numerous reports (Malinovsky, 1965; Malinovsky et al., 1973; Malinovsky and Visnanska, 1975; Malinovsky

and Novotna, 1977; Baumel et al., 1993; Aslan and Takci, 1998; Aycan and Duzler, 2000; Dursun, 2002; Kurtul, 2002) indicate this artery to stem from the right hepatic artery in various avian species. In the present study which was conducted in the red falcon, an artery of the gall bladder with the previously reported origin was determined to exist.

In the red falcons examined, the right hepatic artery was also ascertained to spring from the left branch of the celiac artery. In contrast to this, various literatures (McLeod et al., 1964; Malinovsky, 1965; Malinovsky et al., 1973; Malinovsky and Visnanska, 1975; Malinovsky and Novotna, 1977; Nickel et al., 1977; Baumel et al., 1993; Aslan and Takci, 1998; Dursun, 2002; Kurtul, 2002) have reported the right hepatic artery to originate from the right branch of the celiac artery.

The determination of the origin of the inferior proventricular artery and inferior gastric artery from the left branch of the celiac artery in the red falcons examined in the present study is in agreement with the findings of previously conducted studies (Malinovsky and Visnanska, 1975; Nickel et al., 1977; Baumel et al., 1993; Aslan and Takci, 1998; Kurtul, 2000; Dursun, 2002). However, in one of the red falcons examined, the inferior proventricular artery was demonstrated to emanate from the celiac artery.

In one of the red falcons examined in the present study, the first branches of the right branch of the celiac artery were splenic arteries; this is also in compliance with previous research (Doguer and Erencin, 1964; Malinovsky, 1965; Malinovsky et al., 1973; Malinovsky and Visnanska, 1975; Malinovsky and Novotna, 1977; Nickel et al., 1977; Kuru, 1996; Dursun, 2002; Kurtul, 2002). However in the seven remaining red falcons, the first branch was ascertained to be the right superior gastric artery. In the present study, the right branch of the celiac artery, after splitting into its terminal branches, namely, the right inferior gastric artery, ileocecal artery, pancreaticoduodenal artery, duodenojejunal artery and gastroduodenal artery, was determined to distribute to the ventral region of the gaster, and also the duodenum, pancreas and ileum, in agreement with previous reports (Malinovsky and Visnanska, 1975; Malinovsky and Novotna, 1977; Nickel et al., 1977; Baumel et al., 1993).

In conclusion, the present study describes the course and ramification of the celiac artery in the red falcon. By comparing the findings obtained in the present study with previous reports, both the common and singular anatomical features of the celiac artery in the red falcon were shown.

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