

The arterial blood supply of the foot of the domesticated ducks (*Anas domesticus*).

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With 8 figures, 2 tables

Received July, accepted for publication December 2013

Abstract

The arterial supply of the foot was carried out on ten adult, healthy domestic ducks. The arteries were demonstrated by injection of colored gum milk latex and treated by the ordinary method of preserving. The arterial supply of the foot was achieved mainly by the cranial tibial artery. The foot received its arterial supply through two sets of arteries; dorsal and plantar. The dorsal set comprised the Rete tibiotarsale and A.metatarsalis dorsalis communis. The plantar set of arteries supplying the foot was derived from the Aa. intermetatarsales plantares and the plantar arch. The digital arteries arose from the latter arch except those of the 2nd digit and mostly the lateral artery of the 4th digit. The metatarsal pad was supplied by single pulvinar branch arising from either the plantar arch or A. digitalis III lateralis. The interdigital web was supplied by fine transverse rami arising from the Aa. digitales III medialis and lateralis, A. digitalis II lateralis and A. digitalis IV medialis as well

as a longitudinal branch arising from the latter artery. These rami were anastomosed forming capillary network distributed all over the web.

The results obtained were photographed, described and discussed with those of other of other authors in domestic birds.

Keywords: Arterial supply- foot-domestic duck

Introduction

The progress in the avian surgery increased the demand for more knowledge about the anatomy of the birds. Avian foot was subjected to many injuries; wounds, bumble foot, fibriscess swelling of the metatarsal pad were the most common and needed surgical interference (Heidenreich, 1997; Routh, 2000; Cooper, 2002). On reviewing the available literature there was not any adequate information about the arterial supply of this region in the duck. On the other hand the arterial supply of the pelvic limb in birds has been outlined by several authors,

Mcleod et al. (1964), Koch (1973), Baumel (1975), Nickel et al. (1977) and El-Gammal (2012) in the domestic fowl, Fitzgerald (1969) in the coturnix quail, Midtgard (1981) and Dursun (2002) in the different domestic birds, Can and Ozdemir (2010) in the Japanese quail and El-Nahla et al., (2010) in the ostrich. Therefore, current study was performed to be highlight for the arterial vascularization of the foot of this bird as a model which may be helpful in surgical approach to this region in different avian breeds.

Material and Methods

The present work was carried out on ten healthy domestic ducks (*Anas domestica*) weighing about 2.5 to 3.5 kg. Before exsanguinations, the ducks were anaesthetized by intramuscular injection of 0.5 cc of 2% xylazine hydrochloride to ensure proper relaxation and avoid vasoconstriction, then injected with heparin (Cal Heparin, 5000 I.U. diluted by 1 - 2 cm. saline solution) through the wing vein.

Each specimen was exsanguinated through the common carotid arteries. The breast muscle and sternum were removed to expose the descending aorta through which a Nelaton catheter of size 8F to 10F was introduced just caudal to the heart. The injection approach com-

prised 60% latex neoprene coloured red with Rottring ink and the specimens were kept in 10% formalin 4% phenol and 1% glycerin three days before dissection.

The nomenclature used in this study was that given by the Baumel et al., (1993)

Results

The arterial supply of the foot was derived from one main source, the cranial tibial artery (Fig.1/2) that represented the continuation of the popliteal artery (Fig.1/1) through the distal interosseous foramen (Fig.1/a) between the tibiotarsus (Fig.1/b) and fibula (Fig.1/ c). It descended along the cranial aspect of the tibiotarsus to its distal third where it detached 2-3 collateral branches that concurred in forming a vascular network called the Rete tibiotarsale after which it continued distally as the A. metatarsalis dorsalis communis. The arterial architecture of the foot could be arranged into two sets; dorsal and plantar.

I-The dorsal set

The dorsal set of arteries supplying the foot comprised the **Rete tibiotarsale** and A.metatarsale dorsalis communis.

Rete tibiotarsale

The tibiotarsal rete (Fig.1, 2, 5 /3) was formed of multiple parallel ves-

sels that located along the distal end of the cranial surface of the tibiotarsus, the flexor surface of the tarsus (Fig.1, 2/d) as well as the proximal end of the tarsometatarsus. These vessels comprised the collateral branches arising from the distal third of the cranial tibial artery, deep fibular (Fig.1/5), superficial fibular (Fig.1/6) and lateral sural arteries (Fig.1/14) arteries as well as some closely related veins. They branched and re-united with the axially oriented cranial tibial artery that continued distally beyond this rete as the common dorsal metatarsal artery.

A. metatarsalis dorsalis communis

The common dorsal metatarsal artery (Fig.2, 4, 5/7) constituted the distalward continuation of the cranial tibial artery after traversing the **Rete tibiotarsale**. It descended along the flexor surface of the tarsus, under the transverse ligaments of the tarsometatarsus. On reaching the level of the proximal vascular foramen of the tarsometatarsus it gave off the Aa. Tarsae plantares and then divided into two branches; the medial and lateral dorsal metatarsal arteries.

A. metatarsalis dorsalis medialis:

The medial dorsal metatarsal artery (Fig.2, 4, 5/ 8) was the smaller of

the two vessels arisen from the A. metatarsalis dorsalis communis. It descended along the dorsomedial aspect of the tarsometatarsus in accompany with the corresponding dorsal metatarsal nerve (Fig.4/ r) and terminated just proximal to the metatarsophalangeal articulation of the 2nd phalanx by dividing into the Aa. digitales II medialis and lateralis. Along its course it detached fine braches that supplied the tendon of the M. extensor digitorum communis, M. extensor proprius digiti III and M. extensor hallucis longus.

A. metatarsalis dorsalis lateralis

The lateral dorsal metatarsal artery (Fig.2, 4, 5/9) from points of its size and direction, it is considered as the direct continuation of the A. metatarsalis dorsalis communis. It descended along the dorsal aspect of the tarsometatarsus accompanied with the corresponding dorsal metatarsal nerve (Fig.4/ r) to the level of the distal vascular foramen (Fig.2, 3/h) of this bone through which it passed to the plantar aspect and joined the plantar arch. Throughout its course the lateral dorsal metatarsal artery gave off branches supplying the tendon of the M. extensor digitorum communis as well as the M. extensor proprius digiti III and Mm. extensor breves digiti III and IV.

II-The plantar set

The plantar set of arteries supplying the foot was derived from Aa.tarseae plantares and the plantar arch.

Aa. intermetatarsales plantares:

The medial (Fig. 2, 3/10) and lateral (Fig. 3/11) plantar inter-metatarsal arteries were given off from the common dorsal metatarsal artery on the level of the **proximal vascular foramina** (Fig.2, 3/f) of the tarso-metatarsus. In eight specimens these two vessels originated by very short common stem vessel. Each of these vessels pierced through the corresponding proximal vascular foramen of the tarso-metatarsus and gained the plantar aspect where it soon divided into two branches; an ascending or recurrent branch and a descending branch. Both **ascending branches; represented the Aa. tarsales plantares, medialis (Fig.2, 3/12) and lateralis (Fig.3/13)** which extended proximally along the corresponding aspect of the tarsus, where it detaches fine articular branches to that joint and cutaneous branches supplying the skin on either side of the joint and then anastomosed with the corresponding medial (Fig.1/ 15) and lateral (Fig.1/ 16) branches of the A. suralis lateralis (Fig.1/14). The descending branches were ex-

tended distally as the **Aa. metatarsales plantares**.

Aa. metatarsales plantares:

The medial (Fig.2, 3/17) and lateral (Fig.3/18) plantar metatarsal arteries represented the distal branches of the corresponding plantar tarsal arteries on the sides of the plantar aspect of the tarsometatarsus. They extended distally, giving several small branches to the M. flexor hallucis longus and M. flexor digitorum longus as well as the tendon of the M. flexor digitorum profundus and M. flexor digitorum superficialis. The two vessels were connected through 1-2 transverse **communicating branches** (Fig. 3/ 19) and terminated by joining the lateral dorsal metatarsal (after its emergence from the distal foramen of the tarsometatarsus) forming the plantar arch.

Arcus plantaris:

The plantar arch (Fig.3/20) was formed by the communication established between the plantar metatarsal arteries with the lateral dorsal metatarsal artery after its emergence from the distal foramen of the tarsometatarsus. It was located on the deep face of the common digital flexor tendon just proximal to the metatarsophalangeal articulations and it detached the pulvinar branch and most of the digital arteries.

R. Pulvinaris:

The pulvinar branch (Fig.6/21) arose from the plantar arch. In five specimens it was given from the A. digitalis III lateralis and entered medial aspect the metatarsal pad (Fig.6/i) where it ramified into 3-4branches.

Aa. digitales:

Each digit was supplied by two arteries medial and lateral, except the 1st digit was supplied by single artery extending on its plantar side. All digital arteries arose from the plantar arterial arch except those of the 2nd digit and the lateral artery of the 4th digit.

A. digitalis I:

The digital I artery (Fig.2, 3, 6/22) arose from the medial side of the plantar arch and extended along the plantar aspect of the first digit.

Aa. digitales II medialis and lateralis:

The medial (Figs 2, 3,4,5,7,8/23) and lateral (Figs 2,3,4,5,6,7,8/24) digital II arteries originated by the bifurcation of the medial dorsal metatarsal artery and extended along the corresponding aspect of the second digit.

A. digitalis III medialis:

The medial digital III artery (Fig. 3, 4,5,6,7,8/ 25) was detached independently from the plantar arch. It

passed through the medial intertrochlear notch (Fig.2 and 3 /j) deep to the metatarsal pad, giving fine twigs to this pad then extended along the medial aspect of the 3rd digit.

A. digitalis III lateralis and A. digitalis IV medialis:

The lateral digital III artery (Fig.3, 4, 5, 6, 7, 8/26) and the medial digital IV artery (Figs 2,3,4,5,7,8/ 27) originated by common stem from the plantar arch. This stem passed through the lateral intertrochlear notch (Fig.2, 3 /k) deep to the metatarsal pad, giving fine twigs to this pad then bifurcated to give the latter two vessels that extended along the lateral aspect of the 3rd digit and the medial side of the 4th digit respectively.

A. digitales IV lateralis:

The lateral digital IV artery (Fig., 3, 4, 5, 6, 8/28) arose from the lateral plantar metatarsal artery just before it joins the plantar arch, but In four specimens it was given from the latter arch. It descended alongside the lateral aspect of the 4th digit.

Along their course the digital arteries gave off fine branches that distributed dorsally to the digital extensor tendons and plantarly to the digital flexor tendons. Moreover transverse anastomotic branches

(Figs 3,6,7/ 29) were observed between the medial and lateral digital arteries of the same digit on both dorsal and plantar aspects just distal to the interphalangeal articulations. The digital arteries of each digit were also communicated at the end of the digit, on the plantar aspect of the 3rd phalanx (Fig. 3, 6 /q) forming a sort of a terminal arch (Fig. 3/30).

The arterial supply of the interdigital (foot) web was achieved through numerous transverse rami (Fig.4, 8/31) arising from the A. digitalis II lateralis and Aa. digitales III medialis and ramified throughout the **tela interdigitalis medialis** (Fig.4,5,7 and 8/n), Similar branches arose from A. digitalis III lateralis and A. digitalis IV medialis and arborized in the **tela interdigitalis lateralis** (Fig.4,5,7 and 8/o) . These rami were anastomosed forming a plentiful arterial rete that distributed all over the foot web. Moreover a **longitudinal branch** (Fig. 4, 5, 7 and 8/32) was detached from A. digitalis IV medialis and extended distally across the tela interdigitalis lateralis towards its free margin.

Discussion

The present study recorded that the cranial tibial artery was the direct continuation of the popliteal artery in the distal portion of the leg and foot. The cranial tibial artery continued

distally until it reached the flexor surface of the hock joint where it continued as the common dorsal metatarsal artery, a result resembles that demonstrated by Mcleod et al. (1964), Baumel (1975), Nickel et al.(1977) in the domestic fowl and El-Nahla et al.(2010) in the ostrich. Can and Ozdemir (2010) in the Japanese quail agreed to the previous result but did not mention the common dorsal metatarsal artery in their result. Koch (1973) in the domestic fowl stated that the cranial tibial artery was divided proximal to the tarsal joint into two branches, which supplied the toes.

The present work stated that the collateral branches arising from the distal third of the cranial tibial artery, deep fibular, superficial fibular and lateral sural arteries in addition to some closely related veins formed the Rete tibiotarsale. Similar observations were recorded by Fitzgerald (1969) in the coturnix quail, Midtgard (1981) in the different birds and Dursun (2002) in the domestic birds. Nickel et al. (1977) in the domestic birds named this vascular net as the rete tarsometatarsicus which was formed by the joining of A.tibialis caudalis, A.tibialis medialis and A.tibialis lateralis. Baumel (1975), El-Gammal (2012) and Swielim et al. (2012) did not mention the fibular and lateral sural arteries as a component of this rete in

the domestic fowl and added that it was differentiated into two retae; *Rete tibialis cranialis*, proximal to the tarsal joint and *rete tarsi dorsalis distal to this joint*.

The present investigation revealed that the common dorsal metatarsal artery constituted the distalward continuation of the cranial tibial artery after traversing the Rete tibio-tarsale. It gave off the medial and lateral plantar intermetatarsal arteries then gave rise to the medial and lateral dorsal metatarsal arteries. On the other hand Mcleod et al. (1964), Baumel (1975), Nickel et al. (1977), Baumel et al. (1993), El-Gammal (2012) and Swielim et al. (2012) in the domestic fowl and El-Nahla et al. (2010) in the ostrich mentioned that the common dorsal metatarsal artery was terminated at the base of the digits by forming the digital arteries. Mcleod et al. (1964) in the domestic fowl named this vessel as the great metatarsal artery. It may be added that the lateral dorsal metatarsal artery in the duck pierced through the distal vascular foramen of the tarso-metatarsus to join the plantar arch, in similitude to the distal perforating branch described by Ghoshal (1975) in the domestic animals.

In the domestic duck, medial and lateral plantar intermetatarsal arteries were given off from the common

dorsal metatarsal artery on the dorsal aspect of the proximal end of the tarsometatarsus similar to that recorded by Baumel (1975), Baumel et al. (1993) in the domestic fowl and El-Nahla et al., (2010) in the ostrich. On the other hand, El-Gammal (2012) and Swielim et al. (2012) mentioned that in the domestic fowl, the corresponding vessels arose from the Rete tarsi dorsalis. Nickel et al., (1977) in the domestic fowl mentioned that the latter two vessels arose as single artery that soon divided into the lateral and medial branches and named this vessel as the plantar metatarsal artery a result which observed in eight specimens only in the present study. Moreover, each of these vessels pierced through the corresponding proximal vascular foramen and this behavior could be matched favorably with the proximal perforating branch mentioned by Ghoshal (1975) in the domestic animals. On reaching the plantar aspect each of these vessels was soon divided into two branches; an ascending and a descending branch, the same was recorded by El-Nahla et al. (2010) in the ostrich and El-Gammal (2012) and Swielim et al. (2012) in the domestic fowl.

The current investigation revealed that each digit was supplied by two arteries medial and lateral, except the 1st digit was supplied by single

artery and all the digital arteries arose from the plantar arterial arch except those of the 2nd digit and the lateral artery of the 4th digit arising from the medial dorsal metatarsal and lateral plantar metatarsal arteries respectively. El-Gammal (2012) and Swielim et al. (2012) revealed that the plantar arterial arch gave off the medial and lateral digital I, medial digital II, medial digital III and the lateral digital IV arteries, the medial dorsal metatarsal artery detached the lateral digit II artery, while the lateral dorsal metatarsal artery gave both lateral digital III artery and medial digital IV artery. In Ostrich, El-Nahla et al., (2010) described four digital arteries; two arose from the common dorsal metatarsal artery to run on the abaxial surface of the third and fourth digits and the remaining two arose from the plantar metatarsal artery and the common dorsal metatarsal artery to run on the abaxial surface of the fourth and third digits, respectively. Nickel et al., (1977) in the domestic fowl mentioned that the first, second and fourth digits are supplied by one digital artery for each, whereas the third digit was supplied by two digital arteries. The digital arteries of the first and second digits and the medial digital artery of the third digit originated from the plantar arterial arch, whereas the lateral digital artery of the third digit and the digital

artery of the fourth digit arose directly from the lateral metatarsal artery. Baumel (1975) and Baumel et al., (1993) in the domestic fowl reported that the proper digital arteries to the first and second digits came either from the plantar arch or directly from the plantar metatarsal artery, while the digital arteries to the third and fourth digits arose from the dorsal metatarsal arteries.

The plenty of arterial supply to the interdigital (foot) web of the duck as revealed in the present study explained its thermoregulatory function as recorded by Kardong (2008) who mentioned that retia mirabilia in the legs and feet of birds transfer heat from the outgoing (hot) blood in the arteries to the incoming (cold) blood in the veins. The effect of this biological heat exchanger is that the internal temperature of the feet is much closer to the ambient temperature, thus reducing heat loss.

According to the current investigation the metatarsal pad was supplied by one main branch, the R. pulvinaris arising from either the plantar arch or the A. digitalis III lateralis, According to Baumel (1975, 1993) and Nickel et al., (1977) in the domestic fowl, the pulvinar artery arose from the common dorsal metatarsal artery and passed through the distal foramen of the tarsometatarsal

tarsus. It is prudent to legate this R. pulvinaris before surgical removal of fibriscess swelling of the metatarsal pad in the duck.

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Legend for the figures

1 A. popliteal, 2 A. tibialis cranialis, 3 Rete tibiotarsale, 4 A. fibularis, 5 A. fibularis profundus, 6 A. fibularis superficialis, 7 A. metatarsalis dorsalis communis, 8 A. metatarsalis dorsalis medialis, 9 A. metatarsalis dorsalis lateralis, 10 A. intermetatarsalis plantaris medialis, 11 A. intermetatarsalis plantaris lateralis 12 A. tarsalis plantaris medialis, 13 A. tarsalis plantaris lateralis, 14 A. suralis lateralis, 15 R. medialis of 13, 16 R. lateralis of 13, 17 A. metatarsalis plantaris medialis, 18 A. metatarsalis plantaris lateralis, 19 Rr. communicans, 20 Arcus plantaris, 21 R. Pulvinaris, 22 A. digitalis I , 23 A. digitalis II medialis, 24 A. digitalis II lateralis, 25 A. digitalis III medialis, 26 A. digitalis III lateralis, 27 A. digitalis IV medialis, 28 A. digitalis IV lateralis, 29 anastomotic branches, 30 Arcus terminalis, 31 Transverse branches, 32 Longitudinal branch.

Tibiotarsus, Fibula, Tarsus, Tarsometatarsus, Proximal vascular foramen, Metatarsophalangeal articulation, Distal vascular foramen, Pulvinus metatarsalis, Medial intertrochlear notch, Lateral intertrochlear notch, Common digital extensor tendon, Superficial digital flexor tendon, Tela interdigitalis medialis, Tela interdigitalis lateralis, Pulvinus digitalis, Phalanx unguis (terminalis), Nn. Metatarsales dorsales.

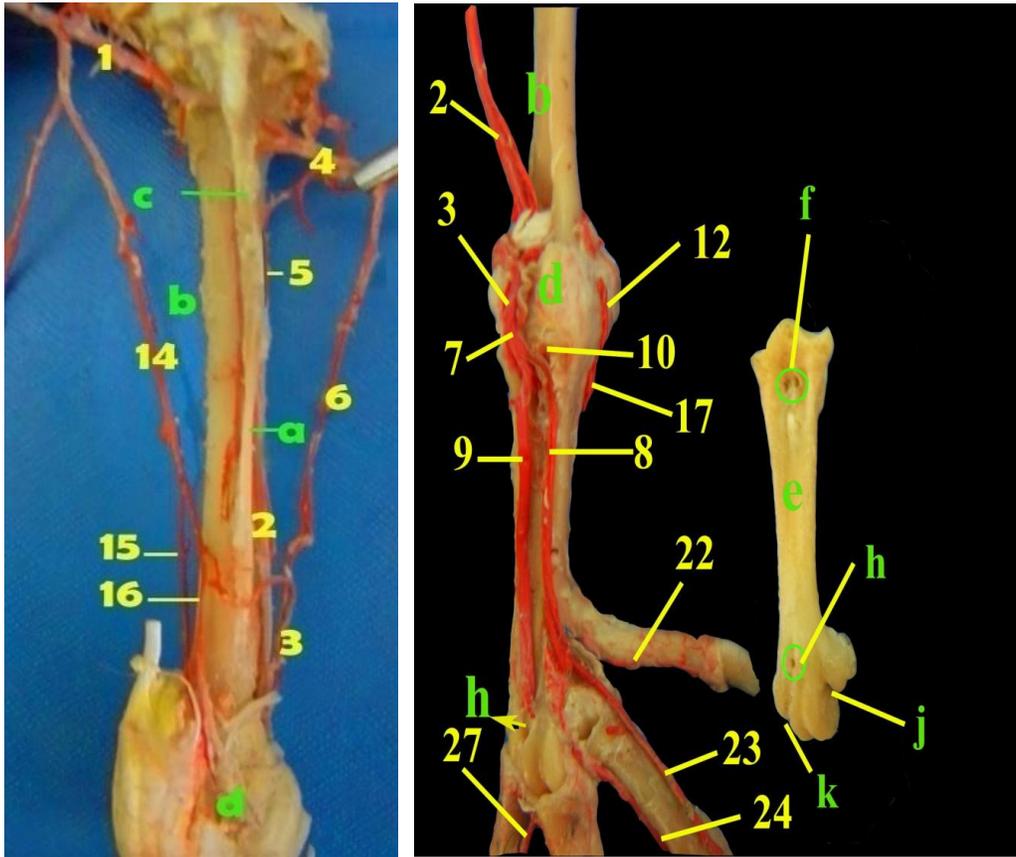


Fig (1): A photograph (left) of the right leg region of the duck showing the arteries forming the Rete tibiotarsale (lateral view).

Fig (2): A photograph (right) showing arteries of the right shank and tibiotarsus of the duck (dorsomedial view)

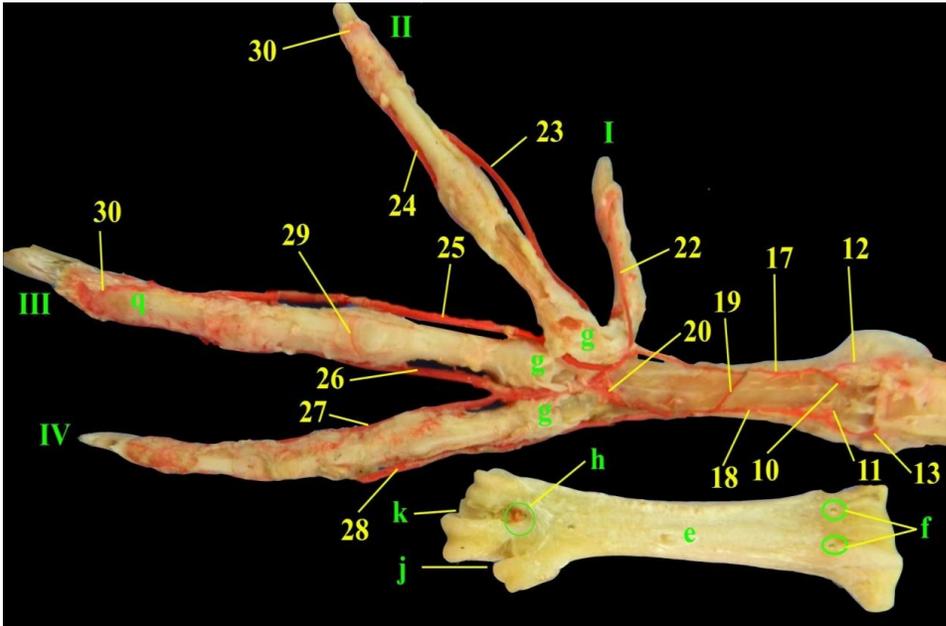


Fig (3): A photograph showing arteries of the right shank and foot and tibiotarsus of the duck (plantar view). The digital flexor tendons were removed.

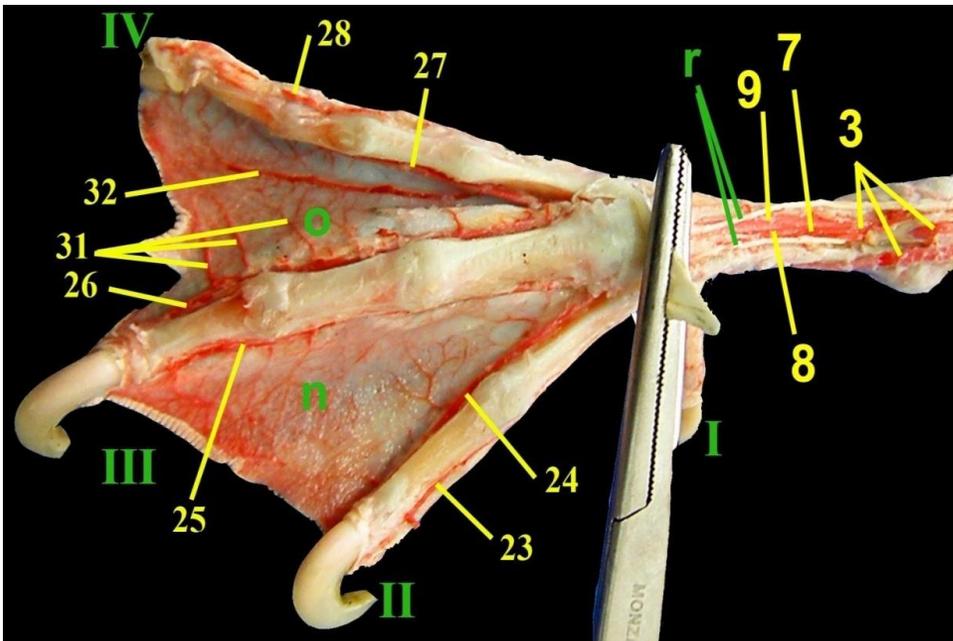


Fig (4): A photograph showing the arteries of the right shank and foot of the duck (dorsomedial view). The common digital extensor tendon was reflected.

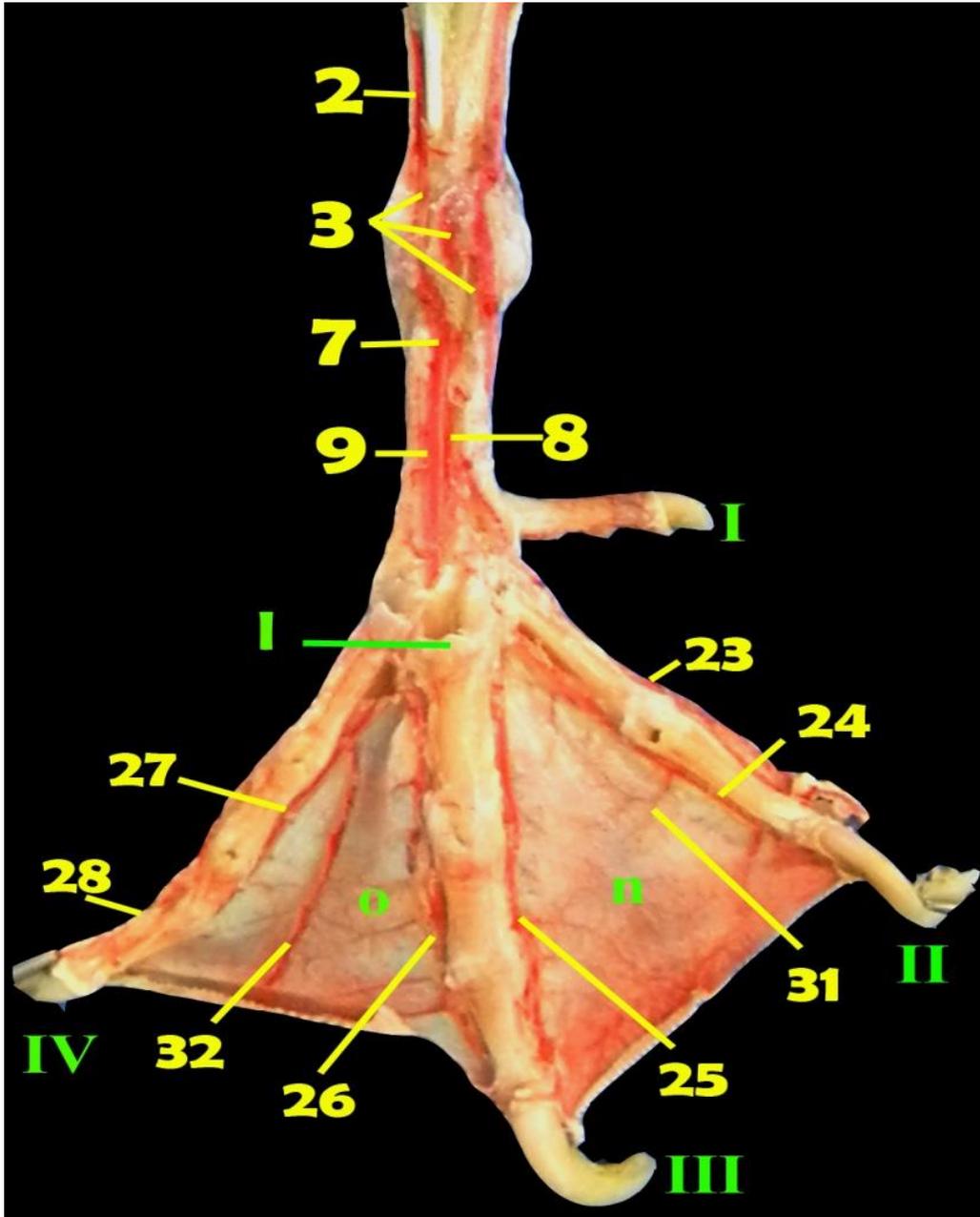


Fig (5): A photograph showing the arteries of the shank and foot of the right pelvic limb of the duck (dorsal view). The common digital extensor tendon was removed.

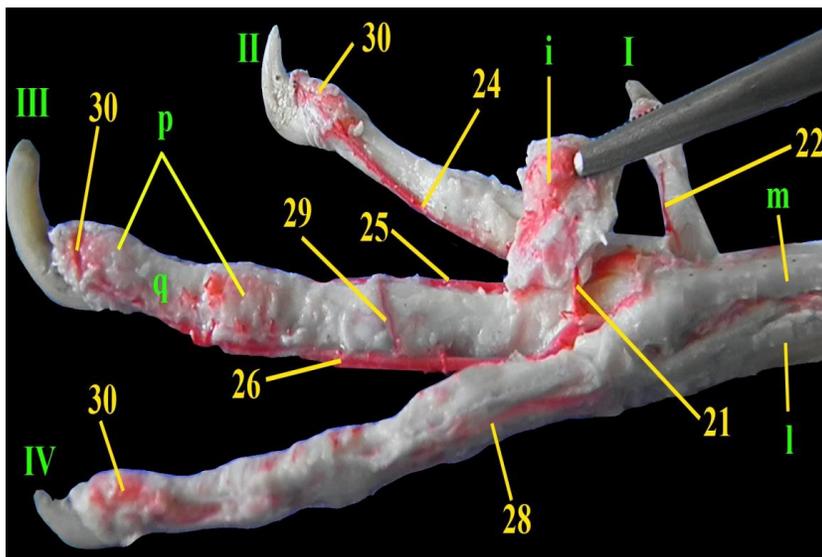


Fig (6): A photograph showing the Arteries of the right foot (lateral view)

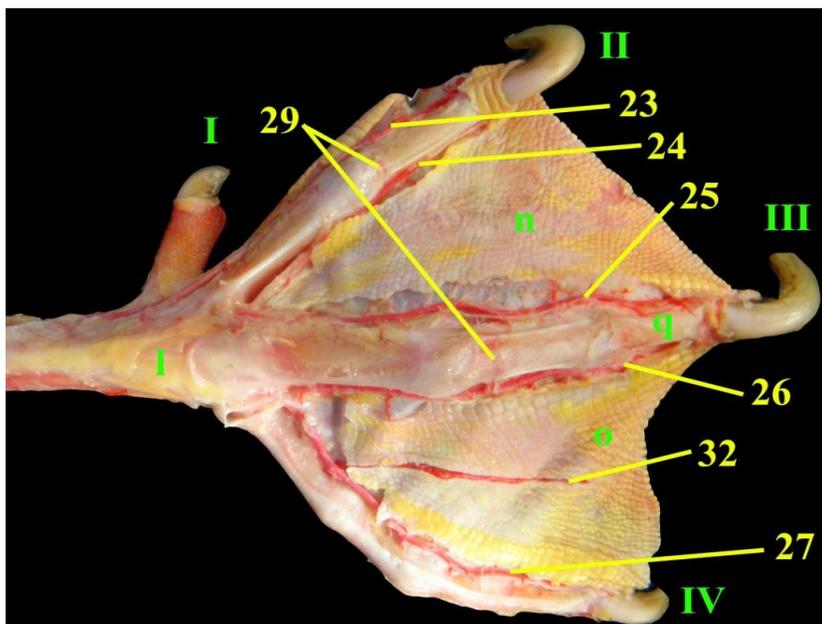


Fig (7): A photograph showing the arteries of the right foot (dorsal view of a dissected specimen).

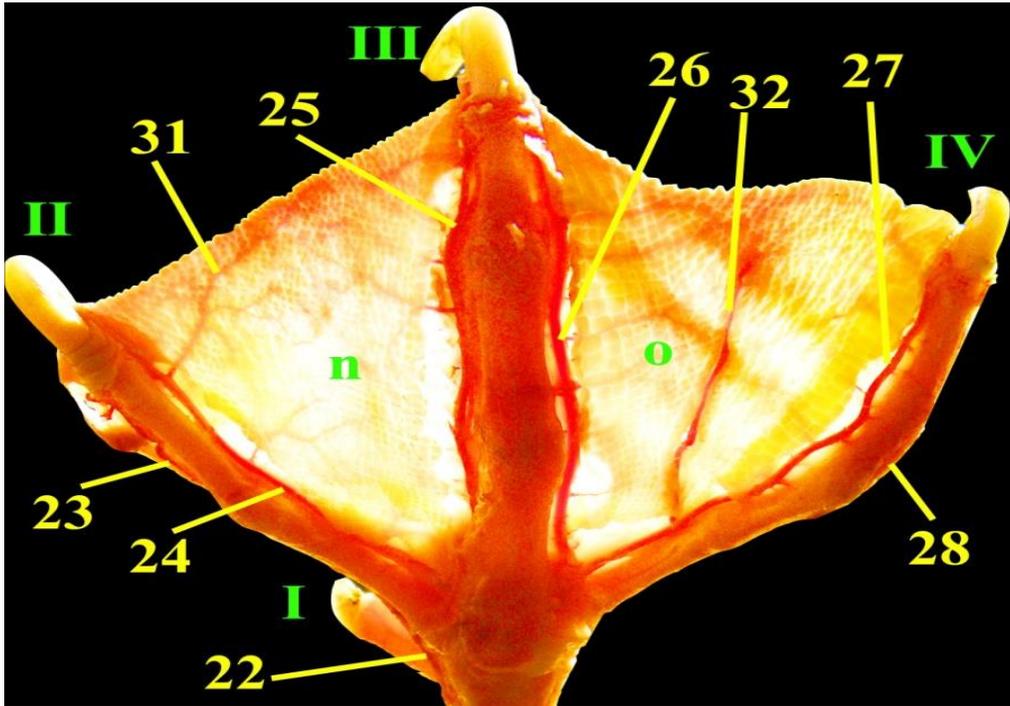


Fig (8): A photograph showing the arteries of the right foot (dorsal view with light background).

Animals of this issue

Domesticated duck (*A. p. domesticus*)



Kingdom: Animalia & Phylum: Chordata & Class: Aves & Order: Anseriformes & Family: Anatidae
& Genus: *Anas* / *Cairina* & Species: *A. platyrhynchos*; *Cairina moschata* & Subspecies:
A.p.domesticus

Duck is the common name for a large number of species in the Anatidae family of birds, which also includes swans and geese. The ducks are divided among several subfamilies in the Anatidae family; they do not represent a monophyletic group (the group of all descendants of a single common ancestral species) but a form taxon, since swans and geese are not considered ducks. Ducks are mostly aquatic birds, mostly smaller than the swans and geese, and may be found in both fresh water and sea water.

Domesticated ducks are ducks that are raised for meat, eggs and down. Many ducks are also kept for show, as pets, or for their ornamental value. Almost all of the varieties of domesticated ducks are descended from the Mallard (*Anas platyrhynchos*), apart from the Muscovy Duck (*Cairina moschata*).

Ducks are farmed for their meat, eggs, and down. A minority of ducks are also kept for *foie gras* production.

Source: Wikipedia, the free encyclopaedia