

Anatomy of the Red Panda (*Ailurus fulgens*)

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Abstract

The red panda (*Ailurus fulgens*) is an endangered species primarily distributed in the southern China and Himalayas. It lives in mountain forests with bamboo understory. This review outlines the normal anatomy of the red panda in terms of its musculoskeletal system, respiratory system, circulatory system, digestive system and urogenital system. Knowledge of the normal anatomy of individual animal species is important for species identification and accurate interpretation and diagnosis of diseases.

Keywords: anatomy, red panda

1. Introduction

The red panda (*Ailurus fulgens*) (Figure 1) is classified as an endangered species by the International Union for Conservation of Nature and Natural Resources (IUCN, 2018). It belongs to order; Carnivora, family; Ailuridae, and genus; *Ailurus* (Wei and Zhang, 2009; IUCN, 2018). The red panda is the only living species of the family Ailuridae and genus *Ailurus* and is closely related to mustelids, procyonids and skunks (Wei and Zhang, 2009; Groves, 2011).

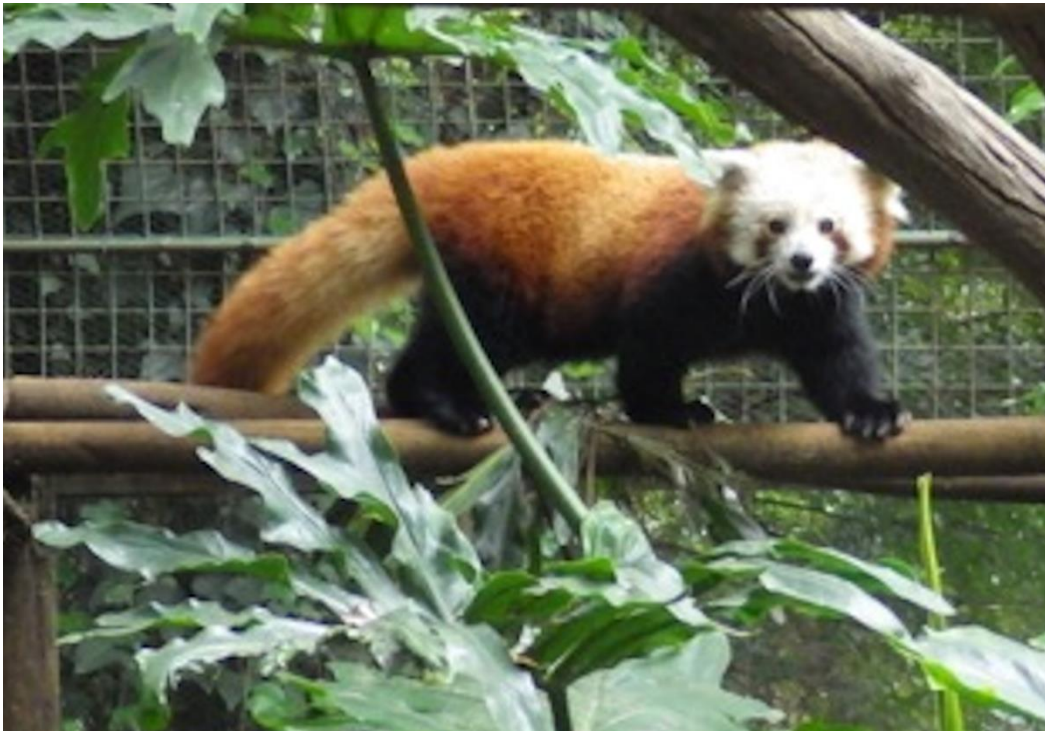


Figure 1. A photograph of an adult red panda (*Ailurus fulgens fulgens*)

It is primarily distributed in India, Burma, China, Bhutan and Nepal (Roberts and Gittleman, 1984; Ghose and Dutta, 2011). The red panda is mainly an arboreal animal living in mountain forests with bamboo understory at an altitude of 1 500 to 4 800 m (Srivastav *et al.*, 2009). It is found in multiple vegetation types like deciduous forests, coniferous forests, evergreen forests, deciduous and coniferous mixed forests and evergreen and deciduous broad-leaf forests (Wei and Zhang, 2011). Red pandas habitat contains tree stumps, high density of shrubs, and fallen logs that provide an easy access to bamboo leaves (Wei and Zhang, 2011). Apart from spending most of their time in trees, red pandas prefer other elevated surfaces such as rocks (Roberts and Gittleman, 1984; Pradhan *et al.*, 2001). Trees provide red pandas with sites for sleeping, nesting, resting and escaping from predators (Roberts and Gittleman, 1984; Srivastav *et al.*, 2009; Eriksson *et al.*, 2010).

The head and body length of red pandas ranges from 56 to 62.5 cm (Roberts and Gittleman, 1984). The tail length ranges from 37 to 47.2 cm (Roberts and Gittleman, 1984). Wild red pandas weigh between four to five kg (Preece, 2011). The mean weight of adult females and males in captivity is 4.9 kg (range: 4.2 - 6.0 kg) and 5 kg (range: 3.7-6.2 kg), respectively, (Roberts and Gittleman, 1984). The lifespan of the red panda in the wild ranges from 8 to 10 years, whereas in captivity the average lifespan is 13.4 years (Heath and Platnick, 2008). There is no sexual dimorphism in the size and colour (Roberts and Gittleman, 1984).

Red panda forage primarily on the ground (Roberts and Gittleman, 1984) and is largely a vegetarian feeding mainly on bamboo leaves [80-90%] (Roberts and Gittleman, 1984; Wei and Zhang, 2009). They also feed on insects, bamboo shoots, small vertebrates, birds, flowers, berries, eggs and seeds (Roberts and Gittleman, 1984; Srivastav *et al.*, 2009; Wei and Zhang,

2011). Bamboo leaves of the genera *Thamnocalamus*, *Phyllostachys*, *Chimonobambusa*, *Sinarundinaria* and *Qiongzhusa* form its main diet (Roberts and Gittleman, 1984; Nijboer and Dierenfeld, 2011).

This review outlines the normal anatomy of the red panda as a reference for clinical use and species identification.

2. Anatomy

2.1 Musculoskeletal System

The vertebral formula of the red panda is 7 cervical, 14 thoracic, 6 lumbar, 3 fused sacral and up to 19 caudal (coccygeal) vertebrae [C7, T14, L6, S3, Cd19] (Flower, 1870; Fisher 2011; Makungu *et al.*, 2016; Makungu *et al.*, 2018). However, it is uncommon to find red pandas with 15 thoracic and 5 lumbar vertebrae (Makungu, 2015). Further, 19 thoracolumbar vertebrae have been reported in a red panda with 14 thoracic and five lumbar vertebrae (Makungu, 2015). The spinous processes of the thoracolumbar vertebrae are short (Figure 2A) (Makungu *et al.*, 2016; Makungu *et al.*, 2018). The size of the thoracic vertebrae increase from cranial to caudal with the thoracic vertebra 11 (T11) frequently being an anticlinal vertebra and rarely T10 (Makungu *et al.*, 2016). Lumbosacral transitional vertebra and the presence of two fused sacral segments have been reported in red pandas (Makungu *et al.*, 2018). The number of ribs in red pandas is mainly 14 pairs which correspond to the number of thoracic vertebrae (Figure 2). Of the 14 pairs, the last two pairs are floating ribs (Figure 2) (Makungu *et al.*, 2016). Pandas with 15 pairs of ribs, the last three pairs are floating (Makungu *et al.*, 2016). The sternum is fairly straight and consists of the manubrium sterni, xiphoid process and six sternebrae (Figure 2A) (Makungu *et al.*, 2016).

In heavy red pandas hypaxial muscles are easily seen on ventrodorsal radiographs of the abdomen (Makungu *et al.*, 2018). Further, accumulation of large amount of abdominal fat is seen in the retroperitoneal space and ventral to the liver in heavy red pandas on right lateral abdominal radiographs (Makungu *et al.*, 2018).

The scapula of the red panda is wide craniocaudally with a large hamate process (Figure 2) and stout coracoid process, which are indicative of its arboreality (Roberts and Gittleman, 1984; Makungu *et al.*, 2015b). Rudimentary clavicles may be seen in some red pandas on radiographs of the shoulder joints (Makungu *et al.*, 2015b; Makungu *et al.*, 2016). The major tubercle of the humerus does not extend above the head of the humerus and the area for the insertion of the infraspinatus muscle is at the same level as the head of the humerus (Makungu *et al.*, 2015b). The medial epicondyle, which provides the origin for the flexor muscles of the carpus and digits and the lateral supracondylar crest, which provides the origin for the brachioradialis muscle that supinates the antebrachium are prominent (Makungu *et al.*, 2015b). The supracondylar foramen is present in red pandas and transmits the median nerve (Fisher, 2011). The radial tuberosity which provides the insertion of the biceps brachii muscle, a flexor of the elbow joint, is prominent and further distally located. Additionally, the head of the ulna is well-developed and stout (Makungu *et al.*, 2015b).

The carpus of the red panda consists of seven carpal bones with the accessory carpal bone

being directed palmarolaterally (Makungu *et al.*, 2015b). The sesamoid bone for the abductor digit I longus muscle, which abducts the carpal joint and carpometacarpal joint of digit I is relatively prominent and acts as a ‘false thumb’ for the grasping actions of the manus (Endo *et al.*, 2001; Antón *et al.*, 2006; Fisher *et al.*, 2009; Makungu *et al.*, 2015b). The pelvic bone has a wide ventromedial surface of the ilium. The ilial wings are almost parallel to each other and the ischiatic tuberosities are not prominent (Makungu *et al.*, 2015a). The cranial and caudal ramus of the pubic bone are wide. Red pandas have a wide and shallow trochlea of the femur. The cochlea grooves of the tibia and the trochlea of the talus are shallow (Makungu *et al.*, 2015a). Additionally, the lateral process of the base of the fifth metatarsal bone is directed laterally (Makungu *et al.*, 2015a). The metacarpal and metatarsal bones are widely spaced (Makungu *et al.*, 2015a, b).

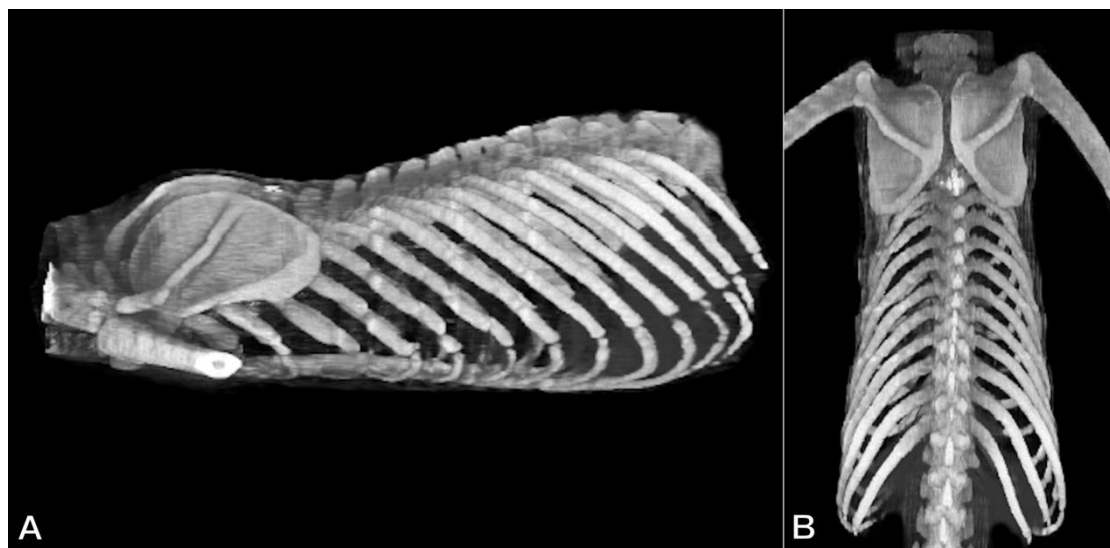


Figure 2 Lateral (A) and dorsal (B) views of a 3D volume-rendered computed tomography images (using a grey scale default) of the thorax of an adult red panda. The spinous processes of the thoracic vertebrae are relatively short. Note the wide scapula with large hamate process. Note also the presence of 14 pairs of ribs which correspond to the number of thoracic vertebrae. The last two pairs of ribs are floating and the sternum is fairly straight.

2.2 Respiratory System

The thyroid, cricoid, and arytenoid cartilages of the larynx in the red panda are reduced as seen in procyonids (Fisher, 2011). The thyroid and cricoid cartilages are very narrow dorsoventrally (Flower, 1870). The epiglottis is in the form of an equilateral triangle (Flower, 1870).

The trachea of the red panda is approximately 11.4 cm in length and 1.3 cm in average width (Flower, 1870). It consists of 38 cartilage rings, which are incompletely dorsally (Flower, 1870; Makungu, 2015). On thoracic radiographs, the trachea is seen with mineralized cartilage rings and its external diameter measures 1.35 ± 0.13 cm in average (Makungu *et al.*, 2016). On the dorsoventral radiographic view of the thorax, the trachea runs slightly to the right of the spine (Makungu *et al.*, 2016). In majority of red pandas, the carina is located at the level of the fifth intercostal space (Makungu *et al.*, 2016). The trachea branches into two

short principal bronchi i.e. the right and left principal bronchi (Flower, 1870). The latter is slightly longer and narrower than the former (Flower, 1870). Each principal bronchus divides into cranial and caudal branches (Flower, 1870).

The left lung consists of two triangular lobes i.e. the cranial and caudal lobes (Flower, 1870; Makungu, 2015). The caudal lobe is slightly larger than the cranial lobe (Flower, 1870). The cranial lobe of the left lung is not subdivided into the cranial and caudal parts (Makungu, 2015). The right lung has four lobes namely; the cranial, middle, caudal and accessory lobes (Makungu, 2015). The accessory lobe is pointed and lies in the medial surface of the caudal lobe (Flower, 1870). The cranial branch of each principal bronchus is confined to the cranial branch of each lung (Flower, 1870; Makungu 2015). The caudal branch of the left principal bronchus is confined to the caudal lobe of the left lung, whereas, the caudal branch of the right principal bronchus also sends bronchial branches to the accessory and middle lobes (Flower, 1870; Makungu, 2015).

2.3 Circulatory System

The heart is shaped like a narrow cone with a rounded apex (Flower, 1870). It is approximately 5 cm in length with a thickness of 3.8 cm and 3.3 cm from side to side and cranial to caudal, respectively, (Flower, 1870). On thoracic radiographs the cardiac silhouette appears ovoid and oblique in position (Makungu *et al.*, 2016). In older animals the cardiac silhouette and aortic arch are elongated with the former being more horizontally positioned (Makungu *et al.*, 2016). The size of the cardiac silhouette with respect to vertebral heart score has been reported to be 8.34 ± 0.25 and 8.78 ± 0.34 on the right lateral and dorsoventral radiographs of the thorax, respectively, (Makungu *et al.*, 2016). The pericardium is loaded with fat (Flower, 1870).

The elongated spleen is without a notch or fissure and is located on the left of the stomach (Flower, 1870). On the ventrodorsal radiographs of the abdomen, the spleen is seen lateral to the left kidney adjacent to the left body wall (Makungu *et al.*, 2018). It is 14.5 cm long (Flower, 1870) with a mean thickness of 1.42 ± 0.28 cm (Makungu *et al.*, 2018).

The thymus, a lymphoid organ involved in the development of lymphocytes (Bezuidenhout *et al.*, 2000) is very conspicuous (Flower, 1870). It is an oblong compressed body which lies cranial to the heart (Flower, 1870). The thymus measures approximately 3.8 cm in length and 1.3 cm in thickness (Flower, 1870).

2.4 Digestive System

The red panda has 36 to 38 teeth, with the following dental formula: I3/3, C1/1, PM3/3-4 and M2/2 (Roberts and Gittleman, 1984). The canines and incisors are characterized by low crown heights, whereas, the premolars and molars are distinguished by a number of accessory cusps (Fisher, 2011). The premolar cusps are rounded and low (Fisher, 2011). The upper fourth premolar is large with five cusps (Roberts and Gittleman, 1984). Additionally, the second and third upper and lower premolars are also large and robust (Roberts and Gittleman, 1984), with their width exceeding their length (Fisher, 2011). The large surface of cheek tooth facilitates mediolateral movement, which is important for effective grinding of bamboo and

fibrous plant materials (Roberts and Gittleman, 1984; Fisher, 2011).

The tongue is approximately 7.6 cm in length from the base to the apex, with a maximum width of 2.8 cm (Flower, 1870). The caudal half of the tongue is thick and fleshy, and the dorsal surface is flat cranially (Flower, 1870). The mucosa on the dorsal surface forms five types of papillae namely; the conical, foliate, fungiform, filiformes and circumvallate papillae (Flower, 1870; Carlsson, 1925; Roberts and Gittleman, 1984; Fisher, 2011). The papillae are soft and small (Flower, 1870). The tonsils are approximately 0.6 cm in length and are very distinct (Flower, 1870). The salivary glands are relatively large as seen in most omnivorous carnivores (Carlsson, 1925). The parotid salivary gland duct opens into the oral cavity at the level of the third premolars (Flower, 1870). The ovoid mandibular salivary gland, which is smaller than the parotid salivary gland measures 2.5 cm in length with a greatest thickness of 1.3 cm. Its duct terminates in an orifice at the sublingual caruncle (Flower, 1870).

The liver consists of four lobes; the left, quadrate, right and caudate lobes (Makungu, 2015). The left lobe is sub-divided into the left lateral and left medial lobes (Makungu, 2015). Similarly, the right lobe is also sub-divided into the right lateral and right medial lobes (Makungu, 2015). The caudate lobe has two processes i.e. the papillary and caudate processes. The caudate process of the caudate lobe presents with a renal fossa (Makungu, 2015). The gall bladder is situated between the right medial and quadrate lobes (Makungu, 2015). On ultrasonography, the mean wall thickness of the gall bladder has been reported to be 0.86 ± 0.18 mm (Makungu, 2015).

The stomach consists of a single chamber (Flower, 1870). The thick walled pylorus is narrow and tubular, whereas, the fundus is large and spherical (Flower, 1870; Carlsson 1925; Roberts and Gittleman, 1984). The pylorus is frequently located to the right of the midline and cranially to the fundus on ventrodorsal radiographs of the abdomen (Makungu *et al.*, 2018). The digestive tract is relatively short measuring 4.2 times the body length (Roberts and Gittleman, 1984). The length from the pylorus to the anus has been reported to be approximately 264.2 cm (Flower, 1870). The ascending, transverse and descending colons are relatively short and the colon and rectum measures 18 cm in length (Carlsson 1925). The caecum is absent and externally there is no clear distinction between the ileum and colon (Flower, 1870). The external diameter of the large intestine is approximately 2 times the external diameter of the small intestine (Makungu *et al.*, 2018). Further, the mean external diameter of the small and large intestines measured on abdominal radiographs is 0.9 ± 0.37 cm and 1.8 ± 0.22 cm, respectively (Makungu *et al.*, 2018). Bunching of small intestine in the right central abdomen has been observed in heavy red pandas (Makungu *et al.*, 2018).

2.5 Urogenital System

The ovoid kidneys (Makungu, 2015) are not lobulated with the right kidney slightly more dorsal and cranial than the left kidney (Flower, 1870; Makungu *et al.*, 2018). The right kidney is larger than the left kidney with a mean length and width of 3.98 ± 0.33 cm and 2.19 ± 0.24 cm, respectively (Makungu, 2015). The mean length and width of the left kidney are 3.85 ± 0.27 cm and 2.16 ± 0.19 cm, respectively (Makungu, 2015). The red panda kidney is also prone to physiological accumulation of fat (Zwart *et al.*, 1989). The oblong urinary bladder

has a mean wall thickness of 1.46 ± 0.36 mm (Makungu, 2015; Makungu *et al.*, 2018). However, the thickness of the wall of the urinary bladder depends on the degree of bladder distension (Geisse *et al.*, 1997).

The penis is relatively short and it is approximately 5 cm in length from the junction of the crura to the end of the glans (Flower, 1870; Roberts and Gittleman, 1984). The testes are approximately 2 cm long and 1.3 cm wide and appear like oval elevations under the skin (Flower, 1870; Carlsson 1925). The os penis is relatively short about 2 cm long (Flower, 1870; Roberts and Gittleman, 1984; Makungu *et al.*, 2015a).

3. Conclusion

This review has provided information on the normal anatomy of the musculoskeletal, respiratory, circulatory, digestive and urogenital systems of the red panda. Although the red panda shares anatomical features with other members in the order Carnivora, it possesses some unique anatomical features. Information obtained from this review will serve as guidance for clinical use and for identification of this species.

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