Gross Morphology and Histology of The Heart and Lungs of Small Flying Fox (*Pteropus hypomelanus*)

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Abstract

Samples of small flying fox were collected from Bababu Dinagat Islands and Hundred Islands Pangasinan and were subjected to gross morphology and histological evaluation. Gross anatomy evaluation revealed that the heart of small flying fox is oval in shape with the base of the heart being wider than the apex and surrounded by pericardium that appears as a transparent and firm structure. Fats and lymphatic tissue are also found around the heart and its blood vessels. The heart has a mean weight of 4.7 ± 0.42 grams for male and 4.7 ± 1.92 grams for female. Its left and right atrial wall showed no difference in their thickness and has a smooth wall while the left ventricular wall is twice the thickness of the right ventricular wall. The heart samples have two papillary muscles on the right and left ventricle. The number of chordae tendinae on the left ventricle is 5 while it has four chordae tendinae on the right ventricle. Female small flying fox right lung have a mean length of 5.4 ± 1.47 cm, mean width of 6.47 ± 0.47 cm and mean weight of 6.83 ± 1.90 grams. The male small flying fox right lung has a mean length of 5.50 ± 0.14 cm, mean width of 6.45 ± 0.35 cm and mean weight of 6.85 ± 0.07 grams. The female small flying fox left lung has a mean length of 5.17 ± 0.90 cm, mean width of 5.17 ± 0.61 cm and mean weight of 5.0 ± 0.96 grams. The male small flying fox left lung has a mean length of 5.15 ± 0.35 cm, mean width of 5.15 ± 0.64 cm and mean weight of 5.0 ± 0.28 grams. Similar with other mammals or bats, the primary bronchi are lined with pseudostratified columnar epithelium, the secondary bronchi lined with columnar epithelium and the tertiary bronchi have a cuboidal lining epithelium. The bronchioles are lined with simple cuboidal epithelium while the alveoli are lined with simple squamous epithelium. Type I and Type II pneumocytes were also observed.

Keywords: flying fox, heart, lobation, morphometric, Dinagat Islands, Hundred Islands

Introduction

Bats are nocturnal warm-blooded animals. They can reproduce and produce milk to feed their young, and they have fur (Reynolds, 2006). In fact, bats are the only true flying mammals, so they are considered a distinct group of mammals (Alijani & Ghassemi, 2016). Fruit bats such as flying foxes Pteropus spp. and Acerodon spp. have become increasingly endangered due to bushmeat and medicine hunting (Mildenstein, 2014; Tanalgo & Hugh-es, 2018). Flying foxes play a critical role in island ecosystems, where they frequently act as key pollinators and seed dispersers both within and between islands (Elmqvist et al., 1993; Helgen et al., 2010; McConkey & Drake, 2006, 2007; Zoology, 1998). The small flying fox is the largest member of the hypomelanus species group (Canals et al., 2005; Zoology, 1998) and was added to the Con-vention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) list in 2017.

One of the most important parts of the body is the cardiovascular system. The heart and vessels are responsible for distributing blood to other parts of the body and for gas exchange in the lungs (Frandson et al., 1966). Among mammals' bats have the largest heart relative to its body mass (Canals et al., 2011; Swartz et al., 2003). The heart is a muscular four chambered organ that drives the circulatory system (Sisson, 1923; Tucak, 2011). The internal and external anatomy of the heart can differ significantly between orders and between families within an order (Rowlatt & Park, 1968). The first thing that occurs during flight, as with any form of exercise, is a dramatic increase in the amount of blood returning to the heart. Since, bats are the only mammals that can fly, changes in the morphology and physiology of their organs, such as the heart, are to be expected (Alijani & Ghassemi, 2016).

In all animals such as flying fox, oxygen is a vital requirement. The respiratory system has two major functions, and these are delivering oxygen and removing carbon dioxide (Frandson et al., 1966). The respiretory system consists essentially of the lung and the passages that conducts air into and out of the lungs. The anatomy of the respiratory system of bats is fundamentally mammalian. However, the lungs of bats have been remarkably morphometrically retained (Maina, 1985, 2000; Maina et al., 1982).

The respiratory system is primarily comprised of the lung and the passageways that carry air into and out of the lungs. Bats' respiratory system is fundamentally mammalian in nature (Maina, 2000).

Materials and Methods

Description of the Study

A) Dinagat Island

The survey was undertaken at eight locations in the municipalities of Basilisa and Loreto in the Province of Dinagat Islands (Map 1; Table 1). The locations included sections of lowland primary forest, mature secondary forests, and forests close to heavily disturbed sites, among other habitat types (i.e., mining operations). The island covers a total land area of 139.9 km2 and is known for its undulating hilly landscape.

B) Hundred Island, Alaminos, Pangasinan

The lower rocks of the island's Kegelkarst type makes up the Hundred Islands of the Lingayen Gulf (Uhlig 1980). The Hundred Islands National Park is made up of 123 islands that cover a total area of 1,676 hectares (Map 2; Table 2). In 1983, the Hundred Islands were designated as a national park (PAWB 2004d), and in 2001, they were designated as a National Geological Monument (NCGS 2001). It is a tourist destination with a thriving tourism industry.

Field Data Collection

The existence and abundance of volant animals in the research region were determined using standardized sampling procedures and sample preservation. Mist nets were put near the ground and at canopy height (20–25 m) to capture bats and sample both strata. Two to three mist nets were vertically arranged over each other and then elevated using a pulley technique described by Ingle (1993). The nets were left open from 18:00 to 06:00, although every 30 minutes from 18:00 to 24:00, the nets were examined to collect any captives. Depending on the availability of nets, weather circumstances, and geography of the area, the quantity of nets put varied across sample sites.

External Features

The external features of the heart and lungs such as shape, appearance of the base, apex, pericardium, and other connected structures were described. The texture was also noted. The lobes of the lungs were identified and described.

Morphometric Evaluation

The dimensions (length, width) of the heart were measured using a digital vernier caliper. The thickness of the wall of the atrium and ventricles were measured using a digital vernier caliper and evaluated. The hearts were weighed using a digital weighing scale. Hearth length was measured from the base of the heart to the tip of the apex; the width was measured at its widest part. External circumference was measured at three sites: around the base, at the middle and at the apex. The mean and standard deviation was calculated.

The five heart samples were dissected from the right atrium to the right

ventricle with a sharp scalpel to reveal the walls of both compartments. The atrial and ventricular thicknesses were determined by measuring the middle part of each compartment with a Vernier caliper. The interventricular septum's thickness was also measured. The average of all samples was determined. In each chamber, the number of papillary muscles and chordae tendinae, regardless of size, was counted.

The length and width of the five lungs were measured using a digital vernier caliper at the longest and widest part of the lobe, respectively. The weight was measured using a digital weighing scale. Lobations of the lungs were based on the presence of the secondary bronchi.

Microscopic Examination

The five heart and lung samples were subjected for histological section preparation. Hematoxylin and eosin (H&E) stains were used on transverse portions of the heart base and apex. The cells and connective tissue present in the section of the heart were identified and observed. The left and right lungs were dissected and defined. Slide sections were photo-graphed using a digital camera and viewed under a digital microscope.

Ethical Statement

Animal care and use guidelines at the international, national, and/or institutional levels were followed. The procedures used in this study were in compliance with current Philippine regulations, as well as the DENR's and the Protected Area Management Board's ethical standards, and were approved under Wildlife Gratuitous Permit No. R13-2019-33.

Results and Discussion

Two formalin Preserved bats collected from Lake Bababu, Dinagat Islands and three formalin preserved bats collected from Hundred Islands, Alaminos, Pangasinan. The heart and lungs were observed regardless of the age and sex of the animals.

External Features of the Heart

The heart is slightly oval (Fig 1). The same observation, the bat’s heart has been noted by (Alijani & Ghassemi, 2016; Rowlatt & Park, 1968). However, it has been described by (Frandson et al., 1966; Uopasai & Bunterm, 2012) that the typical shape of the heart of mammals to be conical. The base of the heart is wider than the apex with the same as the observation noted by (Alijani & Ghassemi, 2016; Rowlatt & Park, 1968). Usually, 60% of the heart of animals is situated at the left side of the midline center and located between 3rd and 6th rib (Frandson et al., 1966). The long axis subtends an angle of 40” to the midline; the apex is rotated to the left. Slightly more than half the heart lies to the left of the midline (Rowlatt & Park, 1968).

All samples have smooth texture and surrounded by pericardium that

appear as a transparent but slightly firm. Pericardium is a fibroserous sac enclosing the heart which is attached to the great vessels at the base and continued ventrally (Sisson, 1923; Tucak, 2011). There are also presence of fats and lymphatic tissue around the primary blood vessels (Plate 2). It is noted that, the thick lymphatic tissue around large artery and veins of bats heart contributes to the lymph transfer largely (Alijani & Ghassemi, 2016). According to (Wang et al., 2010) the presence of high adipose mass and thick walls of the heart can cause its heaviness.

Weight of the Heart

Table (3) shows the heart measurements of small flying fox. The heart has a mean weight of 4.7 grams for both male and female. It was already identified that bats have heart with relatively greater weight among mammals (Joseph, 1908).

Heart Dimensions

Heart length was measured from the base to the apex of the heart while the width was measured at its widest span. The mean length and width together with the right and left ventricular thickness and the interventricular septum of the heart samples are shown in table (3).

Thickness of the Walls of Two Atria and Two Ventricles

The heart of any mammal is composed of four separate chambers arranged in parallel and is very similar in construction in monotremes, marsupials and placental mammals. As shown in Table (3), the left and right atrial wall showed no difference which is both 0.1 cm in thickness. The left ventricular wall is almost thrice the thickness of the right ventricle wall (figs 3 and 4). Interventricular septum is very thick muscular partition between the two ventricles. The wall of the two atria is smooth and not as thick as the wall of the left ventricle (Figs 3 and 4). The same was observed by (Alijani & Ghassemi, 2016; Rowlatt & Park, 1968). Heathfield et al., (2013) also stated that the thickness of the left ventricle was significantly higher than the right. Alijani & Ghassemi (2016) stated in fruit bats that the left and right side of the heart were different significantly in volume and wall thickness of the chambers. Sisson, (1923) and Tucak (2011) also stated that in domestic animals the left ventricle has a thicker wall because it performs greater work in pumping blood throughout the body. The left side of the bats heart is much more alike to the heart of placental mammals than the right side (Rowlatt and Park, 1968). Also, the left ventricle forms the apex of the heart (Uopasai and Bunterm, 2012).

Number of Chordae Tendinae and Papillary Muscle

The heart samples have two papillary muscles on the right and left ventricle. Papillary muscles are muscular projections serving as attachment for

tendinous cords also known as the chordae tendinae of the atrioventricular (AV) valve (Sisson, 1923; Tucak, 2011). The chordae tendinae were counted individually regardless of the size and appearance. The number of chordae tendinae on the left ventricle is 5 with two papillary muscles while there are four chordae tendinae on the right ventricle with two papillary muscles.

Microscopic Features of the Heart

The heart is a muscular organ whose wall is composed of an endocardium, myocardium and epicardium. The thickness and composition of the wall vary, being thickest in the ventricles and thinnest in the atria (Bacha, 2020). As shown in Fig (5), the heart of the small flying fox is composed of the same mammalian outer epicardium, middle myocardium and inner endocardium. The endocardium is thin and has a smooth layer that lines the cardiac chambers. The myocardium is very thick, composed of cardiac muscle fibers and forms the bulk of the heart muscle. The epicardium is a part of the pericardium while myocardium makes up the majority of the cardiac wall in bats (Kerth, 2008).

Blood Vessels of the Heart

The heart is well vascularized, receiving about 5% of the output of the left ventricle in man and much even higher percentage in animals, depending on the animal condition (Kerth, 2008). Fig (6) shows a section from the right coronary artery of the heart of small flying fox. Blood vessels has three layers which includes tunica intima, tunica media and tunica adventitia. Tunica intima is the innermost layer and is composed of simple squamous epithelium. This layer is in contact with blood and lines the lumen. It is also responsible for regulation of permeability, blood flow and production of anticoagulants. Tunica media is the thickest and is located between the smooth muscle layer and tunica adventitia. This means that the tunica media of the small flying fox provides elasticity and structural support to the artery. The tunica adventitia, the outermost layer, is composed of connective tissue that blends with other structures like fat as shown in fig (6). This tunic is responsible in providing structural support anchoring the vessel to the surround-ding tissue.

The abundant fat cells in the sub-epicardium of ventricles are consistent with the findings of (Alijani & Ghassemi, 2016). The excess fat accumulation in their heart functions as the main depot for fuel storage in the intense activity, hibernation and thermoregulation spatially in small mammal. Therefore, these fat cells are related to high metabolism and adaptability of this species to fly. Since they are the only mammals that has the ability to fly.

Bats have active life, and considering the high metabolism of this species

and its high energy requirement, most of these changes are to ensure the adequate oxygen delivery to the tissues of the body (Tadjalli et al., 2009; Wacker et al., 2012). The thick lymphatic tissue around coronary arteries and veins contributes to the large lymph transfer.

Gross Morphology of Lungs

Figure (7) and Figure (8) show the gross appearance of a formalin preserved right and left lungs of a small flying fox. The lungs have a smooth texture with a glistened brownish surface. The colour of healthy mammalian lungs varies in intensity depending on blood content. It is fresh pink in many mammalian specimens but a much deeper red in lungs obtained from animals that were not bled (Uopasai and Bunterm, 2012). As the study was conducted on formalin-preserved specimens. The fresh colour of the lung tissue was not possible to describe.

The right lung is larger than the left lung which is typical of the mammalian lungs. As described by (Maina, 2000), bat lungs are architecturally mammalian. The right lung is composed of four lobes namely cranial lobe, middle lobe, caudal lobe, and accessory lobe. An indentation is grossly visible at the right cranial lobe. The middle lobe is the largest lobe situated in between the cranial and caudal lobes. Whereas the accessory lobe can be observed at the caudal view of the right lungs while the rest are present at the cranial view of the lungs. This arrangement is described in all mammalian lungs (Maina, 2000).

On the other hand, the left lung is composed only of two lobes (Fig 8). The left cranial lobe is not divided into cranial and caudal parts as described in other domestic mammals like dog (Maina et al., 1982; Sisson, 1923; Tucak, 2011).

Schematic illustration of the lungs of the small flying fox (Fig 9) shows the distinct presence of the lobes having the same manner to other mammalian species. The lobes are grossly distinguishable in most species by the deep interlobar fissures. The generalized lobation for domestic species is two lobes for the left lung and four lobes for the right one (Sisson, 1923; Tucak, 2011).

Morphometry of the Lungs

The morphometric assessment of the lung specimens of the small flying fox is shown in Tables (4-7). The mean measure of the right lung is higher than the left lung. This is in accordance with other mammalian species that the right lung is bigger than the left lung.

The female small flying fox right lungs shows in Table (4) have a mean length of 5.4 ± 1.47 cm, mean width of 6.47 ± 0.47 cm, and have a weight of 6.83 ± 1.90 grams. The male small flying fox right lungs shows in Table (5) have a mean length of 5.5 ± 0.14 cm, mean width of 6.45 ± 0.35 cm, and has a weight of 6.85 ± 0.07 grams. Appa-

rently, there are no literature stating the established length, weight, and width of the bats to compare with.

Table (6) shows the mean length, width, and weight of the left lungs of female small flying fox. Based on the data gathered the lungs have a mean value of 5.17 ± 0.90 cm for the length, 5.17 ± 0.61 cm for the width and 5.0 ± 0.96 grams for the weight. Table (7) shows the mean length, width, and weight of the left lungs of male small flying fox. The mean length is 5.15 ± 0.35 cm, the mean width is 5.15 ± 0.64 cm, and the mean weight is 5.0 ± 0.28 grams.

Histologic Description of Lungs

The microscopic anatomy of the tissue section of the lungs of the small flying fox was observed under a digital microscope. The lining epithelium and the cells present were documented.

The primary bronchi (Fig 10) are lined by pseudostratified ciliated columnar epithelium with goblet cells. Next to the epithelium is the hyaline cartilage plate. The lining epithelium or the respiratory epithelium manages in-haled air, capture particles and propel them upward. The function of the goblet cells is to secret mucus which traps inhaled particles and protect the lining epithelium. Whereas the hyaline cartilage serves as structural frame-work and support.

The primary Bronchus is surrounded by alveolar ducts and few blood vessels filled with blood. The bronchial tree begins with the bifurcation of the trachea by the formation of the right and left primary bronchi. Each primary bronchus divides into lobar bronchi, which supply the various lobes of the lungs and are named according to the lobe supplied. The lobar bronchi divide into segmental bronchi, then sub-divides into subsegmental bronchi. Then true bronchiole, which branch out to form the terminal bronchiole (Kerth, 2008). The terminal bronchioles, branch into two or more respiratory bronchioles, which divide into alveolar ducts that, in turn, empty into alveolar sacs (Bacha, 2020).

The lining epithelium of the secondary bronchus (Fig 11) is columnar in shape. The secondary bronchus is surrounded by blood vessels, bronchioles, and alveolar ducts. It branches out from the primary bronchus and supply the various lobes of the lungs (Kerth, 2008).

The tertiary bronchi (Fig 12) are lined by a cuboidal lining epithelium. There are no cilia and goblet cells observed. A thin layer of connective tissue lies below the epithelium and succided by bundles of smooth muscle fibers. The inner wall of each tertiary bronchus is pierced by numerous openings. Each of which leads into a cavity called an atrium (air vesicle).

The bronchioles (Fig 13) are lined with ciliated columnar cells. Moreover, the mucosa of the bronchioles is folded,

unless the lungs were inflated at the time when the tissue was processed. The alveoli are lined mainly by exceedingly thin squamous epithelial cells (Type I pneumocytes) and fewer Type II pneumocytes. Type II are a bit more rounded compared to Type I and which produce surfactant (Bacha, 2020).

Respiratory bronchioles Fig (13) branch from the ends of terminal bronchioles. They are lined by a cuboidal epithelium, which became flattened distally, and their walls contain some smooth muscle fibers (Bacha, 2020). The terminal bronchioles are followed by the alveolar ducts, which terminates into alveolar sacs. Then alveoli which forms the walls of the sacs are lined with thin squamous epithelial cell (Type I & Type II pneumocytes) (Bacha, 2020; Kerth, 2008).

A histologic cross section of the lungs showing a small vein of a small flying fox filled with RBCs (fig 15). The vein is surrounded by the alveolar sac and alveoli. The pulmonary veins return the aerated blood from the left atrium to the heart. The branches of the pulmonary veins do not always follow the bronchial tree, but sometimes run separately (Kerth, 2008).

Morphometric Comparison to Other Species of Bats

There are no available literature confirming the morphometric values of the heart and lungs of other species of bats. At this time, comparison may not be possible. A morphometric study of the lungs of different bats was already done by (Maina et al., 1982). However, the morphometric values such as the size, width, and length were not indicated. They only measured para-meter is the lung volume capacity. Another study was carried out by Yao et al., (2012), on the relative heart masses, described only the orientation of heart without mentioning of any morphometric values.

Conclusion and Recommendation

A total of 5 samples were subjected to the study. Two species of *Pteropus hypomelanus* were collected from Dinagat Island and three others were collected from Hundred Islands in Alaminos, Pangasinan. The samples were subjected to gross and histologic evaluation. Gross anatomy evaluation of all the heart samples revealed that the heart of the small flying fox is oval in shape, with its base wider than the apex. Pericardium appears as a transparent and slightly firm sac that surrounds the heart. Fatty and lymphatic tissue are seen around the heart (atrium part) and its blood vessels. The wall of the two ventricles is thick but the left ventricle was two times thicker than the right ventricle. The wall of the two atria is smooth and not as thick as the wall of the ventricles. It has a very thick interventricular septum between the two ventricles. Histologic eva-

luation revealed three layers of the heart namely: epicardium, myocardium and endocardium and the three layers of blood vessels which include tunica intima, tunica media and tunica adventitia.

The external features of the lungs were described including the morphometric measurements such as length, width, and weight. The right lung is bigger than left lung. The left lung is composed of cranial and caudal lobes while the right lung is composed of cranial, middle, caudal, and accessory lobes. The female Small flying fox right lungs have a mean length of 5.40 ± 1.47 cm, mean width of 6.47 ± 0.47 cm and mean weight of 6.83 ± 1.90 grams. The male small flying fox right lungs have a mean length of 5.50 ± 0.14 cm, mean width of 6.45 ± 0.35 cm and mean weight of 6.85 ± 0.07 grams. The Female left lungs of the small flying fox have a mean length of 5.17 ± 0.90 cm, mean width of 5.17 ± 0.61 cm and mean weight of 5.0 ± 0.96 grams. The male left lung of the small flying fox has a mean length of 5.15 ± 0.35 cm, mean width of 5.15 ± 0.64 cm and mean weight of 5.0 ± 0.28 grams. Histologic evaluation revealed that the primary bronchi are lined with pseudostratified columnar epithelium, the secondary bronchi are lined with columnar epithelium and the tertiary bronchi have a cuboidal lining epithelium. The bronchioles are lined with simple cuboidal epithelium while the alveoli are lined with simple squamous epithelium. Type I and Type II pneumocytes were also observed.

Conclusion

The heart and lungs of the fruit flying fox (*Pteropus hypomelanus*) follow the overall route design of the mammalian heart, including the arrangement of atrium and ventricles, according to the results of this study. The heart, which is positioned in the ventral half of the thoracic cavity between the planes of the 4th and 9th ribs, is also similar to that of other mammals. The lobation pattern is the same in both lungs, with the right lung having more lobes than the left one.

The authors were also able to determine the heart and lung morpho-metric mean values. The heart weighs 4.70 ± 0.42 grams for the male and 4.70 ± 1.92 grams for the female, has a length of 3.15 ± 0.21 cm and 2.7 ± 0.53 for the male and female respectively, and a width of 2.05 ± 0.21 and 1.73 ± 0.35 cm for male and female respectively at its broadest point. The right ventricles of the male and female measures 0.10 cm ± 0.0. The left ventricle of the male measures 0.45 ± 0.01 and 0.45 ± 0.03 for the female, the left and right atrium for both male and female is 0.1 ± 0.0 cm, and the interventricular septum of the male is 0.35 ± 0.0 cm and 0.35 ± 0.01 cm for the female.

The length of the female and male small flying fox right lungs is 5.4 ± 1.47

cm and 5.5 ± 0.14 cm respectively, the width is 6.47 ± 0.47 cm and 6.45 ± 0.35 cm, and the weight is 6.83 ± 1.90 g and 6.85 ± 0.07 g, respectively. The length of the female and male small flying fox's left lung is 5.17 ± 0.90 cm and 5.15 ± 0.35 cm, and the width is 5.17 ± 0.61 cm and 5.15 ± 0.64 cm respectively, with a weight of 5.0 ± 0.28 grams for the male and 5.0 ± 0.96 grams for the female. Microscopically, the lining epitheliums are identical to those found in other mammalian species.

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Map (1): The eight sampling locations are located in Loreto and Basilisa, Philippines (10.1282° N, 125.6095° E).

Map (2): Sampling location is located in Cuenca Island (Hundred Island, Alaminos, Pangasinan)

Table (1): The faunal samples were gathered and documented at sites in the towns of Loreto and Basilisa in the province of Dinagat Islands, Philippines.

Sampling Sites	Coordinates	Elevation (m)	Site Description
Mt. Arayat	10°07'30.4" N 125°37'03.9"E	395	Composed of patches of primary forest located far from the mining areas but are minimally disturbed by logging
Mt. Bil-at	10°24'28.8"N 125°39'51.8"E	92	Adjacent to a strip-mining operation; highly disturbed site with only patches of primary forest remaining
Cambiatao	10°5'58.14"N 125°33'24.5"E	138	Secondary growth forest dominated by herbaceous plants and shrubs; decommissioned mine site; minimal disturbance
Mt. Magkuno	10°24'19.2"N 125°37'39.5"E	249	Located adjacent to a strip-mining operation; highly disturbed site with patches of primary forest
Rosita	10°24'28.8"N 125°33'29.0"E	138	Ranges from open areas to secondary forests; dominated by herbaceous plants and shrubs; decommissioned mine site; minimal disturbance
Mt. Kongking	10°24'6.9"N 125°38'49.7"E	619	Located adjacent to a strip-mining operation; highly disturbed site with patches of primary forest
Mt. San Ramon	10°24'5"N 125°38'22.3"E	624	Disturbed by strip mining; only patches of primary forest remain in the site
Mt. Redondo	10°20'54.7"N 125°38'5.9"E	845	High altitude “bonsai forest”; located adjacent to a mine pit; minimally disturbed

Table (2): Sample site in the Island of Cuenca, Alaminos Pangasinan

Sampling Sites	Coordinates	Elevation (m)	Site Description
Cuenca Island	16°12'50.0"N 120°02'13"E	66	Located in the vicinity of Quezon Island.

Table (3): The mean of heart measurements of P. hypomelanus

	Male	Female
Heart Weight (g)	4.70 ± 0.42	4.7 ± 1.92
Heart Length (cm)	3.15 ± 0.21	2.7 ± 0.53
Heart Width (cm)	2.05 ± 0.21	1.73 ± 0.35
Right Ventricle Wall (cm)	0.1 ± 0.0	0.1 ± 0.0
Left Ventricle Wall (cm)	0.45 ± 0.01	0.45 ± 0.03
Right Atrium Wall (cm)	0.1 ± 0.0	0.1 ± 0.0
Left Atrium Wall (cm)	0.1 ± 0.0	0.1 ± 0.0
Interventricular Septum (cm)	0.35 ± 0.0	0.35 ± 0.01

Table (4): Mean morphometric values of the right lung of female small flying fox.

TEST ANIMAL	LENGTH (cm)	WIDTH (cm)	WEIGHT (g)
Right 1 (Female)	4.1	6.1	4.9
Right 2 (Female)	5.1	7.0	6.9
Right 3 (Female)	7.0	6.3	8.7
MEAN	**5.40** ± 1.47	**6.47** ± 0.47	**6.83** ± 1.90

Table (5): Mean morphometric values of the right lung of male small flying fox.

TEST ANIMAL	LENGTH (cm)	WIDTH (cm)	WEIGHT (g)
Right 1 (Male)	5.6	6.2	6.8
Right 2 (Male)	5.4	6.7	6.9
MEAN	**5.50** ± 0.14	**6.45** ± 0.35	**6.85** ± 0.07

Table (6). Mean morphometric values of the left lung of female small flying fox

TEST ANIMAL	LENGTH (cm)	WIDTH (cm)	WEIGHT (g)
Left 1 (Female)	4.3	4.5	3.9
Left 2 (Female)	6.1	5.7	5.4
Left 3 (Female)	5.1	5.3	5.7
MEAN	**5.17** ± 0.90	**5.17** ± 0.61	**5.0** ± 0.96

Table (7): Mean morphometric values of the left lung of male small flying fox.

TEST ANIMAL	LENGTH (cm)	WIDTH (cm)	WEIGHT (g)
Left 1 (Male)	4.9	4.7	5.2
Left 2 (Male)	5.4	5.6	4.8
MEAN	**5.15** ± 0.35	**5.15** ± 0.64	**5.0** ± 0.28

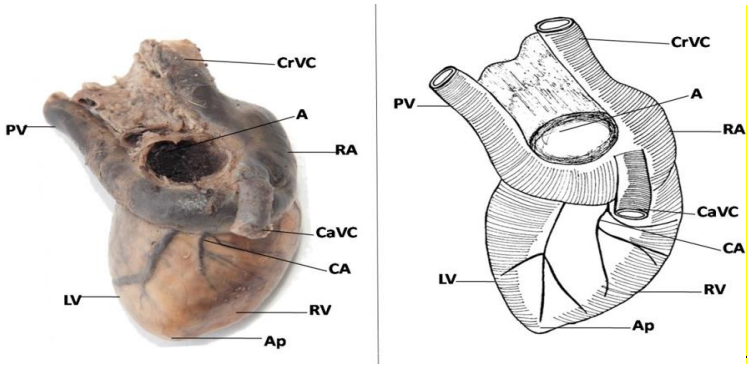

Fig (1): Small flying fox heart gross and schematic appearance. The heart showing Cranial Vena Cava (CrVC), Pulmonary Vein (PV), cut Aorta (A), Right Atrium (RA), Caudal Vena Cava (CaCV), Coronary Artery (CA), Left Ventricle (LV), Right Ventricle (RV) and Apex (Ap).

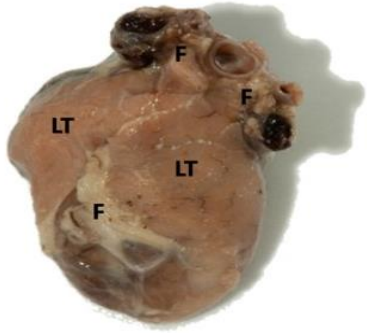

Fig (2): Heart of small flying fox showing fats (F) and lymphatic tissue (LT) around the atrium and the blood vessels

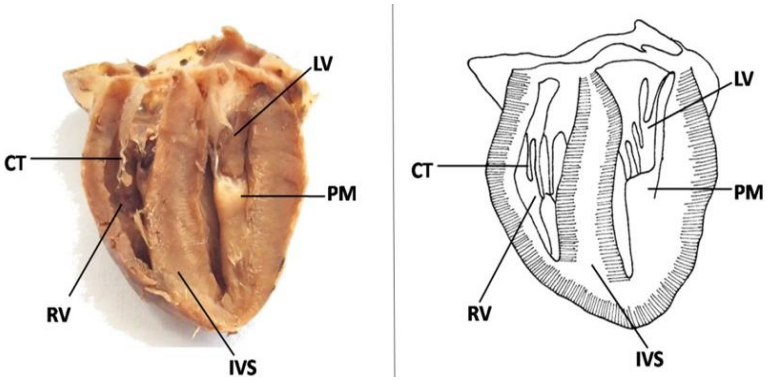

Fig (3): Gross and schematic male small flying fox heart cut along the long axis to show the ventricular cavities, chordae tendinae, and papillary muscle. The heart is showing right ventricle (RV), left ventricle (LV) together with the chordae tendinae (CT), papillary muscle (PM) and the interventricular septum (IVS).

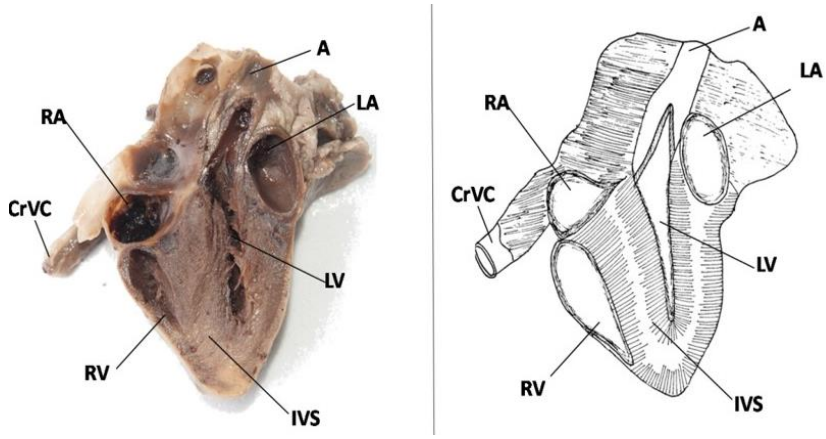

Fig (4): Image showing female small flying fox cu along the long axis to show both atria and ventricular cavities. The half of the heart is showing right atrium (RA), right ventricle (RV), left atrium (LA), left ventricle (LV), interventricular septum (IVS), aorta (A), and cranial vena cava (CrVC).

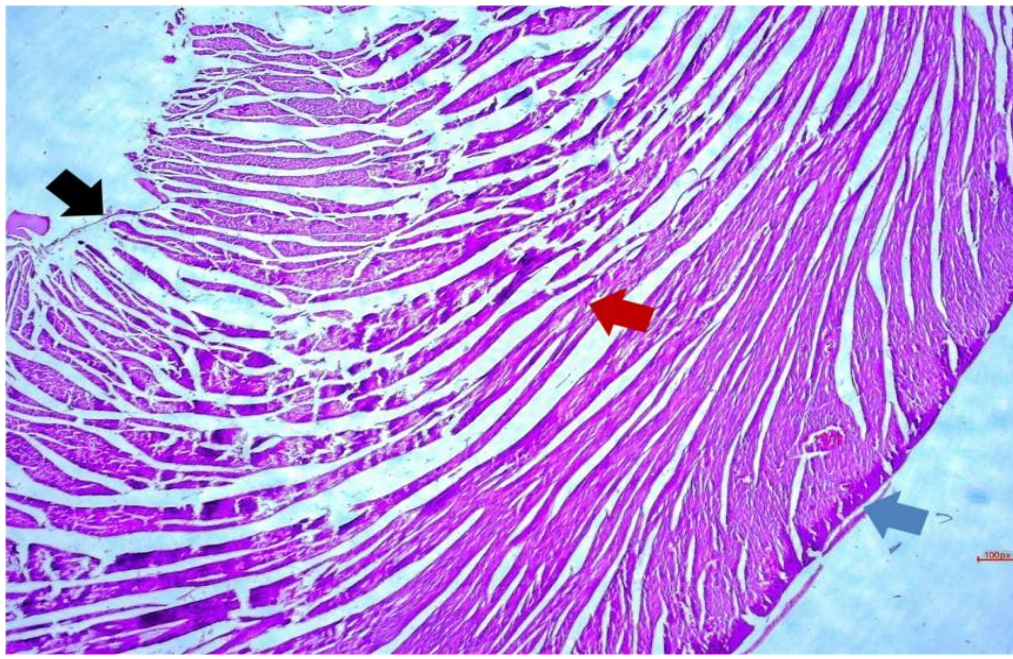

Fig (5): Transverse section of the heart apex showing three layers of the heart. The blue arrow indicates the epicardium, the red arrow indicates the myocardium and the black arrow indicates endocardium.

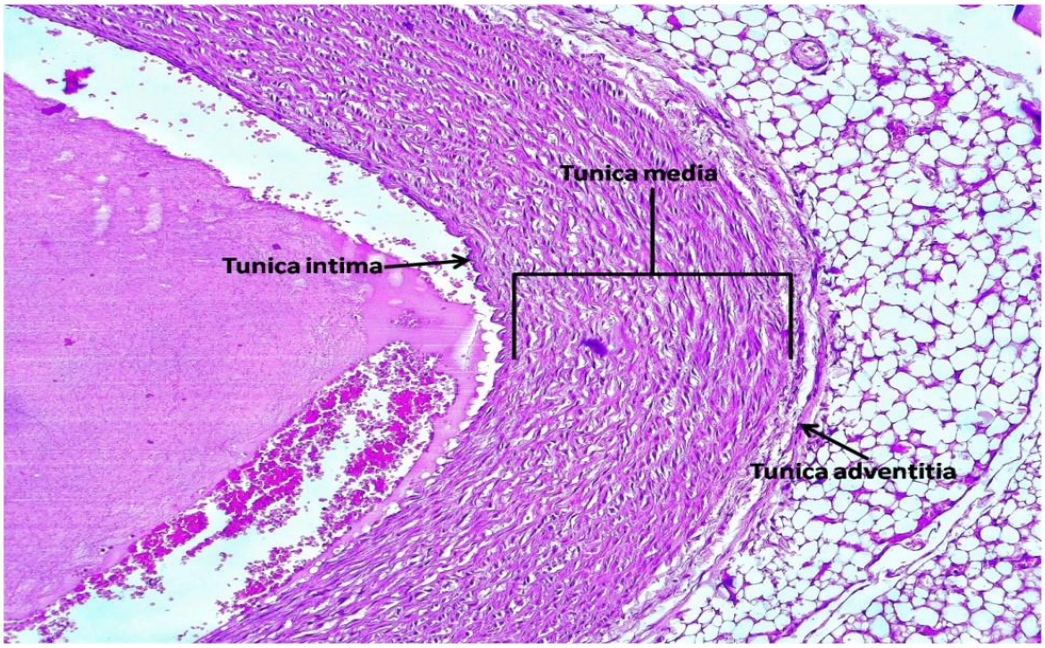

Fig (6): Transverse section of right coronary artery showing its three layers (400x). Notice the abundant fatty cells beyond tunica adventitia.

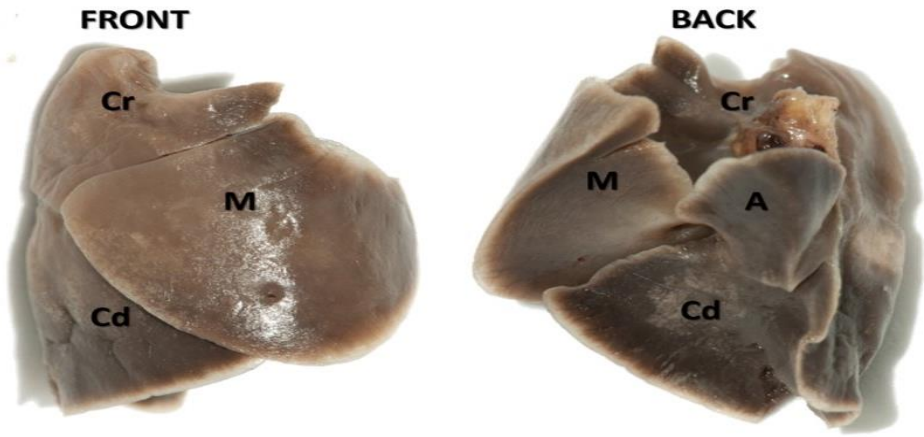

Fig (7): Gross anatomy of the formalin-preserved right lung of a small flying fox. Cranial (Cr), Middle (M), Caudal (Cd), and accessory (A) lobes of the lung.

Fig (8): Gross anatomy of the left lung of small fleying fox. The left lung consists of Cranial (Cr) lobe or the apical part of the lung and the Caudal (Cd) lobe or the diaphragmatic part of the lung.

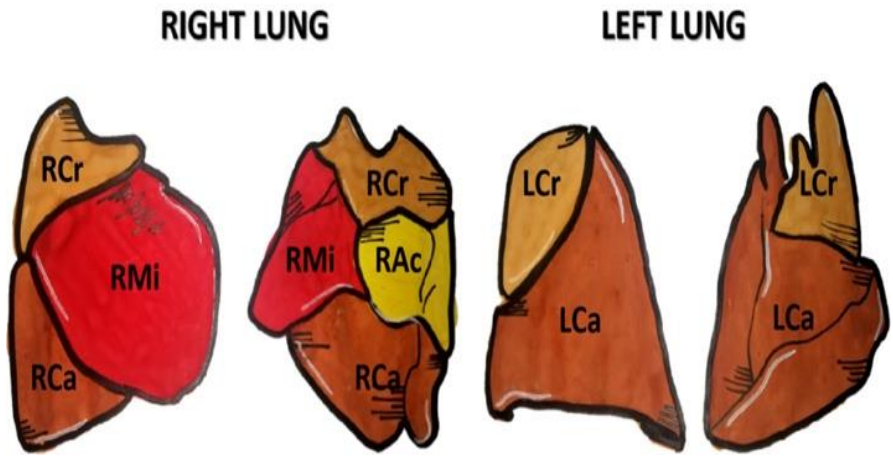

Fig (9): Schematic illustration of gross anatomy of the small flying fox. The right lung is composed of Right Cranial Lobe (RCr), Right Caudal Lobe (RCa), Middle Lobe (RMi) and Accessory Lobe (RAc). The left lung is composed of cranial lobe (LCr) and Caudal Lobe (LCa)

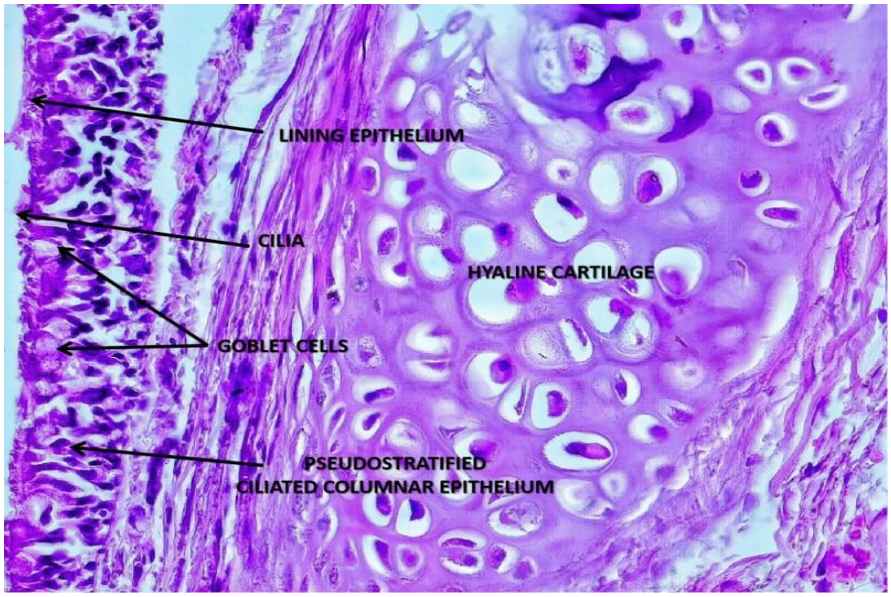

Fig (10): Histologic section of the lung demonstrating the lining epithelium of the primary bronchus, Pseudostratified ciliated columnar epitheium, goblet cells and hyaline cartilage. H&E (400x)

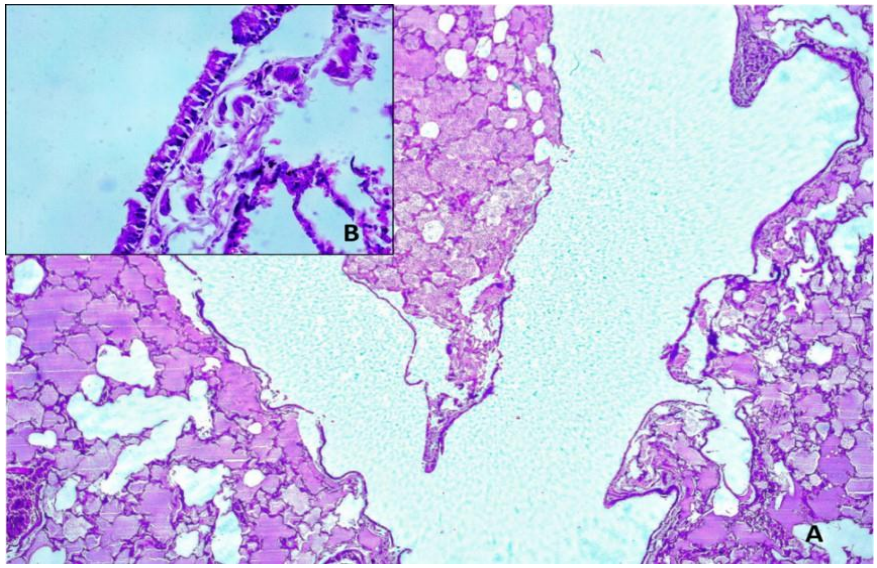

Fig (11): (A) Histologic cross section of the lungs of a small flying fox showing secondary bronchus. H&E (100x). (B) The columnar lining epithelium. H&E (400x)

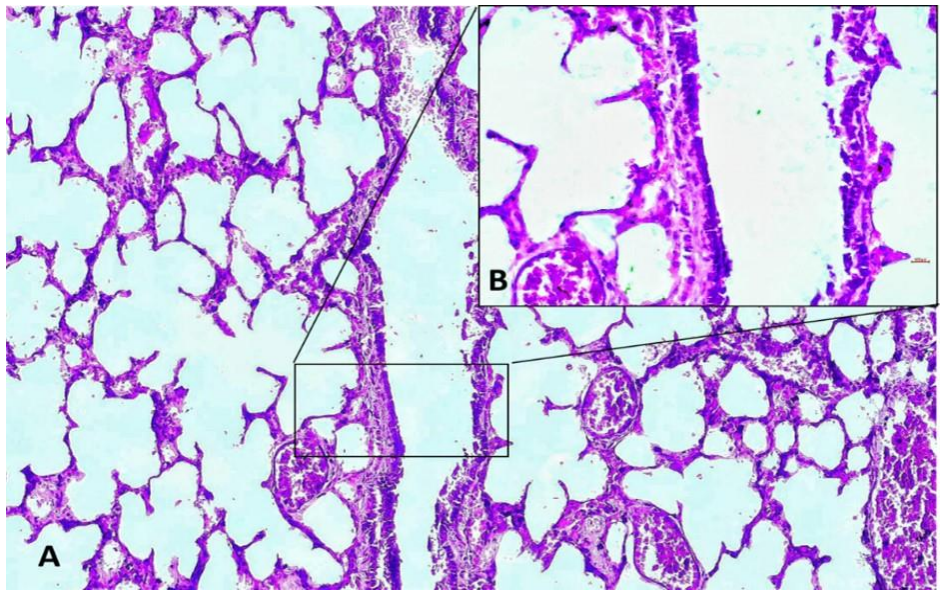

Fig (12): (A) Histologic cross section of the apical part showing the Tertiary bronchi of the lung of a small flying fox. H&E (100x). (B) the tertiary bronchi lined by cuboidal epithelium. H&E (400x).

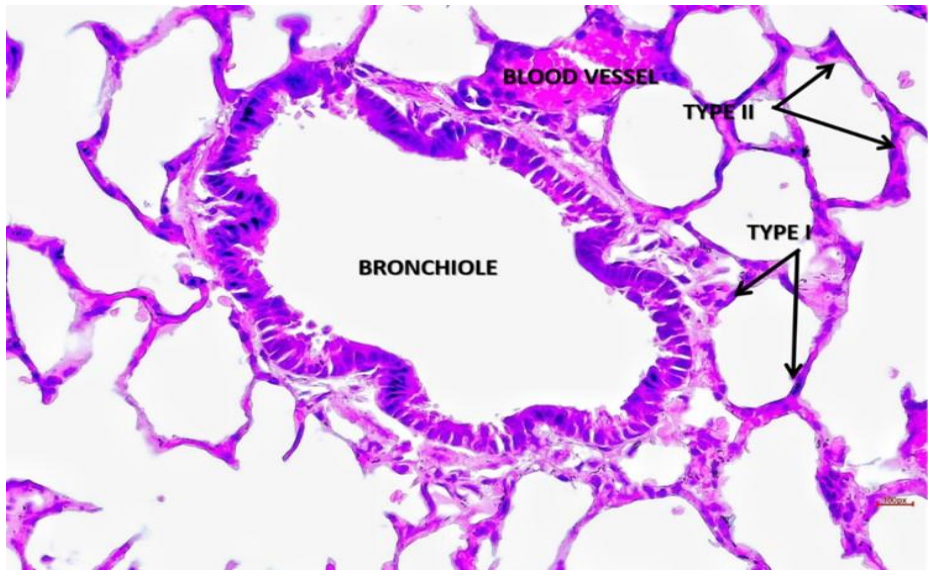

Fig (13): Histologic cross section of the lung displaying the bronchiole, Blood vessel, Type I and Type II pneumocytes. H&E (400x).

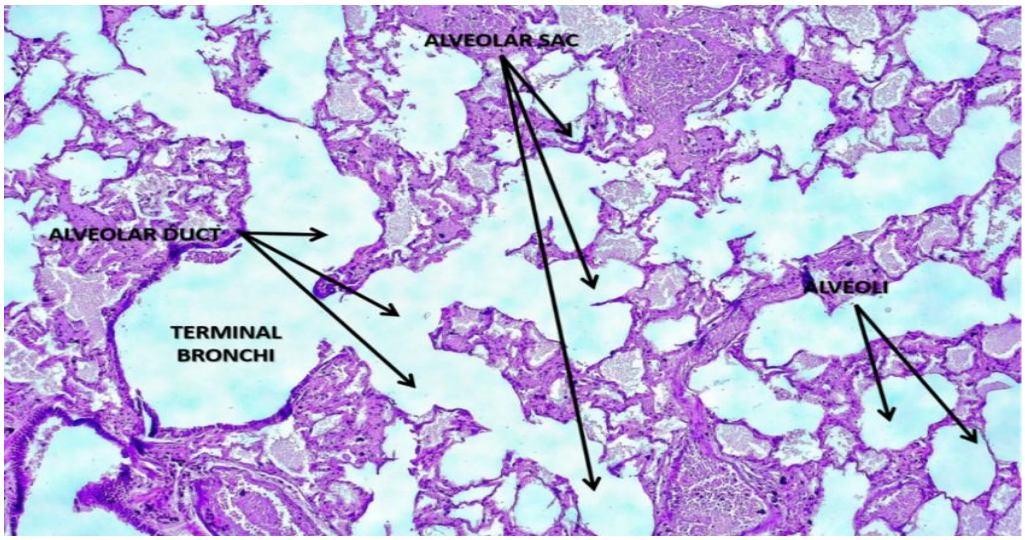

Fig (14): Cross section of the lung demonstrating the terminal bronchiole, the alveolar ducts, the alveolar sacs and the alveoli. H&E (400x).

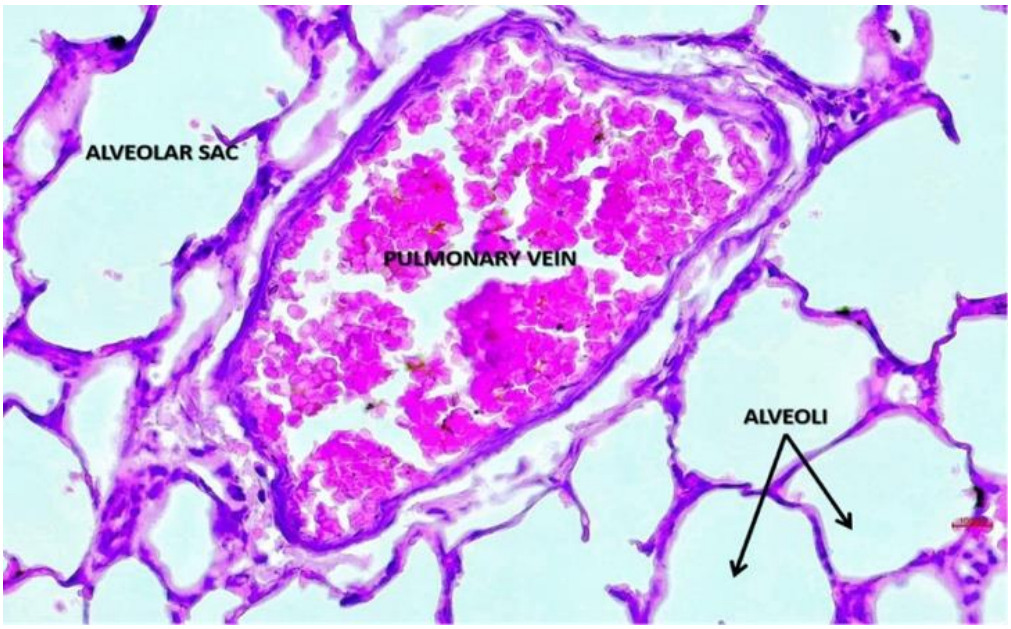

Fig (15): Histologic section of the lung showing a venule surrounded by alveolar sac and alveoli. H&E (400x).

Animal species in this Issue

Small Flying Fox (*Pteropus hypomelanus*)

Kingdom: Animalia & Phylum: Chordata & Class: Mammalia & Order: Chiropetra & Family: Pteropodidae & Genus: ***Pteropus*** & Species: ***P. hypomelanus***

The small flying fox, island flying fox or variable flying fox (*Pteropus hypomelanus*) is a species of flying fox in the family Pteropodidae. It is found in Australia, Cambodia, Indonesia, Malaysia, the Maldives, Myanmar, Papua New Guinea, the Philippines , the Solomon Islands, Thailand, and Vietnam.

The small flying fox is quite variable in its colouring. The head is usually dark brown but can be yellowish-brown and is paler in the eastern part of the animal's range. The back is tawny-brown and the underparts some shade of buff. The ears are partially furred and the wing membranes are black. The fur is short on the back and medium-length on the underparts. This bat can be distinguished from the rather similar Ryukyu flying fox (*Pteropus dasymallus*) by the fact that its tibia are bare rather than covered with fur.

Small flying foxes feed mostly on the fruit of native and introduced trees but also consume flowers and nectar. The diet includes pawpaws, mangos, jambul, bananas, figs, flowers of the kapok tree (*Ceiba pentandra*) and the banyan, tree and flowers and fruits of cultivated crops. They consume about half their body weight each day.

Source: Wikipedia, the free encyclopaedia