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Anatomy of Abdominal Aorta in Tatu Peba (*Euphractus sexcinctus* - Linnaeus, 1758): A Descriptive and Comparative Study

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Abstract**—** *Tatu Peba is an animal from Euphractus genus whose anatomy and/or systemic description are little studied, a fundamental understanding of biological system knowledge of this animal. Thus, this work aimed perform an anatomical description of abdominal aorta and Tatu Peba branches through a comparative study using 2 male and 2 female specimens. In this sense, the present work showed unprecedentedly discovery about this animal as the first major branch of abdominal aorta is celiac trunk and the second branch is a. Mesenteric cranial. From ventrolateral face, a. Phrenic caudal, by ventral small face Aa. Accessory Mesenteric and five pairs of Aa. Lombares. Medium distance, between Celiac Trunk and Aa. External Iliacs, born Renal arteries. A. Caudal Mesenteric emerges ventrally to caudal part of large intestine. In the final part of aorta, Aa. External Iliacs borns ventrolaterally and caudally projected. After Aa. External Iliacs origin, the aorta undergoes a drastic reduction of caliber and forms a short trunk that divides into terminal branches of aorta: right internal iliac, Left Internal Iliac and a. Median sinsacral in sagittal plane which emits an a. Lateral to each side, following three caudally. In view of these findings, the present study showed that abdominal aorta of Tatu Peba presents smaller number of branches bought from other mammals and contributes to anatomical description and understanding of important blood vessels in this animal biological system.*

Keywords**— Anatomy, Euphractus sexcinctus, Brazilian fauna, Cerrado biome and Wild animals.**

I. INTRODUCTION

There are 21 species of armadillos described, which 11 are from Brazilian fauna **[1]**. *Euphractus sexcinctus* (Tatu Peba) specie is the only of *Euphractus* genus and belongs *Daypodidae* family inserted in Cingulata order and Xenarthra superorder **[2]**. This animal is regionally known as Tatu Peba or Tatu Peludo **[3]** and the carapace has a variable coloration from yellowish-brown to light brown, formed by 6 to 8 moving bands. The head is conical, the tail long and protected by horny rings and it whitish and long hairs **[4]**, giving rise to the popular name of this species. It is widely distributed in South America, including Brazil where it habits several biomes such as Amazon, Caatinga, Cerrado, Pantanal, Mata Atlântica and Campos **[5]**, savannas, dry forests, semi-deciduous forests and forest edges **[6,7]**.

The general food habit of Tatu Peba involves invertebrates (mainly insects), organic plant material (fruits and tubers, etc.), decomposing animals **[8,9]** and small vertebrates (mainly rodents of the species Calomys sp.) **[10]**. Its activity is mainly diurnal, but eventually has nocturnal activities **[1]**.

This specie is frequently victim of road crashes **[11]** and although its meat has a strong and singular flavor, so much appreciated and constantly hunted **[12]**. Despite trampling deaths, hunting and disturbances caused by anthropic activities, this species is not threatened with extinction **[13]**.

Xenarthra superorder presents some anatomical peculiarities, such as additional joints between the caudal vertebrae, allowing erect posture in some situations. Some authors reports the presence of caudal cavae pair of veins, undifferentiated external genitalia, low metabolism and body temperature ranging from 32.7 ° C to 35.5 ° C **[14,15]**.

The anatomical, topography and systemic descriptions of any specie are fundamental for biological

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system knowledge, as well its importance in clinical veterinary practice. However, even the importance of anatomy of wild animals for the eco-sustainability in biome; as well the value of species in the ecosystem, the anatomy of Tatu Peba is little studied. Considering the importance of circulatory system in animal anatomy as an internal mean of transport and an important access route in clinic, where provides data in clinical intervention or preservation programs, the objective of this work was investigate and describe the anatomy of Abdominal Aorta and its branches in Tatu Peba as a literary subsidy for different areas of knowledge.

II. MATERIAL AND METHODS

The present paper is a descriptive anatomical study with two male and two female specimens of Tatu Peba (*Euphractus sexcinctus* - Linnaeus, 1758), obtained from accidental death on the roadsides of Brazilian Southeast of Goiás, under authorization of SISBIO nº 37072-2. Considering the descriptive approach of this work, statistical analysis is not necessary. All procedures were conducted in accordance with ethical principles and were approved by the Institutional Ethics in Research Committee at the Federal University of Uberlândia (CEUA/UFU nº 067/12).

The study was made in the research laboratory of human and comparative anatomy from the Federal University of Goiás – RC, as previously described by our group **[16]**, were the arterial system was dissected and inject with Latex Art Glue, colored with red pigment Wandalar, through the carotid artery. Subsequently was made a fixation with aqueous 10 % formaldehyde solution to conservation. The preparation of anatomical pieces was performed under consecrated techniques in Macroscopic Anatomy. For this, after trichotomy of anterolateral abdomen region, an incision was made along Linea Alba, from xiphoid process to cranial extremity of the pubic symphysis. Other incisions were performed laterally, accompanying costal border of each side and inguinal region approximated of inguinal ligament. The abdominal wall was laterally open to visceral exposure, then all abdominal part and digestive system secluded, exposing the dorsal wall of abdomen. With an anatomical forceps, the adipose tissue and other tissues were removed to expose abdominal aorta artery and its branches. A stereomicroscope MOTIC SMZ-168, with magnification of 10X was used to dissection procedure.

The Nikon® D7000 18-105 digital camera was used to photographical documentation and description nomenclature adopted is the standard of Nomina Anatomica Veterinaria (2012) **[17]**, elaborated by the International Committee on Veterinary Gross Anatomical Nomenclature.

III. RESULTS

The diaphragmatic pillars of Tatu Peba (*Euphractus sexcinctus*) are long and protrude caudally to level of iliopsoas muscles origin. The aortic gap comprises an space delimited by diaphragmatic pillars through Aorta enters abdominal cavity approximate from level of L_1 and runs along dorsal wall of abdomen, slightly to left of vertebral bodies. The first major branch of abdominal aorta is the *Celiac Trunk*, being the largest branch of abdominal aorta and characterized as unpaired vessel, short and large caliber vessel, originating in ventral aspect of Aorta at level L_2 between the pillars of diaphragm. Soon after its origin, *Celiac Trunk* trifurcases in *Common Hepatic a*. sideways to right, *Left Gastric a*. laterally to left and posterior to *Lienal*.

The second branch of abdominal aorta is *Cranial Mesenteric a*. with unpaired characteristic and large caliber vessel, originating from ventral face at level L_3 near *Celiac Trunk* origin directed to intestines. Near *Cranial Mesenteric a*. origin borns *Left Caudal Phrenic Aa*. as a unique vessel by left ventrolateral face at L_3 level, which is directed to left diaphragmatic pillar and already on diaphragm surface divided into right and left branches, there being no *Caudal Phrenic a*.. Four small accessory mesenteric arteries were identified, one arising from *Left Gastric a*. and the others from aorta.

Five pairs of *Lumbar Arteries* are present in Tatu Peba, which arise from dorsal surface of *Abdominal Aorta*. These arteries are arranged equidistantly from diaphragmatic pillars to final bifurcation of aorta, the fifth pair being already located within pelvis.

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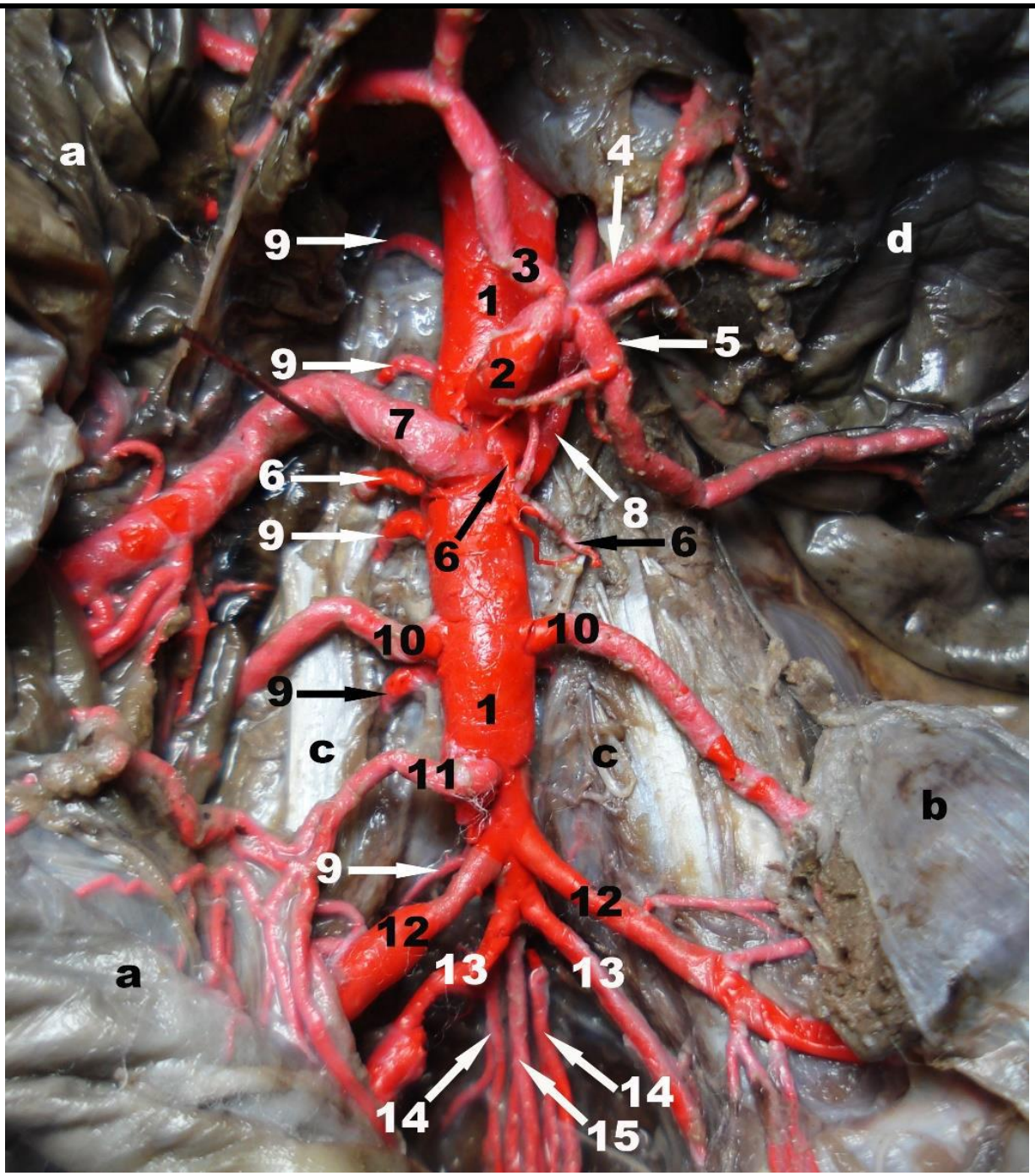

Fig.1: Abdominal part of Aorta. 1- Abdominal Aorta; 2 - Celiac Trunk; 3- Common Hepatic Artery; 4- Lienal Artery; 5 - Left Gastric Artery; 6- Mesenteric Accessory Artery; 7- Cranial Mesenteric Artery; 8- Phrenic Caudal Artery; 9- Lumbar Artery; 10- Renal Artery; 11- Mesenteric Caudal Artery; 12- External Iliac Artery; 13- Internal Iliac Artery; 14- Lateral Sinsacral; 15 - Median Sinsacral Artery.

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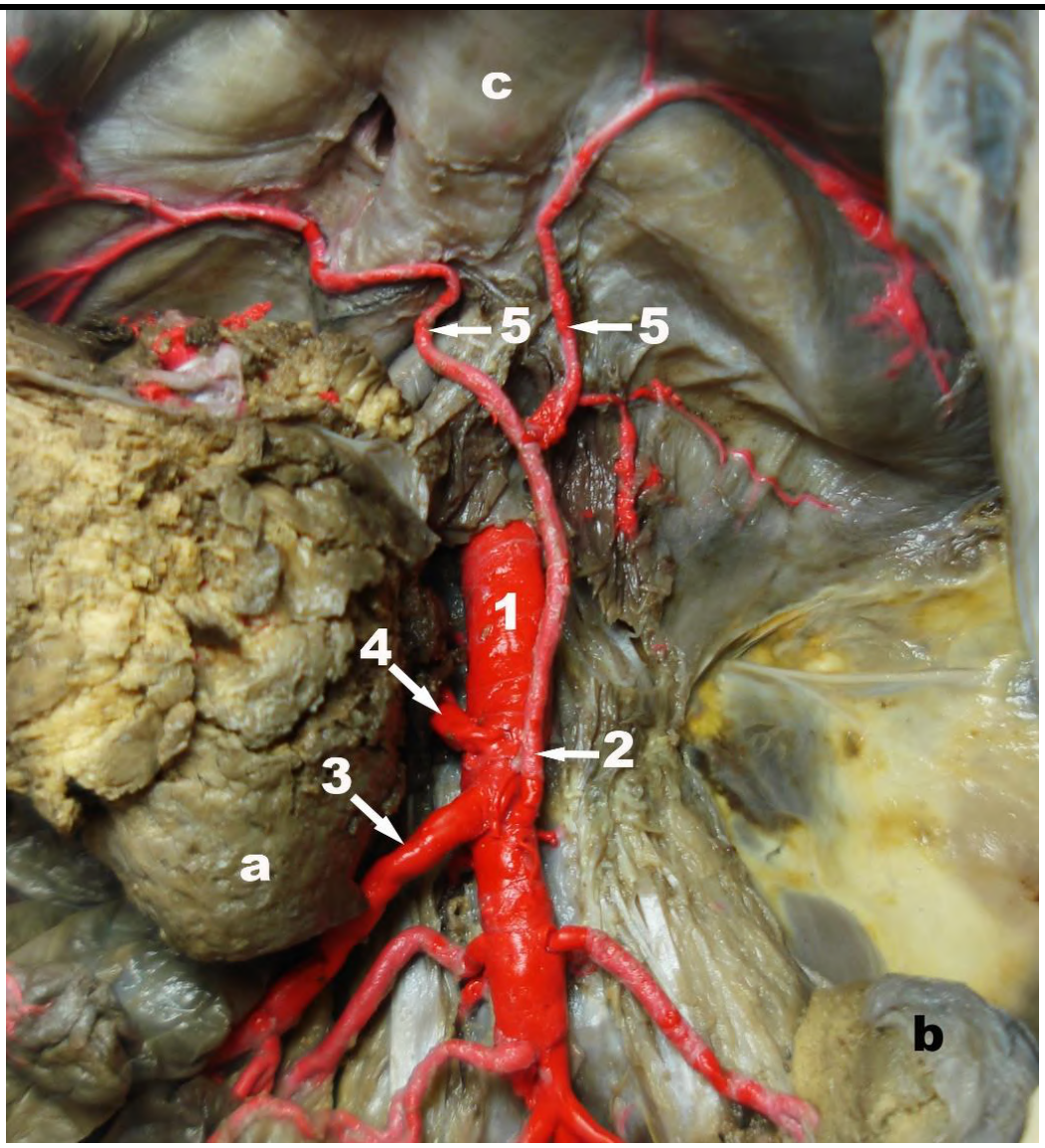

Fig.2: Abdominal part of Aorta. a- Left Liver Lob; b- Kidney; c- Diaphragm; 1- Abdominal Aorta; 2 – Phrenic Caudal Artery; 3- Mesenteric Caudal Artery; 4- Celiac Trunk; 5 – Phrenic Artery Branch.

The average distance between *Celiac Trunk* and *External Iliacs Aa.* at L_3-L_4 level, *Renal Arteries* born laterally, the right being relatively longer than left. In variable numbers, adrenal arteries are branches of *Renal Arteries*. Then, caudally at L_5 *Caudal Mesenteric a.* emerges ventrally to caudal part of large intestine. In final part of aorta (abdominopelvic transition), the *External Iliacs Aa.* borns ventrolaterally and caudally projected. After *External Iliacs Aa.* origin, aorta undergoes a drastic reduction of caliber forming a short trunk and divides into terminal branches of aorta: *the Right Internal Iliac*, *Left Internal Iliac* and in sagittal plane *Median Sinsacral a.* that borns dorsally. *Aa. Internal Iliacs* supply intra-pelvic structures and provide *Gonadais Arteries*, while *Median Sinsacral* emits an *Lateral Sinsacral a.* to each side, following three caudally.

Table.1: Main branches origin of abdominal aorta from Tatu Peba (Euphractus sexcinctus)

Structure	Artery of Origin	Vertebra of Origin
Celiac Trunk	*Abdominal Aorta*	L_2
Cranial Mesenteric Artery	*Abdominal Aorta*	L_3
Phrenic Caudal Artery	*Abdominal Aorta*	L_3
Mesenteric Accessory Artery	*Abdominal Aorta*	L_3
Lumbar Arteries	*Abdominal Aorta*	L_1 - L_5
Artérias Renais	*Aorta abdominal*	L_4

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Artéria Mesentérica Caudal	*Aorta abdominal*	L_5
Artéria Ilíaca Externa	*Aorta abdominal*	*Sinsacro*
Artéria Ilíaca Interna	*Aorta abdominal*	*Sinsacro*
Artéria Sacral Mediana	*Aorta abdominal*	*Sinsacro*
Artérias Sinsacrais	*Aorta abdominal*	*Sinsacro*

IV. DISCUSSION

Although anatomical comparisons between domestical and wild animals, literature research reveals shortage articles of Tatu Peba anatomy and discussions of large Xenarthras group are not prioritized, which require correlation of the present study with pertinent literature in other groups.

The first visceral branch of *Abdominal Aorta* of Tatu Peba is the *Celiac Trunk*, which emerges ventrally at L_2 vertebra after aortic gap and formed by right and left diagrammatic pillars. The *Celiac Trunk* is unique and large caliber vessel originates ventrally from *Abdominal Aorta* and trifurcates in *Left Gastric a.*, *Lienal a.* and *Common Hepatic a.*. When compared to Tamanduá Bandeira (*Myrmecophaga tridactyla*) **[18]** is possible identify close similarity with regard to ramifications of *Celiac Trunk*.

Other representatives of Xenarthras group, similarity Tatu Peba can be viewed with Sloth Bug (*Bradypus variegatus*), since *Celiac Trunk* presents the same origin and branching pattern in least 75% of individuals, occurring 25% of variations when *Celiac Mesenteric Trunk* formation occurs **[19]**, unverified pattern in Tatu Peba. On the other hand, Albuquerque et al, (2017) **[20]** describe that 50% of females and ≅ 33.3% of males present similar disposition to found in Tatu Peba, while formation of *Celiac Mesenteric* occurs in other females and ≅ 66.7% of males.

However Albuquerque *et al.* (2017) **[20]** identify *Phrenic Caudal a.* as the first branch of abdominal aorta, discordant data with findings in Tatu Peba, Macedo *et al.* (2013) **[21]** mention that Tamandua-mirim (*Tamandua tetradactyla*), *Celiac Trunk* emerges separately maintaining the branching pattern observed in other Xenarthras, but only one female of their study a bifurcation of *Celiac Trunk* in *Left Gastric a.* and *Lienal a.* were observed, the *Common Hepatic a.* collateral branch of *Cranial Mesenteric a.*. In relation to pattern of origin and branching of *Celiac Trunk* in other taxonomic groups, Bavaresco *et al.* (2013) in New Zealand rabbits **[22]**, Faria (2016) in Macaco-da-noite **[23]**, Pinheiro *et al.* (2014) in Jaguatirica **[24]** and Culau (2008) in Nutria **[25]**, identify pattern similar to that verified in Tatu Peba.

Described by da Silva *et al.* (2011) that Macaco-de-Cheiro *Left Adrenal a.* born from Celiac Trunk, since Culau *et al.* 2010 **[27]** describe that in gambá 87.5% of have a *Commom Mesenteric Celiac Trunk* formation.

Machado *et al.* (2002) **[28]** also analyzed vascular system of Nutria and observed that in 70% of cases *Celiac Trunk a.* emerges separately and 30% in a common trunk with *Cranial Mesenteric a.*. In the study of Amadori *et al.* (2012) **[29]** which the object of study was Veado Catingueiro (*Mazama gouazoubira*) the group identified that the first branch of *Celiac Trunk* a. is *Phrenic Caudal a.* and after this, *Hepatic a.* and *Left Gastric a.* and *Lienal* issuance.

The same standard is observed in ruminants and equines **[30,31]** and carnivores **[32]** and identified in 16.6% of swine [33] and 10% Nelore cattle **[34]**, contrary to observations of Tatu Peba when a single *Phrenic a.* originates directly from *Abdominal Aorta* and divides into right and left branches.

The second major branch of Abdominal Aorta in Tatu Peba is *Mesenteric Cranial a.*, as occurs in Tamanduá Mirim and Tamanduá Bandeira **[21,35]**. In this context, only Bicho Preguiça present the formation of *Celiac Mesenteric Trunk* between components of Xenarthra Superorder, in the others *Celiac Trunk* and *Mesenteric Cranial a.* originate separately. As most Xenarthras other species share same said arteries independent organization, when *Mesenteric Cranial a.* emerges from ventral face of Aorta and caudally to *Celiac Trunk*, such as: Macaco-de-Cheiro (*Saimiri sciureus*) **[26]**, Macaco-da-Noite (*Aotus azarae infulatus*) **[23]**, Nutria (*Myocastor coypus*) **[25]**, New Zeland Rabbit (*Oryctolagus cuniculus*) **[22]**, Queixada (Tayassu pecari) **[36]**, Paca (*Cuniculus paca*) **[37]**, Cat (*Felis catus*), S.R.D. **[38]** and Jaguatirica (*Leopardus pardalis*) **[24]**. However, the formation of *Mesenteric Celiac Trunk* of some groups can occur, although isolated form of origin predominates in bovine fetuses, Sheep **[39,40]**, Bubalinos **[41]**, Goats **[42]**, Felines **[43]** and finally humans **[44]**, and the formation of *Celiac Mesenteric Trunk* in Tatu Peba is not found.

Immediately after *Celiac Trunk* origin cranially to *Cranial Mesenteric a.* born *Phrenic Caudal a.* and a single medium caliber artery recedes cranially to the left, which reaches caudal face of diaphragm that divides into right and left branches, and there is no right *Phrenic Caudal a.*. Tamanduá Mirim there is two caudal arteries, one left and other right **[21]** and in Bicho Preguiça occurs in unique way, emerging before *Celiac Trunk* **[20]**, in this way the first branch of aorta.

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The literature have little data regarding *Accessory Mesenteric Arteries*, but in Tatu Peba four of them can be counted with variable origins and arise from *Left Gastric a*. or directly from Aorta. Five pairs of *Lumbar Arteries* are present in Tatu Peba, whose origins occur on dorsal aspect of aorta and equidistant from each other, from diaphragm to sinsacral cavity. In Bicho Preguiça it can be identified between two to ten pairs of *Lumbars Aa*, with higher number in female specimens **[20]**. Six pairs can be observed in Nutria **[25]** and Jaguatirica **[24]**, whereas in New Zealand Rabbits seven pairs are observed and three pairs in Tamandua Mirim **[22,21]**.

In Tatu Peba at fourth lumbar vertebra emerge *Right* and *Left Renal a*. in ventrolaterally and independent origin. This pattern is similar to other represents of Xenarthra group such Tamanduá Bandeira **[35]** and Tamandua Mirim **[21]**. However the level origin of Tamanduá mirim, the Right Renal a. is cranial in relation to the left. As in other groups, *Renal Arteries* of Tatu Peba eventually gives branches to adrenal glands **[21]**.

The number of *Renal Arteries* in Tatu Peba specimens studied is constant, always on each side and with branching only inside the organ. In Bicho Preguiça *Left kidney a*. occurs in half female specimens **[20]** and arises bifurcation of *Renal a*. before arrive hilo, similar condition was identified by Silva *et al*. (2013) in Macaco-prego **[45]**.Culau (2008) reports in Nutria **[25]** that *Renal Artery* arises laterally from Aorta, 70% asymmetrical and single and 30% double. Faria (2016) states in Macaco-da-noite **[23]** that *Renal Artery* can arise in common trunk, a particularity not observed in Tatu Peba.

In Tatu-peba, caudally to *Renal Arteries* arise *Mesenteric Caudal a*. from ventral aspect of aorta, whose distribution occurs in the final part of large intestine. This condition is present in Tamanduá Bandeira **[35]**, Tamanduá Mirim **[21]** and Bicho Preguiça in 75% of females and ≅ 83.3% of males **[20]**. With regard to origin and distribution of Caudal Mesenteric a., a strong similarity can be identified between observations in Tatu Peba and Cats S.R.D. **[38]**, as well Paca **[37]** and Queixada **[36]**.

At abdominopelvic transition, *Abdominal Aorta* of Tatu Peba origin laterally to *External Iliac Aa*., two large vessels destined to pelvic limbs. After the origin of *External Iliacs Aa*., aorta undergoes drastic reduction of caliber and follows caudally by short distance and emits terminal branches, being laterally to *Internal Iliac Aa*. e median the *Median Sinsacral a*. The *Internal iliac Aa*. are intended for structures of pelvic cavity, while *Medial Sinsacral* trifurcates in flowing branches that follow caudally on ventral surface of sacrificial. This condition is observed in other animals: horses, cattle and swine **[28]**, cats **[46]** and dog **[47]**. The internal Iliac emerges at the same level following caudolaterally into pelvis, in agreement with the descriptions of Tatu Galinha (*Dasypus novencinctus*) **[48]**; however, in some animals was observed that *External Iliac* branched to *Internal iliac a*., where *Median Sacral a*. is a branch of *Left Internal iliac a*.. In Gambá **[49]** and Nutria **[25]** is described a formation of a common trunk between *Internal* and *External Iliac Aa*., at the same level of *Internal Iliac Aa*. that born from Aorta, dorsally to *Median Sinsacral a*. and paired by two Lateral Sinsacral Aa., following then in direction to the tail.

V. CONCLUSION

The present study demonstrated by unprecedentedly relates that *Abdominal Aorta* of Tatu Peba (*Euphractus sexcinctus*) presents smaller number of branches, different from other mammals. When compared to other components of Xenarthras Superorder and great similarity with regard to number and vascular distribution. Thus, this work contributes to anatomical description and understanding of an important blood vessel in Tatu Peba biological system.

VI. COLABORATORS

Thalles Anthony Duarte Oliveira, Kadija Mohamed Santee, Tarley Santos Oliveira, Vinícius Gonçalves Fontoura and Bruna Silva Lopes were responsible for acquisition, analysis and interpretation of data.

Thiago Sardinha de Oliveira, Roseâmely Angélica de Carvalho Barros and Zenon Silva were responsible for concept, design and preparation of manuscript.

All authors read and approved the final version of manuscript.

CONFLIT OF INTESREST

The authors declare no conflicts of interest associated with this manuscript.

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