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Adrenal Glands of *Chinchilla lanigera* - Study of Anatomical Features with Computed Tomography and Magnetic Resonance Imaging

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ABSTRACT

***Background*:** Since chinchilla (*Chinchilla lanigera*) is frequently used as a laboratory animal, satisfactory data about the imaging anatomical appearance of its adrenal glands, such as their anatomical location and closeness with other abdominal soft tissue and vessels, are important. The aim of this study to determine anatomical features of the chinchilla adrenal gland's using computed tomography and magnetic resonance imaging.

***Materials, Methods & Results*:** We used 12 chinchillas (6 males and 6 females), aged 18 months. The animals were in supine recumbency when contrast-enhanced computed tomography (CT) was performed. Transverse, sagittal and dorsal images of the adrenal glands were obtained with iodinated contrast medium, and 3D reconstruction of the obtained images was applied. The craniocaudal (CrCc - length), dorsoventral (DV - height) and lateromedial (LM - width) diameters were measured using an electronic calliper. Magnetic resonance imaging was performed, and coronal T1-weighted images were obtained. The transverse CT anatomical image at the level of the 3rd lumbar vertebra demonstrated the location of the both adrenal glands in accordance with the grey-white scale's variation. The right adrenal gland was hypo-attenuated and elliptic compared to the right kidney and in close contact to it and to the caudal vena cava. The left adrenal gland was oval and at a distance to the abdominal aorta. The dorsal MRI anatomical study of the chinchilla's abdominal organs at a distance of 10 mm from the spine and in a T1-weighted sequence showed that both adrenal glands were retroperitoneal organs.

***Discussion*:** Post-contrasted CT defined the topography of both glands. The right adrenal gland has an oval shape and is cranially situated to the left gland, whose shape is cylindrical and elongated. The LM diameter of the right gland is higher than that measured in the left gland. Both DV and CrCc diameters of the right gland are lower compared to those of the left gland. The right adrenal gland is in close contact to the caudal vena cava, the right kidney and the liver, and the left adrenal gland is in a distance to the abdominal aorta. The right adrenal gland was close to the caudal vena cava and the right kidney and medially to the left kidney. The successful comparative analysis of the images in 3D reconstruction and post-contrast CT in 2D allowed us to conclude that 3D reconstruction is suitable to obtain detailed information in a summary form regarding the closeness of the glands and their shape, mainly because the results are in a real time and highly comprehensive. Our data are in in agreement with previous findings about the advantages of 3D reconstruction. The research algorithm applied was based on the dorsal visualization of the glands in T1-weighted sequence, achieving a comprehensive and high-quality MRI imaging of the examined organs in chinchillas. Both adrenal glands were retroperitoneal organs and with low signal. The dorsal MRI anatomical study of the chinchilla's abdominal organs at a distance of 10 mm from the spine and in a T1-weighted sequence showed the whole profile of the right and left glands and the cranial position of the right gland to the left one, the close contact between the right gland and the kidney and the distance between the left gland and the left kidney. The MRI results are detailed and comprehensive for interpretation. In conclusion, the results of the present study are comprehensive, detailed and with high resolution. We present data for the anatomical relationships of the studied organs, their shape and macrometric parameters, concluding that the above mentioned modalities are very important tools for studying the chinchilla's adrenal glands to create a morphological base, which is necessary to investigate specific diseases.

Keywords: adrenal glands, chinchilla, CT, imaging anatomy, MRI, 3D reconstruction

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INTRODUCTION

Computed tomography (CT) methods are widely used in non-clinical basic research to study anatomical objects that are individually specific [1,4]. For example, the adrenal glands of chinchillas are enveloped by adipose tissue and located above the kidneys. The right adrenal gland is elliptic and situated medial to the cranial extremity of the right kidney, close to the caudal vena cava, whereas the left one is cylindrical and located medial to the left kidney [20].

The results of CT are used as a base to differentiate normal parameters of the studied organs from pathological alterations [1,5,6]. Post-contrast CT is preferred to investigate the imaging anatomic features of the glands because the glands' boundaries are sharply distinguished form the adjacent soft tissues. Recently, imaging modalities such as CT and magnetic resonance imaging (MRI) have been widely used to investigate the morphologic specifics of adrenal gland lesions [7,13,15].

In MRI, the normal appearance of the glands on T1- and T2-weighted imaging is with low or moderate intensity of the adrenal structures. It is a non-invasive method which is available to differentiate acute from chronic alterations and adenoma from metastases [3].

The aim of the present study was to describe the morphological specifics of the adrenal glands in a live aspect with computed tomography and magnetic resonance imaging, using the chinchilla as the model animal. As the chinchilla is frequently used as a model animal, obtaining reliable data on the imaging anatomical appearance of the animal's adrenal glands, such as their anatomical location and closeness with other abdominal soft tissue and vessels, is of high priority.

MATERIALS AND METHODS

Materials

We used 12 chinchillas (6 males and 6 females), aged 18 months and with a body weight of 0.6 kg. The chinchillas were housed in stainless-steel cages in a controlled environment at temperatures of 20 to 25°C with a 12:12-h light-dark cycle. The animals were fed a standard pellet diet and water *ad libitum*. The chinchillas were clinically healthy.

CT algorithm

While being in supine recumbency, the animals were anaesthetised intramuscularly with tiletamine hydrochloride and zolazepam hydrochloride [Zoletil®[1] - 15 mg/kg]; a 16-row multi-slice spiral CT scanner[2] was used, with a space between slices of 1 mm. Transverse, sagittal and dorsal images of the adrenal glands were obtained with iodinated contrast medium Iohexol [Omnipaque®[3] - 2 mg/kg], which was administered manually through the jugular vein. The CT sections were obtained after a 10 s waiting period, and the 3D reconstruction of the obtained images was applied. The shape of the adrenal glands was investigated, and the dorsal plane was accepted as the most objective one [12].

The craniocaudal (CrCc - length), dorsoventral (DV - height) and lateromedial (LM - width) diameters were measured using an electronic calliper, and the obtained values were accurate to the second sign. Descriptive analysis of the results was performed using Statistica 8 - StatSoft DELL.

MRI algorithm

Magnetic resonance imaging was performed with a 1.5 T MRI system[4]. Axial T2-weighted images were obtained (TR: 3,027 ms, TE: 100 ms, slice thickness: 2 mm, spacing between slices: 2.7 mm), along with axial and coronal T1- and T2-weighted images (TR: 597 ms, TE: 15 ms, slice thickness: 2 mm, spacing between slices: 2.7 mm) [12]. The CT and MRI images were analysed with an FDA-approved software programme[5].

Statistical analysis

Statistical analyses were performed using the SPSS software, v. 19.0, for Windows. The data are reported as means and standard deviations. One-way analysis of variance (ANOVA) was used to compare right-left LM diameter (width), DV diameter (height) and CrCc diameter.

RESULTS

The transverse CT anatomical image at the level of the 3rd lumbar vertebra (L3) demonstrated the location of the both adrenal glands in accordance with the grey-white scale's variation. The right adrenal gland was hypo-attenuated elliptic compared to the right kidney and was in close contact to it and to the caudal vena cava. The left adrenal gland had an oval shape and was in a distance to the abdominal aorta. Its attenuation was similar to that of the spleen. This level of the scan

did not determine the anatomical relationship between the left adrenal gland and the left kidney (Figure 1).

The post-contrasted CT coronal (dorsal) study at the level of the plane at a distance of 10 mm from the spine defined the topography of both glands. The right adrenal gland was cranially situated to the left gland and was hypo-attenuated compared to the right kidney and medially situated to it. The left adrenal gland was located at a distance to the left kidney as its attenuation was lower than that of the corresponding kidney. The right gland had an oval shape, and the left one was cylindrical elongated (Figure 2).

The LM diameter (width) of the right adrenal gland of the chinchilla was 3.97 ± 0.25 mm, whereas that of the left adrenal gland was lower 3.50 ± 0.18 mm. This difference was statistically significant (P = 0.045). The DV diameter (height) of the right adrenal gland was 3.01 ± 0.11 mm, whereas that of the left one was 3.67 ± 0.15 mm. This difference was statistically significant (P = 0.037). The CrCc diameter of the right adrenal gland was 3.87 ± 0.21 mm, whereas that of the left one was significantly greater at 5.24 ± 0.08 mm (P = 0.021; Figure 3).

The 3D coronal reformat image demonstrated the anatomical location of both adrenal glands in the abdominal cavity. The right adrenal gland (in violet) was situated close to the right kidney and touched it; its shape was sharply distinguished and oval to elliptic. The left adrenal gland (in violet) was elongated and cylindrical; it was in visible distance and craniomedially orientated to the left kidney (Figure 4).

The dorsal MRI anatomical study of the chinchilla's abdominal organs at a distance of 10 mm from the spine and in a T1-weighted sequence showed that both adrenal glands were retroperitoneal organs with low signal. The contours of the glands defined the ellipsoid shape of the right gland and the elongated cylindrical shape of the left one. The left and right glands were isosignal to the right and left kidneys. The right adrenal gland was located craniomedially to the right kidney and had anatomical contact with the liver. The left one was situated craniomedially to the left kidney. The distance between the left gland and the kidney was visible as the right adrenal gland was closely situated to the right kidney (Figure 5).

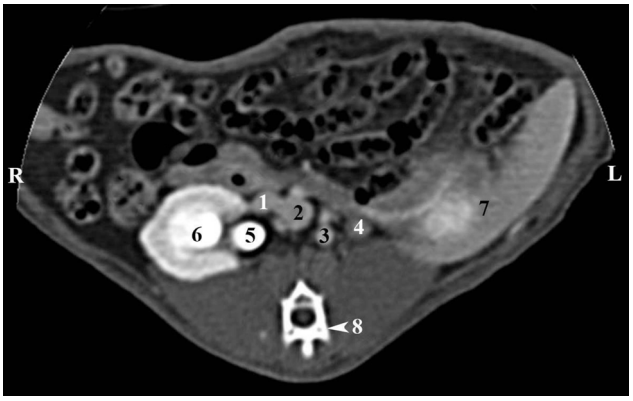

Figure 1. Transverse CT anatomical image at the level of L3 in a chinchilla. R: Right; L: Left. 1- Right adrenal gland; 2- Caudal vena cava; 3- Abdominal aorta; 4- Left adrenal gland.

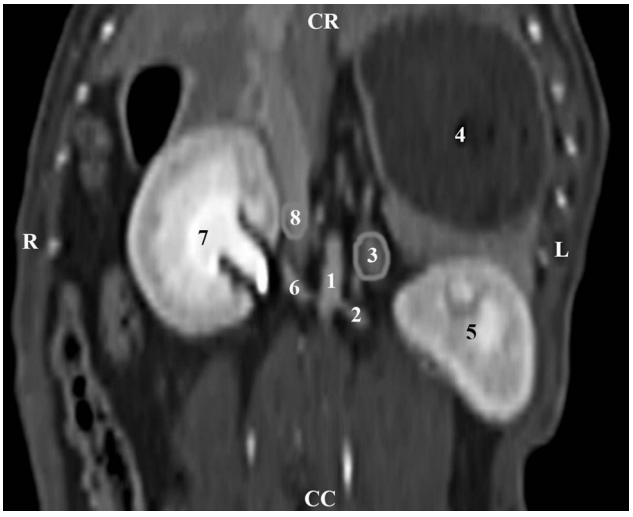

Figure 2. Post contrast CT coronal study at the level of the plane at a distance of 10 mm from the spine in a chinchilla. CR: Cranial; CC: Caudal; R: Right; L: Left. 1- Abdominal aorta; 2- Left renal artery; 3- Left adrenal gland; 4- Stomach; 5- Left kidney; 6- Right renal artery; 7- Right kidney; 8- Right adrenal gland.

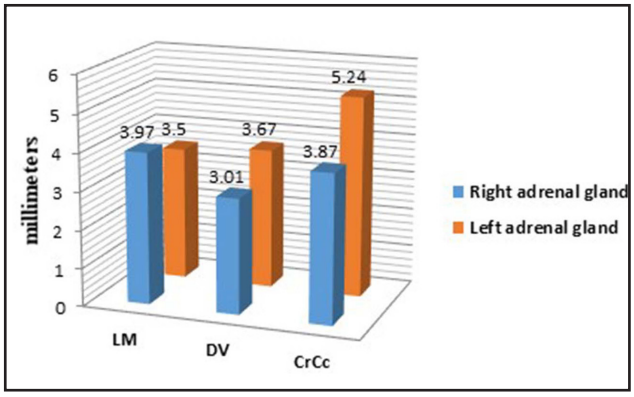

Figure 3. Macrometric parameters of chinchilla's adrenal gland. The craniocaudal (CrCc - lenght), dorsoventral (DV - height) and lateromedial (LM - width).

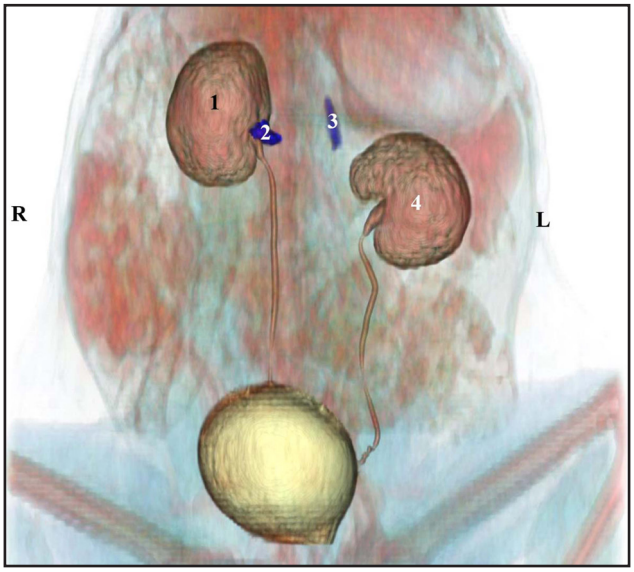

Figure 4. Coronal 3D reformat image. R: Right; L: Left. 1- Right kidney; 2- Right adrenal gland; 3- Left adrenal gland; 4- Left kidney.

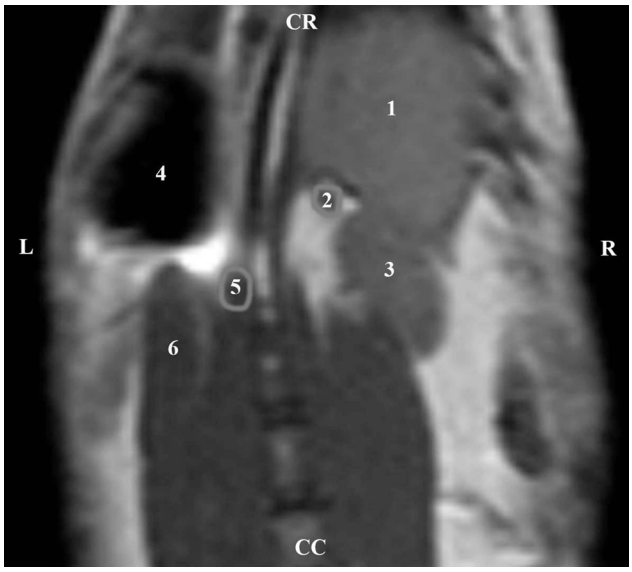

Figure 5. Dorsal MRI anatomical study of the chinchilla's abdominal organs at a distance of 10 mm from the spine and in a T1-weighted sequence. 1- Liver; 2- Right adrenal gland; 3- Right kidney; 4- Stomach; 5- Left adrenal gland; 6- Left kidney.

DISCUSSION

The obtained imaging anatomical results could be used as a morphological base to define the physiological state of the adrenal glands in chinchillas and to diagnose diseases such as the "chew fur" syndrome and Cushing's syndrome [16,18,19]

The post-contrasted CT study defined the topography of both glands. According to our findings, the right adrenal gland has an oval shape and is cranially situated to the left gland, whose shape is cylindrical and elongated. Our results regarding the position of the left gland toward the left kidney (in a distance to it) correspond to the published data for the rabbit adrenal glands [3,4]. In addition, we defined the macrometric parameters of the right and left adrenal glands in chinchillas and assume that the LM diameter of the right gland is higher than that measured in the left gland. Our statistical results show that the DV and CrCc diameters of the right gland were lower compared to those of the left gland.

We claim that the right adrenal gland is in close contact to the caudal vena cava, right kidney and the liver, and the left adrenal gland is in a distance to the abdominal aorta. In agreement to published data on the adrenal glands of the donkey [8], we propose the use of vascular structures and some abdominal organs, such as the liver, as anatomical landmarks to determine the topography of the studied glands.

Our results demonstrate the anatomical localisation of the right adrenal gland close to the caudal vena cava and the right kidney and medially to the left kidney, supporting the theory for the topography of both glands in chinchilla [20].

The presented post-contrast CT information, which characterises the topography, shape and anatomical features of the adrenal glands, supports the use of CT as a method for anatomical studies in the chinchilla. We therefore highlight the post-contrast CT study as a definitive method to investigate the soft tissue characteristics of the chinchilla's adrenal glands. Our findings support previous suggestions [1,4,6] for the use of CT anatomical results as a morphological base.

We propose CT as a suitable imaging modality to study the morphologic features and macrometric specifics of the adrenal glands in chinchillas because the gland boundaries can be well visualised and are sharply distinguished form the adjacent soft tissues. The coronal CT study is available when investigating the shape of both glands (the right one with an oval shape and the left one with a cylindrical, elongated shape). This is in agreement with published data for the application of post-contrast CT in cats [13].

We claim that the post-contrast transverse and coronal CT study of the chinchilla's adrenal glands is appropriate for a detailed imaging anatomical analysis of the macrometric parameters of the organs, their relationships and soft tissue specifics because of the high resolution of the images. These facts provide reason to supplement the opinions on the use of CT in humans and dogs [2,14,15,17].

The successful comparative analysis of the images in 3D reconstruction and the post-contrast CT study in 2D allowed us to conclude that 3D reconstruction represents a detailed information in a summary form, regarding the closeness of the glands and their shape, because they are in real time and highly comprehensive. Therefore, our data about the advantages of 3D reconstruction when studying the adrenal glands of chinchillas complement previous findings [10,11].

In our opinion, the research algorithm applied in this study, which was based on dorsal visualisation of the glands in T1-weighted sequence, can achieve a comprehensive and high-quality MRI imaging of the examined organs in chinchillas. Both adrenal glands were retroperitoneal organs and with low signal. At the same time, we describe their anatomical position toward both kidneys and the relationship of the right adrenal gland with the liver, corresponding to MRI studies of the adrenal glands in humans [3].

The dorsal MRI anatomical study of the chinchilla's abdominal organs at a distance of 10 mm from the spine and in a T1-weighted sequence showed the whole profile of the right and left glands and the cranial position of the right gland to the left one, the close contact between the right gland and the kidney and the distance between the left gland and the left kidney. The MRI results were detailed and highly comprehensive, which leads us to infer that in this aspect, both glands are visible. Our results differ in some aspects from the data obtained in an MRI study of the adrenal glands of dogs, in which the right gland was not highly visible [9].

CONCLUSIONS

The results of the present study using post-contrast CT, 3D reconstruction and MRI are comprehensive, detailed and with high resolution. We present data for the anatomical relationships of the studied organs, their shape and macrometric parameters. Therefore, we can conclude that the above mentioned modalities are very important tools for studying the chinchilla's adrenal glands to create a morphological base, which is necessary to investigate specific diseases.

MANUFACTURERS

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***Ethical approval*.** The study protocol was approved by the Animal Ethics Committee for University of Burdur Mehmet Akif Ersoy, (14.10.2021 Date, Number 76895-819).

***Declaration of interest*.** The authors declared that there is no conflict of interest. The authors alone are responsible for the content and writing of the paper.

REFERENCES

1 **Cardozo L., Gil F. & Ramírez G. 2007.** Computed tomography (CT) of the lungs of the dog using a helical CT scanner, intravenous iodine contrast medium and different CT windows. *Anatomy Histology and Embryology*. 36: 328-331.

2 **Chen L., Zeng X., Li S., Gong C., Peng E., Wu B., Zhang W. & Zhang Y. 2016.** Evaluation of a large adrenal carcinoma with 3D reconstruction of computed tomography images: A case report and literature review. *Journal of X-Ray Science and Technology*. 24: 665-671.

3 **D'Amuri F.V., Maestroni U., Pagnini F., Russo U., Melani E., Ziglioli F., Negrini G., Cella S., Cappabianca S., Reginelli A., Barile A. & De Filippo M. 2019.** Magnetic resonance imaging of adrenal gland: state of the art. *Gland Surgery*. 8: 223-232.

4 **Dilek O.G., Dimitrov R.S., Stamatova-Yovcheva K.D., Yovchev D.G. & Mihaylov R. 2019.** Importance for experiments in human medicine of imaging modalities for macroanatomical and histological study of rabbit suprarenal glands. *Medycyna Weterynaryjna*. 75: 684-692.

5 **Dilek Ö.G., Erden H., Turan E., Dimitrov R., Stamatova-Yovcheva K. & Karakurum E. 2020.** The qualitative and quantitative assessment of the renal cortex of the clinically healthy rabbits. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*. 67: 381-386.

6 **Groell R., Machan L., Schaffler G.J., Uggowitzer M. & Peichel K.H. 1997.** Morphometric measurement of abdominal organs. Comparison of ultrasound and spiral CT. *Acta Radiologica*. 38: 982-985.

7 **Herr K., Muglia V.F., Koff W.J. & Westphalen A.C. 2014.** Imaging of the adrenal gland lesions. *Radiologia Brasileira*. 47: 228-239.

8 **Karakurum E., Özgel Ö. & Dursun N. 2008.** Morphology and arterial vasculature of donkey (*Equus asinus* L.) adrenal gland. *Turkish Journal of Veterinary and Animal Sciences*. 32: 469-473.

9 **Llabres-Diaz F. & Dennis R. 2005.** Magnetic Resonance Imaging of the presumed normal adrenal glands. *Veterinary Radiology and Ultrasound*. 44: 5-19.

10 **Luccichenti G., Cademartiri F., Pezzella F.R., Runza G., Belgrano M., Midiri M., Sabatini U., Bastianello S. & Krestin G.P. 2005.** 3D reconstruction techniques made easy: know-how and pictures. *European Radiology*. 15: 2146-2156.

11 **Maher M., Kaira M., Sahani D., Perumpillichira J.J., Rizzo S., Saini S. & Mueller P.R. 2004.** Techniques, clinical applications, and limitations of 3D reconstruction in CT of the abdomen. *Korean Journal of Radiology*. 5: 55-67.

12 **Mai W., Dennis R. & Paek M. 2018.** Abdominal MRI. In: Mai W. (Ed). *Diagnostic MRI in Dogs and Cats*. Boca Raton: CrC Press, Tylor and Francis Group, pp.723-752.

13 **Mallol C., Altuzarra R., Espada Y., Restrepo M.T., Serrano E. & Novellas R. 2019.** CT characterisation of feline adrenal glands. *Journal of Feline Medicine and Surgery*. 22: 285-291.

14 **Moal J.L., Peillon C., Dacher J.N. & Baste J.M. 2018.** Three-dimensional computed tomography reconstruction for operative planning in robotic segmentectomy: a pilot study. *Journal of Thoracic Disease*. 10: 196-201.

15 **Pineiro M.I.R, de Fornel-Thibaud P., Benchekroun G., Garnier F., Maurey-Guenec C., Delisle F. & Rosenberg D. 2011.** Use of computed tomography adrenal gland measurement for differentiating acth dependence from acth independence in 64 dogs with hyperadenocorticism. *Journal of Veterinary Internal Medicine*. 25: 1066-1074.

16 **Ponzio M.F., Monfort S.L., Busso J.M., Carlini V.P., Ruiz R.D., Fiol de Cuneo M. 2012.** Adrenal activity and anxiety-like behavior in fur-chewing chinchillas (*Chinchilla lanigera*). *Hormones and Behaviour*. 61: 758-762.

17 **Simone P., Diana A., Toaldo M.B., Cipone M., Quinci M. & Pey P. 2021.** CT measures of adrenal gland length and caudal pole diameter are reproducible in large breed dogs: A pilot study. *Veterinary Radiology and Ultrasound*. 62: 402-412.

18 **Spotorno A.E., Zuleta C.A., Valladares J.P. Deane A. & Jimenez J.E. 2009.** *Chinchilla lanigera*. *Mammalian Species*. 758: 1-9.

19 **Vanjonack W.J. & Johnson H.D. 1973.** Relationship of thyroid and adrenal function to "fur-chewing" in the chinchilla. Comparative Biochemistry and Physiology. *A Comparative Physiology*. 45: 117-120.

20 **Wright D.V. 1969.** Observations on the gross and histological morphology of the chinchilla kidney. 12p. Tucson, United States. Master Thesis - Department of Biological Sciences, in partial fulfilment of the requirements for the degree of Master of Science with a major in zoology. Graduate College, The University of Arizona.