Anatomical Study of the Cerebral Hemispheres in the Chinchilla (*Chinchilla lanigera*)

Irina IRIMESCU*[1], Adriana CHENDE[1], Florin GHIURCO[1], Aurel DAMIAN[1]

[1] Faculty of Veterinary Medicine, University of Scientific Sciences and Veterinary Medicine, 3-5 Calea Manastur, 400372, Cluj-Napoca, Romania; *irina.irimescu@yahoo.com

Bulletin UASVM Veterinary Medicine 71 (1) / 2014, 130-136
Print ISSN 1843-5270; Electronic ISSN 1843-5378

Abstract

Taking into consideration the growing importance of this species in the field of neurology research, we have aimed to provide extensive data on the gross morphology of the *Chinchilla lanigera's* cerebral hemispheres. The data was compared to the general features of the rodent brain extracted from literature. Five bodies of *Chinchilla lanigera*, three females and two males, all adults were used in order to obtain cerebral samples. Each segment of the cerebral hemispheres was examined macroscopically, both intact and on seriate sections, in order to register it external features, as well as its internal structure. The examination was performed on both fresh samples and after treating them with a buffered solution of formaldehyde. Gross measurements were also performed, but without the intent of statistical processing. The cerebral hemispheres of the Chinchilla are lissencephalic, and decrease in girth in the oral direction, presenting each a triangular surface. The internal optostriate bodies are well developed and clearly differentiated form the cortex, but the individual cerebral nuclei are hard to distinguish macroscopically, visible as a common gray mass. The most prominent inter-hemispherical segment is the *corpus callosum*, easily underlined by longitudinal sections of the cerebrum, subjacent of the cortex. We have also been able to identify the main ventricular cavities of the cerebrum: the first and second ventricles. The cerebral hemispheres of the Chinchilla retain the main characteristics of the rodent brain. All the common segments were identified and found to closely resemble either the rabbit, or the rat brain, in various proportions.

Keywords:
Chinchilla lanigera, cerebral hemispheres, gross morphology

INTRODUCTION

The Chinchilla is a nocturnal South American rodent adapted to the high altitudes of the Andes (Mohlis, 1983; Sciama, 2001). The majority of authors recognize two feral species: *C. chinchilla* and *C. lanigera* (Jhonson-Delaney and Harrison, 1996; Jimenez, 1996; Spotorno *et al.*, 2004; Woods *et al.*, 2005; Stekelorom-Parmentelat, 2006) which have been combined into the domesticated Chinchilla currently encountered in husbandries, with a predominance of the *C. lanigera* characteristics. The Chinchilla has been long exploited for the exceptional qualities of its fur and became an appreciated house pet. Research has also underlined a particularly well developed middle ear and a three-chambered tympanic bulla (Bennet, 1835 cited by Spotorno *et al.*, 2004) allowing easy surgical access. Several similitudes in auditive sensitivity and cochlear structure between this rodent and humans have been underlined, as well as a high resilience to internal and medium ear infections in the former (Hrapkiewich *et al.*, 1998), thus promoting an interest in using this species as an experimental laboratory model for a number of studies in the field of hearing and auditive cortex.

Creating experimental models in the field of neurology with all of its sub branches demands a detailed anatomical knowledge of gross morphology of the central nervous system of the species involved. This goal has been attained for the main laboratory rodent species, the rat, in extensive studies such as “The Rat Nervous System” (Paxinos, 2004) or “The Rat Brain in Stereotaxic Coordinates” (Paxinos and Watson, 2007). Following the scarcity regarding neuroanatomical data on *C. lanigera* in both local and international literature, this study offers a detailed description of the gross anatomy of the cerebral hemispheres and their adjacent structures in this species, following both surface description and seriate cuts through the cerebrum.

MATERIALS AND METHODS

The research has been carried out in the Comparative Anatomy Laboratory of the Faculty of Veterinary Medicine of Cluj-Napoca, on five bodies of adult Chinchillas (*C. lanigera*), three females and two males. The cerebrum was extracted through a standard dissection technique of skullcap removal. The samples were treated and examined using two approaches: two samples were examined and measured immediately after the extraction, followed by fixation using a 10% neutral buffered formaldehyde solution (Fig.1A and 2A).

For the other three samples, the skullcap was removed and the entire skull piece immersed in the same formaldehyde solution for one hour, prior to the complete extraction, examination and measuring of the cerebrum (Fig.1B and 2B).

The measurements where made with electronic calipers (measuring range 0-150 mm; accuracy 0,01mm). Due to the nature of nervous tissue, these measurements were regarded as general guidelines and did not constitute the subject of statistical analysis.

Macroscopic examinations of the external conformation of the cerebrum where made, followed by transversal and horizontal seriate cuts through the cerebrum. Parallel to the examination, all samples were photographed using a Nikon DX90 digital camera.

The use of the 10% neutral buffered formaldehyde was not only intended for enhancing of the consistence of the samples and thus facilitating the examination, but also for further histological processing of the sections.

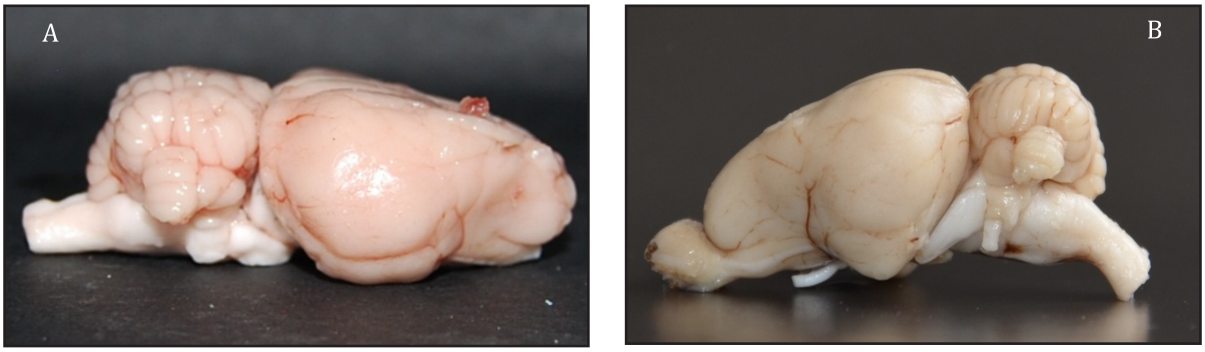

Fig.1 Lateral view of the encephalon extracted before (A) and after (B) formaldehyde fixation.

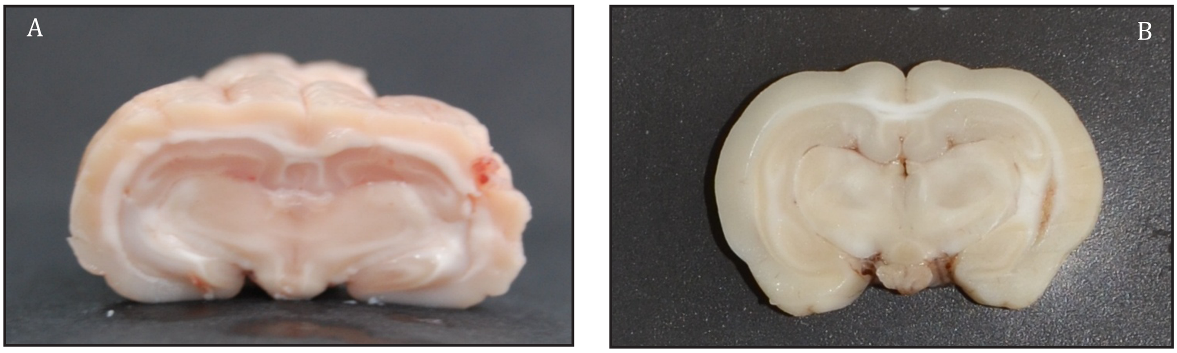

Fig. 2 Transverse cut through the encephalon extracted before (A) and after (B) formaldehyde fixation.

RESULTS AND DISCUSSIONS

The overview assessment of the cerebral hemispheres of the *C. lanigera* prior to detailed inspection reveals as expected that this species conforms to the norm of mammalian cerebral structuring as described in the literature. They represent the highest degree of nervous structuring and occupy most of the volume of the encephalon (Barone and Bortolami, 2004). Their surface is protected by the meninges, which folds in-between the longitudinal fissure and the two symmetrical bodies are connected to each other and to the subjacent segments through a series of structures (Damian, 2011). They are phylogenetically comprised of the rhinencephalon the basal ganglia and the neopallium (Gheție *et al.,* 1956).

The main feature noticeable immediately after the removal of the skullcap and the meninges is the smooth surface of the *C. lanigera*'s cerebral hemispheres, completely devoid of circumvolutions. This aspect is representing a lissencephalic type of central nervous system (Barone and Bortolami, 2004) in accordance with the common neuroanatomical traits of the *Rodentia* order, meaning a cortex with a smaller total surface than in other mammals. The various measurements taken during the examination of the samples are detailed in the table no.1 below. The low natural consistency of the encephalon as well as the contraction caused by the formaldehyde solution during the fixation induces shape and variations that make the data usable for gross assessment only. Values are presented in centimeters.

Tab. 1 Individual and mean values of various measurements of the *Chinchilla lanigera* encephalon

	Experimental group of *C. lanigera*					
	C1	C2	C3	C4	C5	Mean values (cm)
Sex	M	M	F	F	F	
Total bodyweight (g)	557,14	484,96	425,89	563,44	553,71	517,02
Total body length (cm)	43,3 0	37,20	43,00	39,15	44,70	41,47
Total encephalon length (cm)	4,21	3,18	3,78	3,56	3,92	3,73
Total encephalon width (cm)	2,31	2,50	2,57	2,73	2,53	2,53
Medulla oblongata length (cm)	1,20	0,76	0,89	0,91	0,77	0,91
Medulla oblongata width (cm)	1,16	1,02	1,03	1,20	1,04	1,09
Cerebellum length (cm)	1,52	1,33	1,35	1,48	1,59	1,46
Cerebellum width (cm)	2.03	1,85	1,95	1,76	1,99	1,91

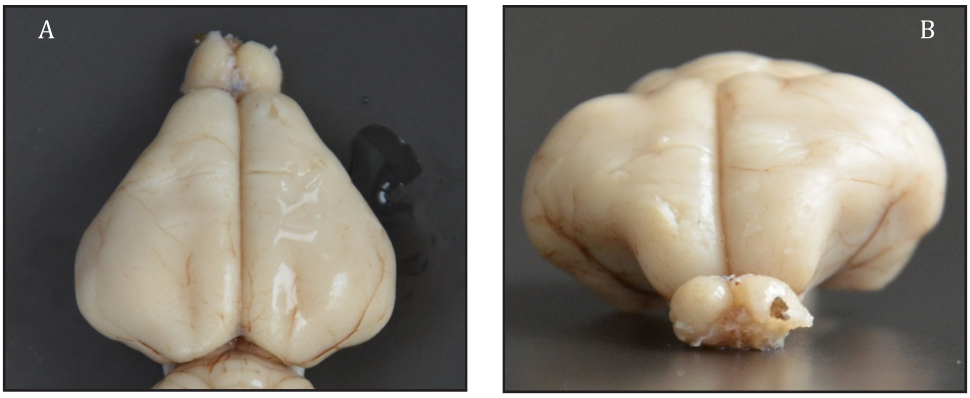

Fig. 3 Cerebral hemispheres - dorsal view (A) and cranial view (B)

Assessed from a dorsal perspective, the two hemispheres reach their maximal width near the aboral extremity and progressively narrow orally, creating the shape of two triangles with caudal bases (Fig. 3A). The longitudinal fissure is framed on each side by a dorsal longitudinal slight protrusion of the hemispheres. These elevations are underlined by a shallow lateral groove, precursor of the suprasylvian groove, visible for the most in the aborally segment of the hemispheres (Fig. 3A and 3B). The hemispheres, together with the other segments they are attached to, have a slightly curved profile, with a dorsal convexity. From this lateral perspective, it is also noticeable that the olfactory bulbs are big, well developed, and surpass the anterior limit of the hemispheres. They take a position slightly oblique in the oro-dorsal direction (Fig. 4A). Their oro-ventral surface present, even after the extraction from the cranial cavity, multiple nerve fibers, comprising the apparent origins of the first pair of cranial nerves, the olfactory nerves (Fig. 4A and 4B).

The olfactory bulbs are continued by the rest of the rhinencephalon, which dominates the ventral face of the cerebrum. This constitutes in all mammals the oldest phylogenetic segment of the telencephalon, especially prominent in rodents (Fig. 4B). From a ventral perspective, the olfactory bulbs are seen decreasing in width toward their base, continued each by a short but thick olfactory peduncle. This splits into two olfactory striae. Each lateral olfactory stria is thin and long, while the medial striae are very narrow and rather hard to highlight. The two olfactory trigones that the olfactory stripes delimit are well developed and very elongated. The oro-lateral rhinal fissure begins on the sides of the olfactory peduncles and closely follows the lateral striae. It is well marked in its oral segment and in the vicinity of the pyriform lobe, while its middle segment is shallow, less obvious.

The pyriform lobes are well developed, round, prominent on the ventral sides, covering in the aboral direction a large segment of the cerebral peduncles and of the optic tracts (Fig. 4B). Their lateral borders are separated from the fronto-parietal region of the cerebral hemispheres by a small shallow groove. The ventral side of the cerebral hemispheres also presents elements belonging to the mezencephalon and the diencephalon: the cerebral peduncles and part of the hypothalamus accompanied by the hypophysis. The cerebral peduncles of the *C. lanigera* are easily identifiable, thick white matter columns, strongly divergent in the oral direction (Fig. 5B). Their aboral ends stem from the pons and their large latero-anterior extremities are covered by the pyriform lobes. They enclose a large interpeduncular fossa. The ventral face of the peduncles present in the middle the apparent origin of the third pair of cranial nerves - the oculomotor nerves.

The diencephalon is also visible on the ventral face of the cerebral hemispheres by the elements housed by the interpeduncular fossa. The latter is covered by an ovoid shape - the pituitary gland of the *C. lanigera* (Fig. 5A). After the removal of the

Fig. 4 Cerebral hemispheres - lateral view (A) and ventral view (B).

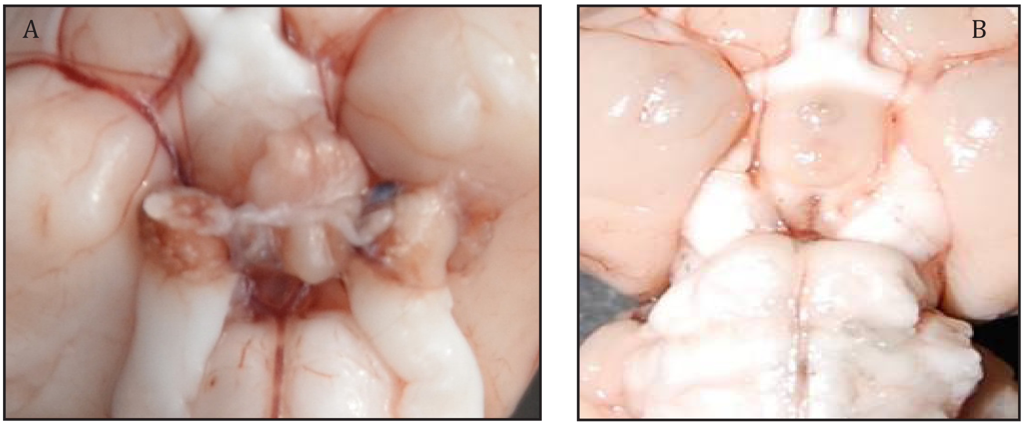

Fig. 5 Hypophysis - ventral view (A); cerebral peduncles and hypothalamus (B).

gland, the interpeduncular fossa becomes visible. It contains a round prominence with a gray hue: the tuber cinereum (Fig. 5B) with a central mark for the insertion of the pituitary stark.

Posterior to the tuber cinereum there lays another round structure of lighter color - the mammillary body. Both structures are well developed compared to the small size of the Chinchilla's encephalon. The oral border of the fossa is lined by the two optic tracts merging into the optic chiasma and generating the optic nerves. Due to the structure of the neopallium and of its subjacent elements, a large number of elements could only be examined through cuts made at different levels through the cerebral hemispheres. A horizontal cut along the middle horizontal plane of the cerebrum reveals the inner structures of the cerebral hemisphere. There is a clear limit between the layers of the cortex and the subjacent elements.

The basal nuclei, part of the optostriate bodies, are present. They are placed antero-laterally to the contour of the thalamus. It is difficult to differentiate them macroscopically. Their surface appears as a less or more compact mass of grey mater, striped with white fibers (Fig.6). The ventral part of the hippocampus is also visible, placed latero-aborally to the thalamic prominence, following the section through Ammon's horn. It is separated by a clear white matter stria from the cerebral cortex, representing the aboral ending of the corpus callosum.

Further details were revealed by practicing seriate transverse cuts though the encephalon. Figure 7 indicates the positioning of four main cuts, which are presented below, in the following images.

Fig. 6 Horizontal cut of the right cerebral hemisphere.

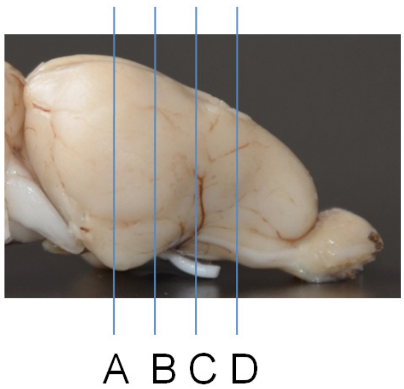

Fig. 7 Positioning of the main transverse cuts through the cerebral hemispheres.

All sections show the exterior border of the hemispheres lined by a homogenous cerebral cortex. The dorsal limit of the sections presents a clear white line separating the cortex from the inner structures, passing from one hemisphere to

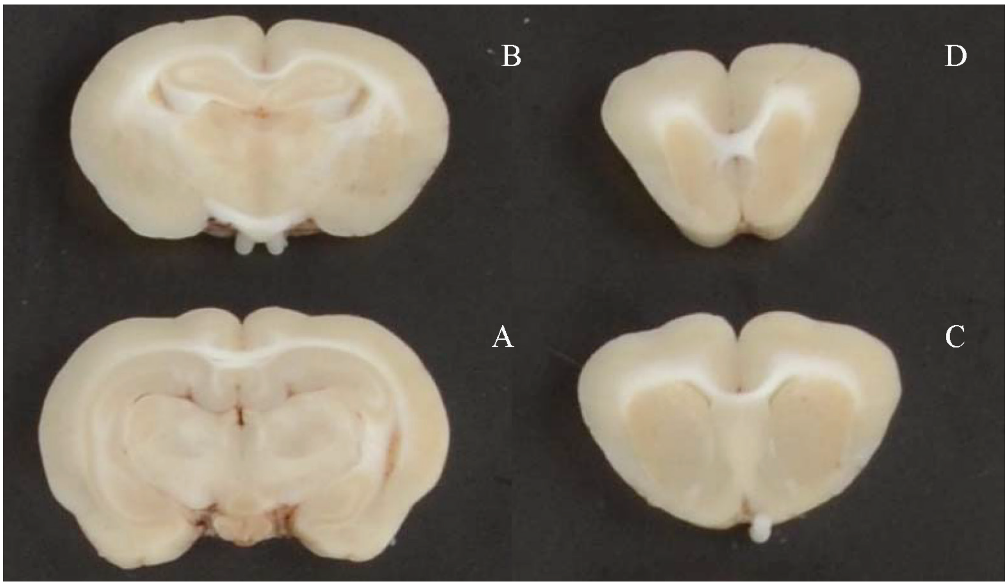

Fig. 8 Transverse cuts through the cerebrum: A - at the middle of the pyriform lobes; B - at the level of the optic chiasma; C - at the oral limit of the pyriform lobes; D - at the middle of the olfactory trigons.

the other in the median line. This is a successive view of the corpus callosum (Fig. 8A, 8B, 8C and 8D).

On one side and the other of the median plane, the centre of the sections is occupied by a common grey matter mass corresponding to the caudate nucleus and the putamen (Fig. 8C and 8D). In the aboral sections, these nuclei are progressively pushed laterally by the central emergence of the thalamus (Fig. 8B and 8A). The aboral cuts (Fig. 8A and 8B) show, subjacent to the corpus callosum, the appearance of the hippocampus and the curved ventro-posterior orientation of the Ammon's horns. The cuts also reveal the part of the ventricular system lodged into the cerebrum - the first and second ventricles. Their oral extremity has a medio-horizontal placement shown in figure 8C, jus under the corpus callosum. Caudally, they maintain their horizontal position and expand laterally, while displaying a much-reduced volume (Fig. 8A and 8B). Figure 8A also shows on the median plane the beginning of the third ventricle in between the two masses of the thalamus.

By comparing both the external conformation and the internal structure of the cerebral hemispheres of the *C. lanigera* to those of the laboratory Rat and of the Rabbit, as described in literature, it is conclusive that they show the same lissencephalic character common to the orders *Rodentia* and *Lagomorpha*.

The similitudes in details, however vary, approaching the Chinchilla to either one of the aforementioned species. For instance, it is noticeable that the shape of the cerebral hemispheres of the Chinchilla is closer to that of the Rabbit, presenting the same narrowing of the oral segment (Barone and Bortolami, 2004), while the Rat has a much rounder aoral extremity of the cerebrum (PAXINOS, G., 2004). The seriate cuts have shown many similitudes of internal structure between the *C. lanigera* and the Rat, whose stereotaxic descryption of the encephalon is fortunately already very well known and available in literature for comparison (PAXINOS, G., C. WATSON, 2007).

CONCLUSION

The results obtained by the isolation and assessment of the external conformation and the seriate cuts of the cerebral hemispheres in the *Chinchilla lanigera*, and their comparison to literature descriptions of the central nervous system of the Rat and Rabbit have been summed up into the following conclusions:

1. The fragility of the central nervous system imposes a fixation of the samples (preferably

prior to the complete extraction form the cranial cavity) for an easier examination.

2. Due to the low reliability of measurements taken on the fresh or fixed samples, these can only have guidelines value; for in-depth reliable measuring it recommended to appeal to modern imaging techniques.
3. The general characteristics of the *C. lanigera* encephalon, mainly the smooth surface of the cerebral hemispheres, belong to the lissencephalic type of the rodent cerebrum, as it is presented in literature.
4. The cerebral hemispheres narrow progressively in the oral direction, taking a triangular shape from the dorsal perspective.
5. The ventral surface of the cerebral hemispheres present two short but thick and divergent cerebral peduncles partially covered by the round posterior extremity of the pyriform lobes.
6. The diencephalon is also discernable through the tuber cinereum and the mammillary body lodged in a large interpeduncular fossa, and covered by a large pituitary gland.
7. The optostriate bodies are prominent on the horizontal cuts of the cerebral hemispheres, but the basal nuclei are visible as a common grey mass, difficult to identify individually form each other.
8. The corpus callosum is the main identifiable interhemispherical structure on the seriate cuts and clearly distinguishes the lining cortex from the internal cerebral segments.
9. The ventricular system of the C*. lanigera* cerebrum appears similar to the general description in rodents. The first and second ventricles are visible as horizontal slits on the transverse seriate cuts, as well as the oral extremity of the third ventricle, above the thalamus.

REFERENCES

10. Barone, R., R. Bortolami (2004). Anatomie Comparee des mammiferes domestiques. Tome 6, Neurologie I, Systeme nerveux central, ed. Vigot, Paris, p. 7-43.
11. Damian, A. (2011). Anatomia sistemului nervs central. E. AcademicPres, Cluj-Napoca, p. 5-10, 14-67.
12. Gheţie, V., I. Th. Riga, E. Paştea (1956). Anatomia sistemului nervos central şi neurovegetativ la animalele domestic. Ed. Agro-silvică de stat, Bucureşti, p. 63-70, 93-129.
13. Hrapkiewicz, K., L. Mendina, D. D. Holmes (1998). Chinchillas. from Hrapkiewicy K., L. Medina, D.D. Holmes (Eds.). Clinical Medicine of Small Mammals and Primates - an introduction. second edition, Ed. Manson Publishing, London, p. 117-132.
14. Jhonson-Delaney, A. Cathy, L. R. Harrison (1996). Exotic companion medicine handbook for veterinarians. Ed. Wingers Pub, Lake Worth, Fla., Ch. Special Rodents, p. 1-15.
15. Jimenez, J. E. (1996). The Extirpation and Current Status of Wild Chinchilla *Chinchilla lanigera* and *C. brevicaudata.* Biological Conservation, 77(1):1-6.
16. Mohlis, C. (1983). Informacion primar sobre la conservacion y manejo de la chinchilla silvestre en Chile. Boletin Tecnico, nr. 3, Corporacion National Forestal, Santiago.
17. Paxinos, G. (2004). The Rat Nervous System. Academic Press, Elsevier Inc., San Diego, California, third edition.
18. Paxinos, G., C. Watson (2007). The Rat Brain in Stereotaxic Coordinates. Academic Press, Elsevier Inc., Burlington, 6th edition.
19. Spotorno, A. E., C. A. Zuleta, J. P. Valladares, A. L. Deane and J. E. Jimenez (2004). Chinchilla lanigera, Mammalian Species. 758:1-9.
20. Stekelorom-Parmentelat, M. D. (2006). Le Chinchilla, nouvel animal de compagnie. These, Ecole Nationale Veterinaire de Lyon, p. 15-18.
21. Woods, C. A. and C. W. Kilpatrick (2005). Infraorder Hystricognathi. In: D. E. Wilson And D. M. Reeder (Eds), Mammal Species of the World. p. 1538-1599. The Johns Hopkins University Press, Baltimore, MD, USA.