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Macro-anatomical investigation of encephalon in donkey*

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Summary: In this macro-anatomical research, the data was based on direct observations of 14 adult donkey brains 10 male and 4 female. The brains were fixed in 10% formalin solution and the investigation was focused on macroscopic descriptions of the brain surface and of dissected brainstem features. Sulci and gyri on the brain hemispheres had quite curly structures. These were not completely symmetrical both among brains of different donkeys and on two hemispheres of same brains. It was determined that an adult donkey brain weight was 370 ± 7 g, brain/body weight ratio was 0.27%; cerebellum/brain weight ratio was 10.54%; and pituitary gland/brain weight ratio was 0.38%.

Key words : Anatomy, donkey, encephalon

Merkepte encephalon'un makroanatomik olarak incelenmesi

Özet: Bu makro-anatomik araştırmada 10 erkek, 4 dişi toplam 14 adet yetişkin merkebin beyni kullanıldı. Beyinler %10'luk formalin solusyonu ile tespit edildikten sonra beyin yüzeyi ve diseke edilen beyin kökü makroskobik olarak incelendi. Merkep beyninde sulci ve gyri'nin oldukça kıvrımlı bir yapıya sahip olduğu; hem bireyler arasında, hem de aynı bireyin hemispherium'ları üzerinde tam bir simetri olmadığı görüldü. Merkepte beynin ağırlığı 370 ± 7 g, olarak saptandı. Beyin / Vücut ağırlıkları oranı % 0.27; Cerebellum / beyin ağırlıkları oranı % 10.54; glandula pituitaria / beyin ağırlıkları oranı % 0.38 olarak hesaplandı.

Anahtar sözcükler : Anatomi, encephalon, merkep.

Introduction

Donkey (*equus asinus*) is a member of the *equidae* family that is classified in the *perissodactyla* subgroup of *ungulata* group (4). To use a horse as a model of odd-toed ungulate mammal in veterinary anatomy education is expensive and because of the body size, its hard to move and preserve. Therefore, generally donkey is used instead of a horse in this field, especially in our country (10).

Gross and sectional anatomy of encephalon which is in the organs of central nervous system have been examined in horse (7, 16, 25), cow (16), sheep (9, 24), goat (25), pig (6, 8), dog (5, 9) and cat (3, 23) in detail. But the anatomical studies done on donkey's encephalon are limited (12, 21).

Investigation of the anatomy of a donkey brain and revelation of its resemblances and differences with respect to the horse is the aim of this study.

Materials and Methods

The fourteen adult donkey brains that were used in this study were obtained from donkeys killed which were to be fed to wild animals kept at the Atatürk Orman Çiftliği. Ten were male, four were female. After the calvaria was removed with tools such as chain saw, electric handsaw etc. from the head, firstly, dura mater, its dublicated layers and cranial nerves were cut with the curved pointed scissors and then, the exposed brain was extracted from the skull (2). The brain was weighed by electronic sensitive balance (Sartorius BP 3100S – OCE). Specimens were originally fixed for 15 days in 10% formalin solution (18). Finally it was dissected by known procedures.

Definition of the anatomical structures are based on the atlases and books that were written about equine anatomy (7, 16, 19, 25). Nomina Anatomica Veterinaria (17) was used for the nomenclature.

Statistical analysis of measurements during the research period were determined by SPSS 14.0 (License no: 9869264) computer statistics program. Mann Whitney U test was used so as to be compared to weigh measurements of brain, cerebellum and pituitary gland among males and females. Wilcoxon signed-rank test was used so as to be compared to extracranial length of encephalon.

* This study has been summarized from a part of the doctoral thesis that it is name of "Anatomy of the brain in donkey and exemination of its transversal sections".

Results

Sulci and gyri on the brain hemispheres had quite curly structures (Figure 1, 2, 3, 4, 5). These were not completely symmetrical both among brains of different animals in same species, and not even on two hemispheres of same brains (Figure 1, 3).

Pituitary gland which is one of the two endocrine glands in the brain, was gray-red colored, pressed down to dorso-laterally and had an oval shape structure (Figure 4). The other one, the pineal gland, was dark brown colored and drop-shaped structure (Figure 4, 7).

There are four large paired rostral and caudal colliculi with rounded surfaces on the mesencephalic tectum. The surface of the rostral colliculi was covered with a layer of gray substance so they were dark colored and larger than the caudal. The caudal colliculi were encased in white substance and they were light colored (Figure 6, 7).

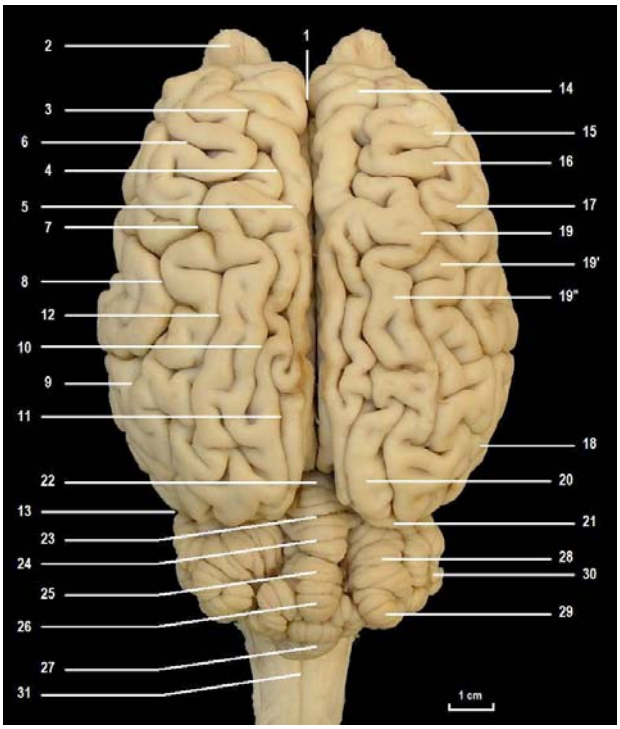

Figure 1. View of encephalon from dorsally in donkey.
Şekil 1. Merkepte encephalon'un dorsal'den görünümü.
[1. Fissura longitudinalis cerebri, 2. Bulbus olfactorius, 3. Sulcus coronalis, 4. Sulcus cruciatus, 5. Sulcus ansatus, 6. Sulcus ectosylvius rostralis, 7. Sulcus suprasylvius rostralis, 8. Sulcus suprasylvius medius, 9. Sulcus suprasylvius caudalis, 10. Sulcus marginalis, 11. Sulcus endomarginalis, 12. Sulcus ectomarginalis, 13. Fissura transversa cerebri, 14. Gyrus precruciatus, 15. Gyrus postcruciatus, 16. Gyrus ectosylvius rostralis, 17. Gyrus ectosylvius medius, 18. Gyrus ectosylvius caudalis, 19. Gyrus ectomarginalis medius, 19'. Pars lateralis, 19". Pars medialis, 20. Gyrus marginalis, 21. Gyrus occipitalis, 22. Culmen, 23. Fissura prima, 24. Declive, 25. Folium vermis, 26. Tuber vermis, 27. Pyramis, 28. Lobulus ansiformis, 29. Lobulus paramedianus, 30. Lobulus Simplex, 31. Sulcus medianus dorsalis]

Diameter of the mesencephalic aqueduct was measured by a way of transversal and sagittal cross sections that were sliced on the mesencephalon level. It was a rather narrow duct that begins caudal end of the third ventricle. Diameter was 3 ± 0.4 mm on this most rostral part of the duct. It had a quite certain wideness beneath the rostral colliculi and its diameter was spread out to 6 ± 0.7 mm. The aqueduct was narrowed again toward caudally and was opened into the fourth ventricle. The width of the duct was 2 ± 0.2 mm at this point (Figure 4). The enlargement of the mesencephalic aqueduct was situated at the same place in all brains. However it had larger ratio in 3 of the 14 brains. The diameters of the canal in these brains were 8.1; 8.6; 7.9 mm respectively.

Four of the 14 brains had unilateral moderate ventriculomegaly (unilateral internal hydrocephalus). One of the lateral ventricles were spread out unilaterally and these were not symmetrical in these brains. The right ventricle was larger than the left in 3 of 4 brains with an asymmetric ventriculomegaly and the left was larger than the right in 1 brain. Two of these 4 brains belong to male donkeys. However, a significant relationship between sex and ventriculomegaly could not be determined.

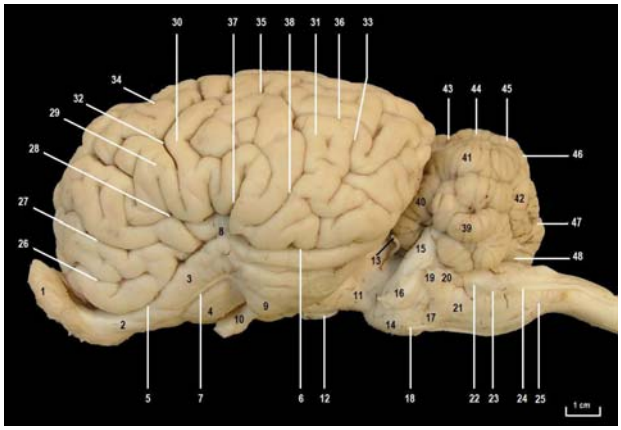

Figure 2. View of encephalon from left side in donkey.
Şekil 2. Merkepte encephalon'un sol yandan görünümü.
[1. Bulbus olfactorius, 2. Pedunculus olfactorius, 3. Tractus olfactorius lateralis, 4. Trigonum olfactorium, 5. Sulcus rhinalis lateralis (pars rostralis) 6. Sulcus rhinalis lateralis (pars caudalis), 7. Sulcus endorhinalis, 8. Fossa lateralis cerebri, 9. Lobus piriformis, 10. Chiasma opticum, 11. Crus cerebri, 12. N. oculomotorius, 13. N. trochlearis, 14. Pons, 15. Pedunculus cerebellaris medius, 16. N. trigeminus, 17. Corpus trapezoideum, 18. N. abducens, 19. N. facialis, 20. N. vestibulocochlearis, 21. Medulla oblongata, 22. N. glossopharyngeus, 23. N. vagus, 24. N. accessorius, 25. N. hypoglossus, 26. Sulcus proreus, 27.Sulcus presylvius, 28. Sulcus diagonalis, 29. Gyrus sylvius rostralis, 30. Gyrus sylvius medius, 31. Gyrus sylvius caudalis, 32. Sulcus ectosylvius rostralis, 33. Sulcus ectosylvius caudalis, 34. Sulcus suprasylvius rostralis, 35. Sulcus suprasylvius medius, 36. Sulcus suprasylvius caudalis, 37. Fissura sylvia, 38. Sulcus obliquus, 39. Lobulus simplex, 40. Lobulus quadrangularis, 41. Lobulus ansiformis, 42. Lobulus paramedianus, 43. Fissura prima, 44. Declive, 45. Folium vermis, 46. Tuber vermis, 47. Pyramis, 48. Uvula]

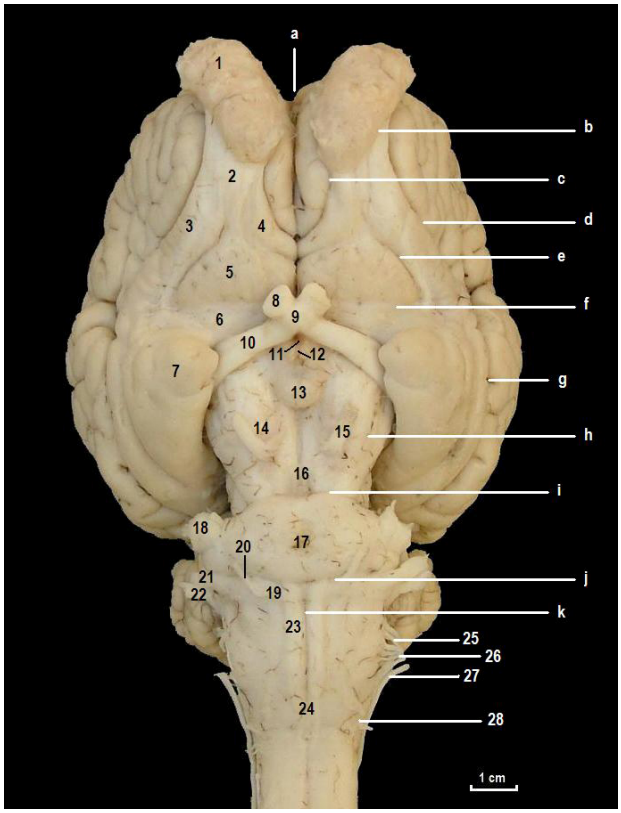

Figure 3. View of encephalon from ventrally in donkey.
Şekil 3. Merkepte encephalon'un ventral'den görünümü.
[1. Bulbus olfactorius, 2. Pedunculus olfactorius, 3. Tractus olfactorius lateralis, 4. Tractus olfactorius medialis, 5. Trigonum olfactorium, 6. Gyrus diagonalis (Brocca'nın diagonal bandı), 7. Lobus piriformis, 8. N. opticus, 9. Chiasma opticum, 10. Tractus opticus, 11. Infundibulum, 12. Tuber cinereum, 13. Corpus mamillare, 14. Crus cerebri, 15. N. oculomotorius, 16. Fossa interpeduncularis, 17. Pons, 18. N. trigeminus, 19. Corpus trapezoideum, 20. N. abducens, 21. N. facialis, 22. N. vestibulocochlearis, 23. Pyramis medulla oblongata, 24. Decussatio pyramidum, 25. N. glossopharyngeus, 26. N. vagus, 27. N. accessorius, 28. N. hypoglossus, a-) Fissura longitudinalis cerebri, b-) Sulcus limitans bulbi olfactorii, c-) Sulcus rhinalis medianus, d-) Sulcus rhinalis lateralis (pars rostralis), e-) Sulcus endorhinalis, f-) Sulcus limitans trigoni olfactorii, g-) Sulcus rhinalis lateralis (pars caudalis), h-) Tractus cruralis transversus, i-) Sulcus pontocruralis, j-) Sulcus pontobulbaris, k-) Fissura mediana ventralis]

The body weight was 140.14 ± 3.84 kg; head weight was 10.22 ± 0.42 kg; brain weight was 370 ± 7 g; cerebellum weight was 39 ± 1 g; pituitary gland weight was 1 ± 0.02 g in donkey (Table 1). Brain / body weight ratio was % 0.27; Cerebellum / brain weight ratio was % 10.54; Pituitary gland / brain weight ratio was % 0.38 (Table 2). Brains of male donkeys were larger and heavier than those of females. So differrences between brain weights of male and female were statistically important ($p<0,01$) whereas the differences between cerebellum and pituitary gland were not ($p>0,05$) (Table 3).

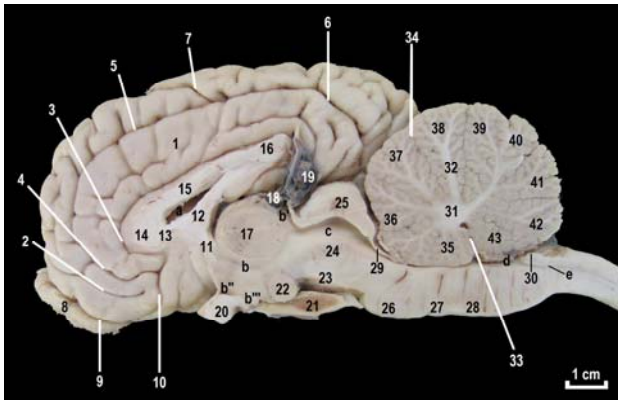

Figure 4. View of encephalon from median axis in donkey.
Şekil 4. Merkepte encephalon'un median hat üzerinden görünümü.
[a) Ventriculus lateralis, b) Ventriculus tertius, b') Recessus pinealis, b'') Recessus opticus, b''') Recessus infundibularis, c) Aqueductus mesencephali, d) Ventriculus quartus, e) Canalis centralis. 1. Cingulum, 2. Sulcus ectogenualis, 3. Sulcus endogenualis, 4. Sulcus genualis, 5. Sulcus splenius, 6. Sulcus calcarinus, 7. Sulcus ansatus, 8. Bulbus olfactorius, 9. Sulcus rhinalis medialis, 10. Sulcus rostralis internus, 11. Commissura rostralis, 12. Fornix, 13. Rostrum corporis callosi, 14. Genu corporis callosi, 15. Truncus corporis callosi, 16. Splenium corporis callosi, 17. Adhesio interthalamica, 18. Habenula, 19. Gl. pinealis, 20. Chiasma opticum, 21. Gl. pituitaria (hypophysis cerebri), 22. Corpus mamillare, 23. Pedunculus cerebri, 24. Tegmentum mesencephali, 25. Tectum mesencephali, 26. Pons, 27. Corpus trapezoideum, 28. Medulla oblongata, 29. Velum medullare rostrale, 30. Velum medullare caudale, 31. Corpus medullare, 32. Lamina alba, 33. Vallecula cerebelli, 34. Fissura prima, 35. Lingula cerebelli, 36. Lobulus centralis, 37. Culmen, 38. Declive, 39. Folium vermis, 40. Tuber vermis, 41. Pyramis, 42. Uvula, 43. Nodulus]

Table 1. Avareges values of body, head, brain, cerebellum and pituitary gland weights in donkey
Tablo 1. Merkepte ortalama vücut, baş, beyin, cerebellum ve glandula pituitaria ağırlığı.

	n	Min. (kg)	Max. (kg)	$\overline{X} \pm S_{\overline{x}}$
Body weight	14	112	162	140,14 ± 3.84
Head weight	14	7.6	12.4	10.22 ± 0.42
Brain weight	14	0.34	0.42	0.37 ± 0.007
Cerebellum weight	4	0.036	0.044	0.039 ± 0.001
Pituitary gland weight	12	0.001	0.002	0.001 ± 0.00002

Table 2. The weight percentage of brain / body, cerebellum / brain and pituitary gland / brain in donkey
Tablo 2. Merkepte beyin / vücut, cerebellum / beyin ve glandula pituitaria / beyin yüzde ağırlık oranları.

Brain / Body	% 0.26
Cerebellum / Brain	% 10.54
Pituitary gland / Brain	% 0.38

Table 3, The weight of brain, cerebellum and pituitary gland in male and female donkey
Tablo 3, Dişi ve erkek merkeplerde beyin, cerebellum ve glandula pituitaria ağırlıkları.

	sex	n	$\overline{X} \pm S_{\bar{x}}$	p
Brain weight	Female	4	0.3435 ± 0.004	**
	Male	10	0.3884 ± 0.007	
Cerebellum	Female	2	0.0360 ± 0.0002	-
weight	Male	2	0.0419 ± 0.002	
Pituitary gland	Female	4	0.0013 ± 0.00002	-
weight	Male	8	0.0014 ± 0.00002	

Tablo 4. Extracranially lengths of brain in donkey.
Tablo 4. Merkepte beynin ekstrakraniyal uzunlukları.

	n	Min. (mm)	Max. (mm)	$\overline{X} \pm S_{\bar{x}}$
Extracranially length	14	133.80	157.20	145.62 ± 2.13
Extracranially width	14	90.40	98.70	93.16 ± 0.72
Extracranially height	14	62.60	75.40	69.12 ± 1.03

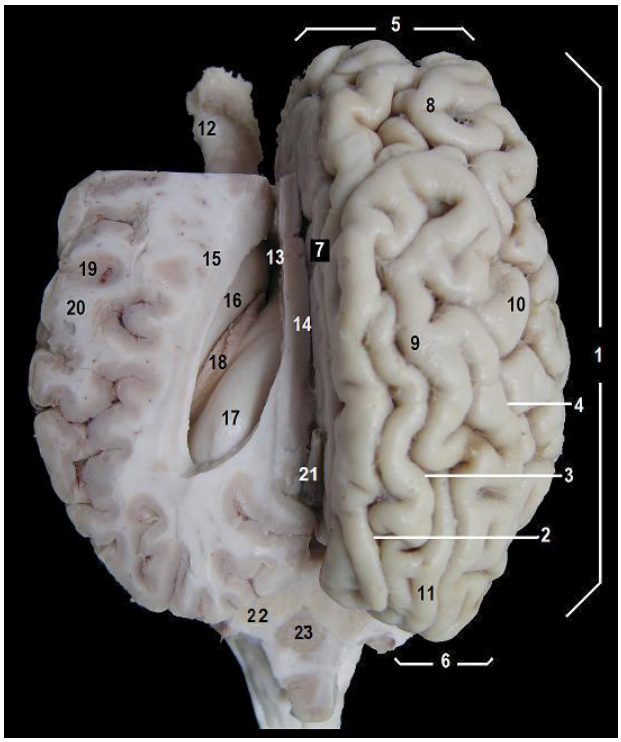

Figure 5. View of right cerebral hemisphere and the base of the left lateral ventricle from dorsally.
Şekil 5. Sağ hemispherium cerebri ve sol ventriculus lateralis tabanının dorsal'den görünümü
[1. Hemispherium cerebri, 2. Sulcus endomarginalis, 3. Sulcus marginalis, 4. Sulcus ectomarginalis, 5. Polus rostralis, 6. Polus caudalis, 7. Facies medialis, 8. Lobus frontalis, 9. Lobus parietalis, 10. Lobus temporalis, 11. Lobus occipitalis, 12. Bulbus olfactorius, 13. Ventriculus lateralis, 14. Corpus callosum, 15. Capsula interna, 16. Nucleus caudatus, 17. Hippocampus (cornu ammonis), 18. Plexus choroideus ventriculi lateralis, 19. Cortex cerebri, 20 Substantia alba, 21. Gl. pinealis, 22. Pedunculus cerebellaris medius, 23. Cerebellum]

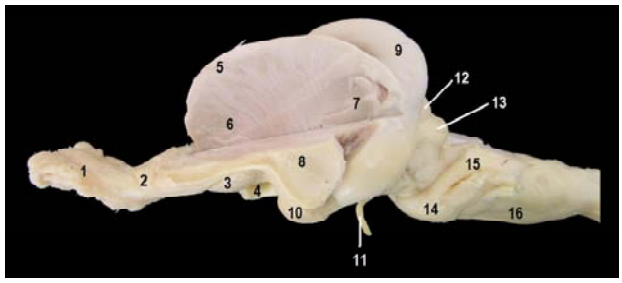

Figure 6, View of brainstem from left side in donkey.
Şekil 6, Merkepte beyin kökünün sol yandan görünümü.
[1. Bulbus olfactorius, 2. Pedunculus olfactorius, 3. Trigonum olfactorium, 4. Chiasma opticum, 5. Capsula interna, 6. Putamen, 7. Cauda nuclei caudati, 8. Claustrum, 9. Hippocampus (cornu ammonis), 10. Lobus piriformis ve corpus amygdaloideum, 11. N. oculomotorius, 12. Colliculus rostralis, 13. Colliculus caudalis, 14. Pons, 15. Pedunculus cerebellaris medius, 16. Medulla oblongata]

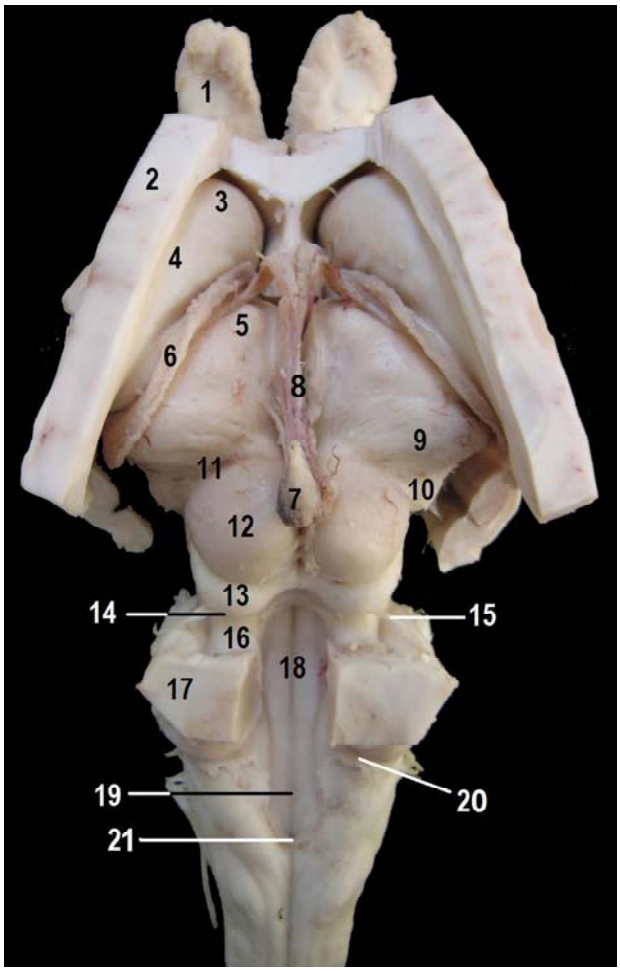

Figure 7. View of brainstem from dorsally in donkey.
Şekil 7. Merkepte beyin kökünün dorsal'den görünümü.
[1. Bulbus olfactorius, 2. Capsula interna, 3. Caput nuclei caudati, 4. Corpus nuclei caudati, 5. Thalamus (tuberculum rostrale thalami), 6. Plexus choroideus ventriculi lateralis, 7. Gl. pinealis, 8. Plexus choroideus ventriculi tertius, 9. Corpus geniculatum laterale, 10. Corpus geniculatum mediale, 11. Sulcus transversus, 12. Colliculus rostralis, 13. Colliculus caudalis, 14. Sulcus postquadrigemina, 15. N. trochlearis, 16. Pedunculus cerebellaris rostralis, 17. Pedunculus cerebellaris medius, 18. Fossa rhomboidea, 19. Sulcus medianus, 20. Recessus lateralis ventriculi quarti, 21. Obex]

Tablo 5. Extracranially lengths of cerebellum in donkey.
Tablo 5. Merkepte cerebellum'un ekstrakraniyal uzunlukları

	n	Min. (mm)	Max. (mm)	$\overline{X} \pm S_{\overline{x}}$
Extracranially length	14	44.10	48.90	47.08±0.420
Extracranially width	14	54.80	58.30	56.48±0.256
Extracranially height	14	37.60	42.90	40.27±0.417

After fixation of the tissues, brain lengths were measured extracranially. The lengths were 145.62 ± 2.13 mm on sagittal axis; 93,16 ± 0.72 mm on horizontal axis and 69.12 ± 1.03 on transversal axis mm (Table 4). Cerebellum was also measured extracranially after fixation and its lengths were 47.08 ± 0.42 mm on sagittal axis; 56.48 ± 0.25 mm on horizontal axis and 40.27 ± 0.41 mm on transversal axis (Table 5).

Discussion and Conclusion

Kurt (15), Taner (20) and Tecirlioğlu (22) have pointed out that shapes and numbers of the sulci and gyri on the brain hemispheres are different both among animals of same species and left and right hemispheres of brains. The present study supports these informations.

Kii et al (14) has determined that clinically normal dogs could have rather widespread ventriculomegaly in lateral ventricles as unilaterally or bilaterally. It is observed that 4 of 14 brains used in the study had unilateral internal hydrocephalus.

Tecirlioğlu (22) has written that mesencephalic aqueduct had an bulb shaped enlargement in the middle part of the duct's length. This enlargement was in beneath the caudal colliculi as to Getty (7). Mesencephalic aqueduct had an enlargement of 6-7 mm caudally from the begining of the canal (beneath the rostral colliculi) in all studied brains.

However body / brain weight ratio was bigger in the local donkey of Turkey. The body and brain weights that were given in the literature data of donkeys in the world were lesser (1). Paralelly to the literature (11) it was determined that the donkey brain was proportionally bigger than the horse's.

Kahle (13) has emphasized that body / brain weights are directly proportional. Statistical data obtained from the study were parallel with the literature.

According to Hifny et al (12) it was notified that the cerebellum weight was 37.6 g; brain / cerebellum weight ratio was 1:9.4 (%10.8) in donkey. Measurements of cerebellum weight in this study was quite similar to the literature data.

In this study, morphological and morphometrical features of donkey brain was observed in detail. In results of the examination, it was suggested that donkey brain was almost similar with horse brain except for the weight and lenght differences, when the obtained data was compared to those in the literature about horse brain. So the donkey brain can be used as a model of the horse brain and the present study will be a reference for brain anatomy of donkeys in veterinary anatomy education.

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