



## GROSS ANATOMICAL AND BIOMETRICAL PARAMETERS OF CEREBRAL HEMISPHERES, ITS FISSURES AND COMMISSURES OF BRAIN OF SURTI BUFFALO (*BUBALUS BUBALIS*)

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### ABSTRACT

The present work was aimed to study the cerebral hemisphere, its fissures and Commissures of brain of Surti buffalo (n=12), an important milch breed of middle Gujarat. The cerebral hemispheres were the largest part of the brain. Both cerebral hemispheres medially separated by longitudinal fissure and caudally by transverse fissure. Each cerebral hemisphere was made up of inner white matter, cerebral medulla and outer grey matter, cerebral cortex which was highly convoluted and presented sulci, gyri and various fissures viz. callosal sulcus, rhinal sulcus, marginal fissure, ectomarginal fissure, transverse fissure, entomarginal fissure and callosomarginal fissure. The overall mean value of width of both cerebral hemispheres together at anterior and posterior aspect was  $8.39 \pm 0.14$  and  $10.34 \pm 0.16$  cm, respectively. The overall mean value of weight and length of both cerebral hemispheres were  $235.71 \pm 2.75$  g,  $11.66 \pm 0.16$  cm, whereas width and height at the level of genu and at the level of splenium of both side of cerebral hemispheres were,  $4.11 \pm 0.27$  and  $5.58 \pm 0.09$ ,  $3.18 \pm 0.04$  and  $2.56 \pm 0.01$  cm, respectively. There were four structures of commissural fibers; the corpus callosum, the anterior commissure, the posterior commissure and the hippocampus commissure that connect the corresponding region of the two cerebral hemispheres. The overall mean value of length and thickness of corpus callosum was  $4.62 \pm 0.08$  and  $0.29 \pm 0.02$  cm.

**Key Words:** Buffalo, Fissures, Commissures, Corpus callosum, Cerebral Hemispheres

### INTRODUCTION

The cerebral hemisphere constitutes the largest part of the brain and occupy the cerebral compartment of cranial cavity. The surface of each cerebral hemisphere is covered by thin layer of grey matter which is termed as cortex while the inner white matter part is called medulla. Cerebral hemisphere which marked by thick ridges the gyri cerebri separated by winding grooves the sulci (Srinivasan, 2012). Commissures Fiber are a number of white matter tracts that cross the midline, connecting the two cerebral hemispheres; The corpus callosum is the largest of the commissural fibres, linking the cerebral cortex of the left and right cerebral hemisphere (Craig *et al.* 2015). The anterior extremity called genu while posterior extremity is called splenium. The portion between genu and splenium is called as truncus (ICAR, 1964). Anterior commissure very important anatomical landmark that connects different parts of the limbic system on both sides and plays a role in the interhemispheric transfer of visual, auditory, and olfactory information between temporal lobes (Wilde *et al.* 2006). The slender posterior

commissure crosses the posterior wall above the entrance to the cerebral aqueduct. It is a very important anatomical landmark which is thought to play a role in the visual system (Getty, 2012). The hippocampal commissure, also called the commissure of the fornix, is a transversely-oriented white matter tract connecting the two hippocampi via the fornices (Gray *et al.* 2008). There is no significant data established on gross anatomical and biometrical parameters of cerebral hemisphere, its fissures and commissures of brain of these animals. Hence, the present work was aimed to study the cerebral hemisphere, its fissures and commissures of brain of Surti buffalo.

## **MATERIALS & METHODS**

The study was carried out at the department of Veterinary Anatomy & Histology, College of Veterinary Science and Animal Husbandry, AAU, Anand, Gujarat. The materials required for the study were collected from normal healthy adult Surti buffaloes immediately after slaughter from the abattoir of Ahmedabad Municipal Corporation. The samples were preserved in 10 % neutral buffered formalin at least for 24 hours. The measurements like weight, length and width of various structures of cerebrum and cerebral commissure of brain were taken with the scientific weighing balance, digital Vernier callipers, non-stretchable thread and scale. The means, standard errors and coefficients of variance were worked out and the differences between right and left side measurements were compared by using student's paired 't' test (Snedcor and Cochran, 1994).

## **RESULTS AND DISCUSSION**

The cerebral hemispheres comprised of right and left cerebral hemisphere, fissures and commissures. These structures are shown in Figure 1-6 and their biometry in Table 1.

### **Cerebral Hemisphere**

The cerebral hemispheres were the largest part of the brain. Medially both the cerebral hemispheres were incompletely separated by longitudinal fissure but connected by corpus callosum formed by commissural fibers. Caudally both the cerebral hemispheres separated from cerebellum by a transverse fissure. (Fig.1). Each hemisphere presented three surfaces and two extremities. The three surfaces were the dorsolateral, medial and ventral while two extremities were the anterior and the posterior. The dorsolateral surface was convex. The medial surface formed the walls of longitudinal fissures and the ventral surface presented different structures of the rhinencephalon and limbic system. (Fig.2). Each cerebral hemisphere was made up of outer grey matter and inner white matter. The inner white matter, cerebral medulla which was placed inside the cortex while outer grey matter, cerebral cortex which was highly convoluted and presented sulci, gyri and various fissures (Fig.4) viz.

- (1) Callosal Sulcus – This sulcus separates the corpus callosum from the dorsal gyrus.
- (2) Rhinal Sulcus – It was very distinct furrow which separated the structures of the rhinencephalon from the other parts of cerebral hemisphere on ventrolateral aspect of cerebral hemisphere.
- (3) Marginal fissure – It was present on middle of the dorsomedial border of cerebral hemisphere and which ends on occipital pole.
- (4) Ectomarginal fissure – It was located lateral to the marginal fissure.
- (5) Transverse Fissure – It started from cranial aspect of longitudinal fissure and run dorsal aspect of frontal pole.
- (6) Entomarginal fissure – It lied medial to the dorso-medial border.

- (7) Calloso-marginal fissure – It was parallel to dorso-medial border of the cerebral hemisphere. It begins in front of genu of splenium.
- (8) Callosal Fissure- It separates the corpus callosum from the gyrus fornicatus (Fig.1,2,3 & 4).

The present findings are matches with the Trotter and Lumb, (1962) in bovine, ICAR (1964) in ox, Frandson and Whitten (1974) in farm animals, Harper and Maser (1975) in American plain buffalo, Zhaohui, *et al.*, (2011) in camel. Srinivasan (2012) in ox and Getty (2012) in bovine, equine. The fissures and sulci found in present study were also reported by Getty, Harper and Maser and Srinivasan.

The overall mean value of the width of both cerebral hemispheres together at anterior aspect was  $8.39 \pm 0.14$  cm (range 7.95 to 9.20 cm) and at posterior aspect  $10.34 \pm 0.16$  cm (range 9.90 to 11.80 cm). Tiwari and Prakash (1990) reported width of whole cerebral hemisphere in buffalo (*Bubalis bubalis*), 9.49 cm which is near by the values of the present study.

The overall mean value of weight of both side was 235.71 g. The mean value of the weight of right cerebral hemisphere was 232.96 g with the range between 209 to 253 g while the weight of left cerebral hemisphere was 238.46 g with the range between 211 to 263 g.

The overall mean value of length of both side was 11.66 cm. The mean value of the length of right cerebral hemisphere was 11.82 cm with the range between 10.8 to 12.55 cm while length of left cerebral hemisphere was 11.50 cm with the range between 10.90 to 11.95 cm.

Harper and Maser (1975) in American plain buffalo reported, the mean length of the right and left forebrain (frontal to occipital pole) 11.19 and 11.43 cm respectively. Parmar *et al.* (2000) in calves reported that the mean length of cerebral hemisphere was 12.25 cm. The length of cerebral hemisphere of Surti buffalo were similar to the length in American plain buffalo but it was lower than the length in calves.

The overall mean value of width at the level of genu and splenium of both sides was 4.11 and 5.58 cm. The mean value of the width of cerebral hemisphere at the level of genu and splenium was 4.37 and 5.66 cm with the range between 3.9 to 4.7 cm and 5.2 to 5.95 cm from the right side and 3.84 and 5.49 cm with the range between 3.6 to 4.22 cm and 5.25 to 6.1 cm from the left side respectively.

The findings of the present study were in accordance with the findings of Harper and Maser (1975) in American plain buffalo, in which they measured the width of cerebral hemisphere from anterior as well as posterior part of the cerebral hemisphere, which was 3.81 and 4.68 cm on right side and 3.81 and 4.65 cm in left side. Tiwari and Prakash (1990) in buffalo in which they measured the width of cerebral hemisphere from rostral as well as caudal cerebral hemisphere at the level of genu and at the level of splenium, which was 3.98 and 4.47 on cm right side and 3.95 and 4.51 cm on left side. The values of the width of the cerebral hemisphere in present study are higher than the values reported by above authors.

The overall mean value of height of both cerebral hemispheres was 3.18 cm. The mean value of the height of cerebral hemisphere at the level of genu and splenium was 3.21 and 2.56 cm with

the range between 3.15 to 3.32 cm and 1.95 to 2.81 cm from the right side and 3.14 and 2.55 cm with the range between 3.1 to 3.29 and 2.1 to 2.79 cm from the left side.

Harper and Maser (1975) in American plain buffalo and Tiwari and Prakash (1990) in buffalo measured the height of cerebral hemisphere from both the places which was 5.27 and 6.40 cm on right side and 5.58 and 6.41 cm on left side at the level of genu and was 3.164 and 2.799 cm on right side and 3.136 and 2.776 cm left side at the level of splenium respectively. The height of the cerebral hemisphere of American plain buffalo was higher but at par with the buffalo.

### **Cerebral Commissures**

There were three different types of medullary fibers viz commissural, projection and association fibers. The commissural fibers connect the corresponding region of the two cerebral hemispheres. There were four structures of commissural fibers; the corpus callosum, the anterior commissure posterior commissure and Hippocampal commissure which connects the two cerebral hemisphere and its structures.

### **Corpus Callosum**

The corpus callosum was largest curved part of white matter located on the floor of the cerebral hemisphere. It connects both the hemispheres ventrally. The callosal fibers radiates from it which reaches up to the cerebral cortex. It forms the floor of the longitudinal fissure and roof of the lateral ventricles (Fig.4). The corpus callosum was presented three different parts; anterior part was genu, the middle truncus and posterior part was splenium. The genu was curved anteriorly, its inferior surface attached with septum pellucidum. The splenium was curved posteriorly over hangs the posterior end of thalami and pineal gland (Fig.3). The inferior surface of the splenium attached with fornix and hippocampus posteriorly. The dorsal surface of the truncus was smooth and covered by a very thin layer of grey matter. The inferior surface was rough and serrated and in the middle it was attached with the dorsal border of septum pellucidum (Fig. 4). Trotter and Lumb, (1962) in bovine, ICAR (1964) in ox, Raybaud (2007) in human, Konig *et al.* (2009) in domestic animals, Getty (2012) in horse, Shrinivasan (2012) in ox, Abedallah *et al.* (2015) in one humped camel and Craig and Frank (2015) in human, reported similar morphology of the corpus callosum as in Surti buffalo.

The average length and thickness of truncus of corpus callosum was  $4.62 \pm 0.08$  cm (range 4.0-4.9 cm) and  $0.29 \pm 0.02$  cm (0.2 to 0.4 cm) respectively. Mohammadpour and Moshtaghi (2006) measured length and height of corpus callosum in Lori goat, which were 38.82 mm and 4.07 mm. These finding were similar with the findings of present study, even though the brain of the Surti buffalo is little larger than the goat.

### **Anterior Commissure**

The anterior commissure was thin bundle of white matter fibers, located between caudate nucleus and thalamus which connect two cerebral hemispheres across the midline. (Fig. 5). The bundles were in semi-circular pattern (half-moon shaped). In mid line it was placed below the septum pellucidum while on lateral aspect it was placed below the choroid plexus of lateral ventricle. Its reaches up to the piriform lobe. The above findings were in accordance with the Wilde *et al.* (2006) in humans, Koing *et al.* (2009) in domestic mammals, Getty (2012) in horse and Ashwell (2016) in mammals. However, they reported that the anterior fibers extend to the olfactory lobes which were not observed in presents study.

### Posterior Commissure

The posterior commissure was rounded, short band of white fibers crossing the middle line on the dorsal aspect of the upper end of the cerebral aqueduct and present behind the third ventricle and thalamus. (Fig.5) The above findings were in accordance with the Gray et al. (2008) in human, Koing *et al.* (2009) in domestic mammal, Hines (2009) in human and Getty (2012) in horse, Ozdemir (2015) in sheep.

### Hippocampus Commissure

The hippocampal commissure is the second largest of the commissural connecting bundles. At the midline it is found directly underneath, and adjoins, the Corpus Callosum, which is the largest of the commissural bundles. At the midline, the hippocampal commissure is also known as the Body of the Fornix. Away from the midline, the fibers of the hippocampal commissure are often called the Fimbria (Fig.6). Amaral and Lavenex (2007) and Gray et al. (2008) in human, Chen *et al.* in (2009) in camel and Kumarvel et al. (2014) in buffalo, & reported Similar topography of hippocampus commissure as in surti buffalo.

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**Conflict of Interest:** All authors declare no conflict of interest.

**Table - 1. Average weight, length, width and height of cerebral hemisphere.**

Parameters	Right			Left			't' Value
	Range	Mean $\pm$ SE	C.V%	Range	Mean $\pm$ SE	C.V%	
Weight (g)	209 to 253	232.96 $\pm$ 4.02	5.97	211 to 263	238.46 $\pm$ 4.82	7.01	0.88 <sup>ab</sup>
Length (cm)	10.8 to 2.55	11.82 $\pm$ 0.17	4.91	10.90 to 11.95	11.50 $\pm$ 0.11	3.39	1.60 <sup>ab</sup>
Width at level of genu (cm)	3.9 to 4.7	4.37 $\pm$ 0.08	6.64	3.6 to 4.22	3.84 $\pm$ 0.06	5.73	5.05 <sup>ab</sup>
Width at level of splenium (cm)	5.2 to 5.95	5.66 $\pm$ 0.06	3.53	5.25 to 6.1	5.49 $\pm$ 0.10	6.01	1.47 <sup>ab</sup>
Height at level of genu (cm)	3.15 to 3.32	3.21 $\pm$ 0.03	3.11	3.1 to 3.29	3.14 $\pm$ 0.04	3.82	1.61 <sup>ab</sup>
Height at level of splenium (cm)	1.95 to 2.81	2.56 $\pm$ 0.07	10.16	2.1 to 2.79	2.55 $\pm$ 0.06	9.01	0.10 <sup>ab</sup>

None of the measurements differed significantly between right and left side by 't' test.

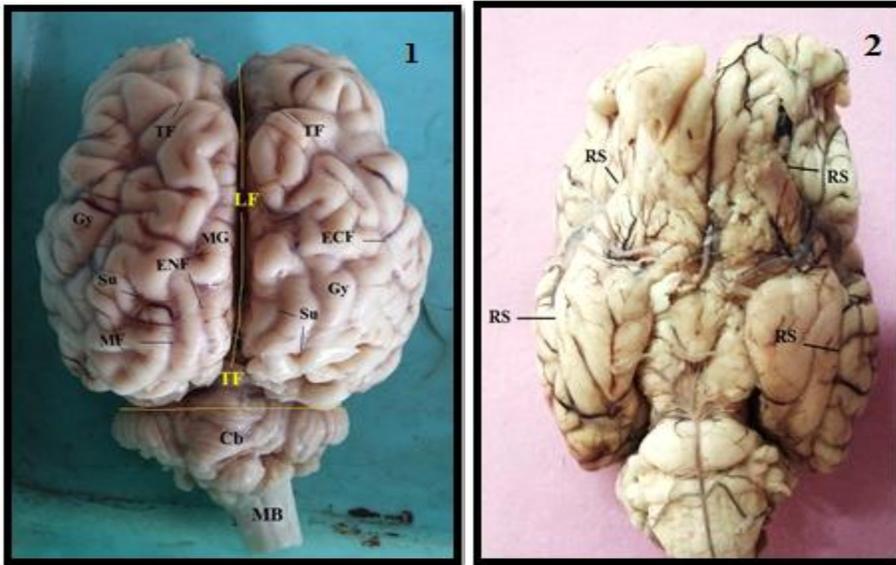


Fig. 1& 2 : Dorsal&Ventral view cerebral hemisphere of brain of Surti buffalo showing (LF) Longitudinal fissure, (TF) Transverse fissure, (Gy) Gyri, (S) Sulci, (Cb) Cerebellum and (MO) Medulla oblongata,(MF) Marginal fissure, Ecto-marginal Fissure, (ENF) Ento -marginal Fissure, (TF) Transvers Fissure, RS) Rhinal Sulcus.

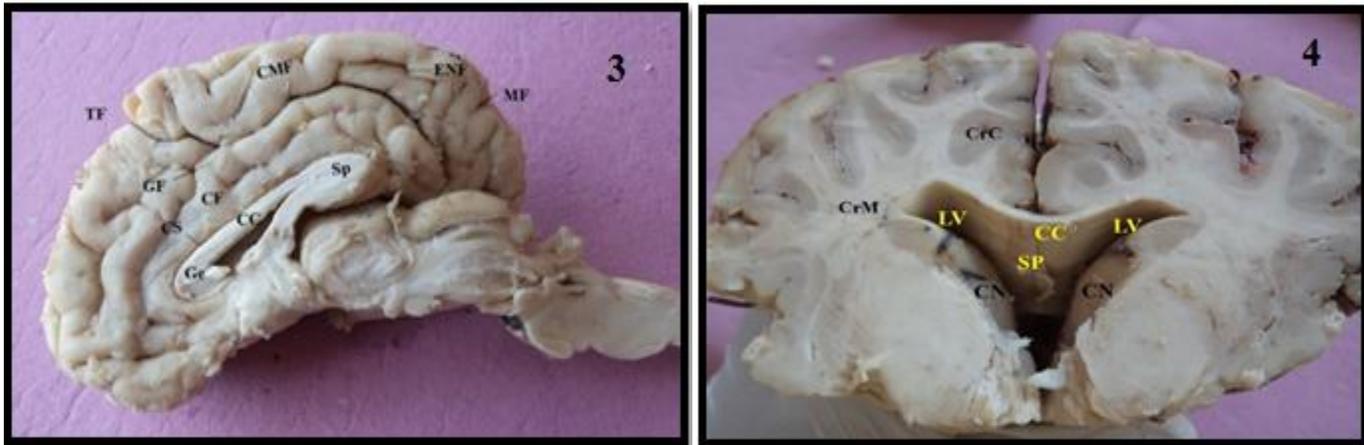


Fig. 3 Mid sagittal & sagittal section of brain showing (MF) Marginal Fissure, (ENF) Ento-marginal Fissure, (CS) Coronal Sulcus, (CF) Callosal Fissure (TF) Transvers Fissure, (GF) Gyrus Fornicates, (CMF) Calloso-Marginal Fissure,CC) Corpus Callosum, (Ge) Genu and (Sp) Splenium, (CrM) Cerebral Medulla white matter, (CrC) Cerebral Cortex gray matter, (CN) Caudate Nucleus, (LV) Lateral Ventricle and (SP) Septum Pullucidum,

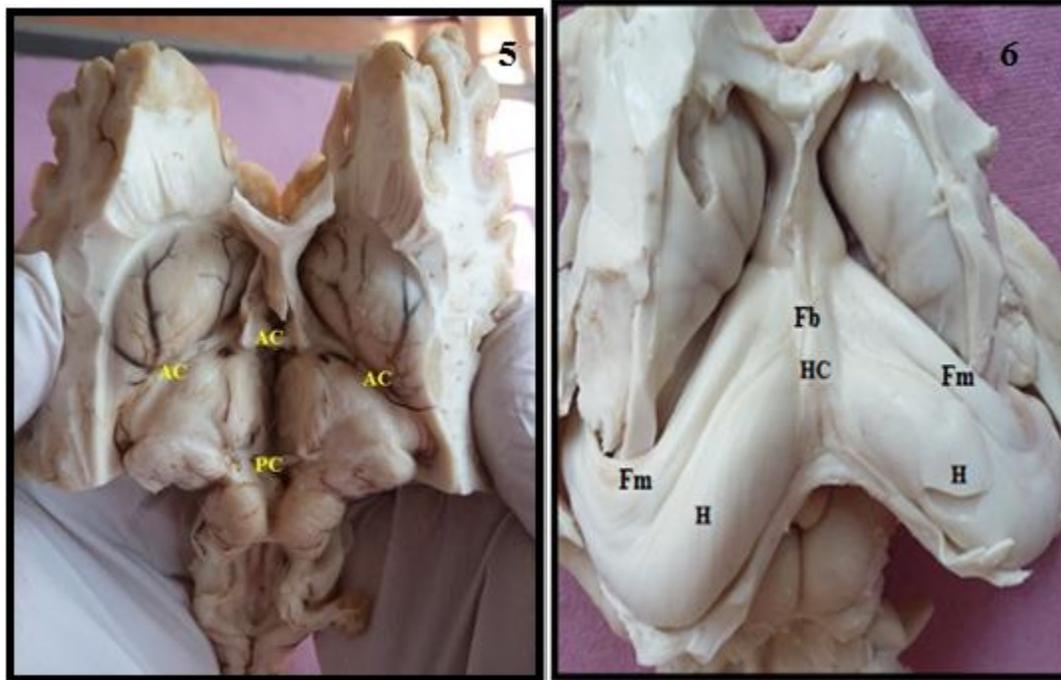


Fig. 5 & 6: Commissures of brain of Surti buffalo showing (AC) Anterior commissure, and (PC) Posterior commissure, (HC) Hippocampus commissure, (Fb) Body of Fornix and (Fm) Fimbriae.

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