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Gyrification Index and Encephalizaton Quotient of Brain of Surti Buffalo (*Bubalus bubalis*)

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Abstract

The brain of Surti buffaloes presents many cortical foldings. These are called gyrification. In the present study on brain of 12 Surti buffaloes, the folded cerebral hemispheres presented various sulci and gyri of different sizes. Gyrification Index (GI) was measured by the sum of the complete exposed surface and superficially exposed surface of cerebral cortex. The overall mean value of gyrification index of both of cerebral hemispheres was 2.52±0.02. The Encephalization Quotient (EQ) is the ratio of brain mass to body mass, which gives rough estimate of the intelligence of the Surti buffaloes. The overall mean value of encephalization quotient of Surti buffaloes was found to be 0.74.

Introduction

The Surti is a breed of water buffalo found in the Charottar tract of Gujarat between the Mahi and Sabarmati rivers. The best animals of this breed are found in Anand, Kaira and Baroda districts of Gujarat (Banerjee, 2014). The surface of the cerebral cortex is marked by thick ridges the gyri cerebri, separated by binding grooves the sulci. The gyrification is the specific pattern formed by the different sulci and gyri of cerebral cortex (Mayhew *et al.,* 1995). Gyrification allows a large cortical surface area and hence greater cognitive functionality to fit inside a smaller cranium. In most mammals, gyrification begins during fetal development (Rakic, 2009).

Intelligence may be defined by the speed and success of how animals solve problems to survive in their natural and social environments (Roth and Dicke, 2005). The brain is considered to be the carrier of intelligence. The encephalization quotient (EQ), defined as the ratio between actual brain size and expected brain size for a given weight, has been employed to assess the intelligence (Jerison, 1973). This study was planned to assess cortical folds, gyrification index and encephalization quotient of

brains of adult Surti buffaloes.

Materials and Methods

The study was carried out at the Department of Veterinary Anatomy & Histology of Veterinary College, AAU, Anand, Gujarat. The materials required for the study were collected from normal healthy adult Surti buffaloes (n=12) immediately after slaughter from the local slaughter house, Anand as well as from Municipal Corporation slaughter house, Ahmadabad. The fresh brain was fixed in 10% formalin for 2 weeks. The fixed brain was sectioned in the coronal plane using meat-slicer. With the help of thread, length of outer contour and length of complete contour were measured. A ratio between the lengths of the total to that of the superficially exposed cortical surface was calculated for each section and this represented the gyrification index (GI). (Zilles *et al.,* 1988). Brain to body weight ratio is the ratio of brain mass to body mass, which is known as encephalization quotient (EQ). The EQ in this study was calculated using only data from fresh brains (n=12). It gives a rough estimate of the intelligence of an animal.

The EQ was calculated with the formula EQ = Ei/0.12P2/3,

Where, Ei and P are the mean weight of the brain and body, respectively (Jerison, 1973).

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

Gyrification Index

The brain of Surti buffaloes was very well developed with grey cortex and white medulla. The cerebral cortex was folded, giving a much greater surface area in the confined volume in the skull of Surti buffaloes. The folded cerebral cortex presented different sized sulci and gyri. The number of gyri was found more towards the posterior aspect as compared to anterior aspect of the cerebral hemisphere. The Surti buffaloes are mammals so the brain surface presented lots of cortical folding just like other mammalian brains. These cortical foldings are called gyrification (Fig. a & b).

Elias and Schwartz (1969) in mammals and Wosinski *et al.* (1996) in dog studied the degree of gyrification of cerebral cortex, which was essentially determined by the size of the brain. Smart and McSherry (1986) reported that the ungulates have extensive cortical gyri. Rakic (2009) reported gyrification as the process of forming the characteristic folds of the cerebral cortex. Gyrification allows a larger cortical surface area and hence greater cognitive functionality to fit inside a smaller cranium. Shrinivasan (2012) reported that the gyrification is a specific pattern formed by different sulci and gyri of cerebral cortex.

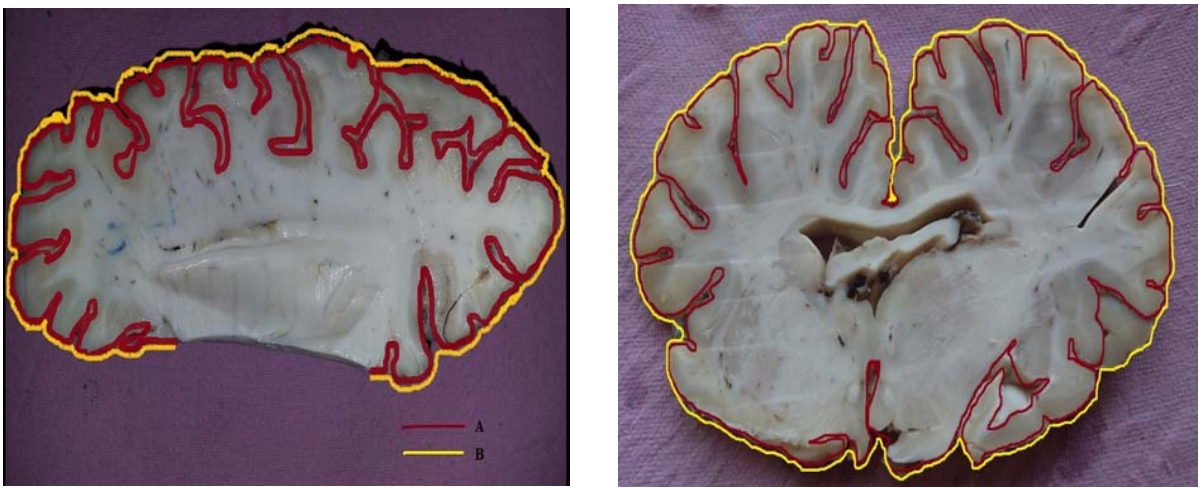

Fig. a & b : Coronal section of brain of Surti buffalo showing gyrification, (A) Complete contour and (B) Outer contour to measure and calculate gyri for gyrification index.

The gyrification index was worked out by measuring the sum of complete exposed surface of cerebral cortex and superficially exposed surface of cerebral cortex (Fig a & b). The overall mean value of the gyrification index of both cerebral hemispheres was 2.52±0.02. The mean values of gyrification index of right and left cerebral hemisphere were 2.51±0.04 cm (range 2.31-2.63 cm) and 2.54±0.04 cm (range 2.33-2.78 cm), respectively, which did not differ significantly.

Zilles *et al.* (2013) reported that the gyrification index of domestic cattle, zebu, sheep, goat and horse was 2.54, 2.53, 2.29, 1.81 and 1.99, respectively. Present results are similar with the domestic cattle and zebu, but higher than the sheep, goat and horse.

Encephalization Quotient (EQ)

The mean weight of brain in the Surti buffalo was 528.33 g, and mean weight of Surti buffalo was 433.29 kg, hence its ratio, the encephalization quotient of Surti buffalo was 0.74.

Shoshani *et al*. (2006) reported that the average EQ of Asian and African elephant was 2.14 and 1.67, respectively. These values are much higher than the value of Surti buffalo. The body weight and the brain weight is almost 5 to 6 times more in elephant than the buffalo and so the value of EQ is more in elephant. Chen *et al.* (2009) in Bactrian camel, Cozzi *et al.* (2014) in horse, Ballarin *et al.* (2016) in domestic *Bos taurus* and Minervini *et al*. (2016) in industrial pig (*Sus scrofa*) studied the ratio between brain mass to body mass and reported their EQ as 1.3, 0.78, 0.56 and 0.60, respectively.

However, Jerison (1973) reported that in this system, a mammal with a brain/body ratio with an EQ value equal to 1.0 is considered to have average EQ. A value of EQ less than 1.0 may be associated with a less than average level of attributes that might be interpreted as "intelligence". Conversely, an EQ value higher than 1.0 may be associated with more than average intelligence. The EQ of the elephant and camel is more than 1.0, while the EQ of horse, Surti buffalo, bovine and pig are less than 1.0. Thus the EQ values show that the elephant and camel are more intelligent, and cattle and pig are less intelligent than Surti buffalo studied.

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Conflict of Interest:

Authors have no conflict of interest.

References:

Ballarin, C., Povinelli1, M., Granato, A., Panin, M., Corain, L., Peruff, A. and Cozzi, B. (2016). The brain of the domestic *Bos taurus*: Weight, encephalization and cerebellar quotients, and comparison with other domestic and wild Cetartiodactyla. *PLoS One,* **11**(4): 1-14.

Banerjee, G.C. (2014). Buffalo. *In: A Text Book of Animal Husbandry.* 8th ed., Oxford & IBH Publishing House, New Delhi, India, pp. 694-727.

Chen, J., Bai, Z., Gao, Z. and Wang, J. (2009). Morphology of rhinencephalon and hippocampal formation of the bactrian camel (*Camelus bactrianus*) with their adaptive features. *Vet. Res.* Commun., **33**: 25-32.

Cozzi, B., Povinelli, M., Ballarin, C. and Granato, A. (2014). The brain of the horse: Weight and cephalization quotients. *Brain Behav. Evol.*, **83**: 9-16.

Elias, H. and Schwartz, D. (1969). Surface areas of the cerebral cortex of mammals determined by stereological methods. *Science*, **166**: 1011-1013.

Jerison, H.J. (1973). *Evolution of the brain and intelligence*. Academic Press, New York and London, pp. 1-482.

Mayhew, T.M., Mwamengele, G.L.M., Dantzer, V. and Williams, V. (1995). The gyrification of mammalian cerebral cortex. *J. Anatomy*, **188**: 53-58.

Minervini, S., Accogli, G., Pirone, A., Graïc, J.M., Cozzi, B. and Desantis, S. (2016). Brain mass and encephalization quotients in the domestic industrial pig (*Sus scrofa*). *PLoS One*, **11**(6): 1-12.

Rakic, P. (2009). Evolution of the neocortex: a perspective from developmental biology. *Nature Reviews Neuroscience*, **10**(10): 724-735.

Roth, G, and Dicke, U. (2005). Evolution of the brain and intelligence. *Trends Cog Sci.*, **9**(5): 250-257. doi: 10.2016/j.tics.2005.03.005.

Shoshani, J., Kupsky, W.J. and Marchant, G.H. (2006). Elephant brain gross morphology, function, comparative anatomy, and evolution. *Brain Res.Bull.*, **70**: 124-157.

Smart, I.H. and McSherry, G.M. (1986). Gyrus formation in the cerebral cortex in ferret. I. Description of external changes. *J. Anatomy,* **146**: 141-154.

Snedecor, G.W. and Cochran, W.G. (1994). *Statistical Methods*. 6th ed., Oxford and IBH Publishing House, Calcutta, India.

Srinivasan, P. (2012). *Veterinary Anatomy of Ox*. Bio-Green Books, New Delhi, pp. 9-15.

Wosinski, M., Schleicher, A. and Zilles, K. (1996). Quantitative analysis of gyrification of cerebral cortex in dogs. *PubMed*. https:// www.researchgate.net/.../14019484.

Zilles, K., Armstrong, E., Schleicher, A. and Kretschmann, H.J. (1988). The human pattern of gyrification in the cerebral cortex. *Anatomy & Embryol.*, **179**: 173-179.

Zilles, K., Gallagher, N. P. and Amunts, K. (2013). Development of cortical folding during evoluation and ontogeny. *Trends in Neurosciences*, 1-10.

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ANNOUNCEMENT: ISSAR-2018 CONFERENCE

XXXIV Annual Convention of the Indian Society for Study of Animal Reproduction (ISSAR) and International Symposium on "Productivity Enhancement through Augmenting Reproductive Efficiency of Livestock for Sustainable Rural Economy" will be hosted in collaboration with the ISSAR Gujarat Chapter by the College of Veterinary Science & Animal Husbandry, ***Anand Agricultural University, Anand - 388 001,*** Gujarat, India ***during December 28-30, 2018***. Brochure containing details of Awards, Sessions, Deadlines, Bank details for NEFT/RTGS, E-mail IDs etc is available on the website of the Society. The date for early bird registration and submission of abstracts is up to **30th November 2018** through e-mail.

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