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## Original Article

# Studies on the development of cerebellum of one-humped camel (*Camelus dromedarius*)

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## Abstract

A histomorphological study of the development of foetal cerebellum was conducted. It was observed that at first trimester there were fewer fissures in the folia which progressively increased towards the third trimester. It was also observed that the histology of cerebellum of camel foetus at first trimester showed clear distinct external granular layer which was thin densely parked with cells which progressively decrease in thickness and amount of cells towards the third trimester. The next layer which was the molecular layer with less cell (stellate and basket) compared to the external germinal layer increased in volume with increased age. The molecular layer was followed by a densely cell (Golgi and granule) packed internal granular layer which progressively increased from first trimester to the third trimester. Purkinje cells which were in-between molecular and internal granular layer were not seen in the first trimester but were gradually becoming more visible in the subsequent trimesters. The development of the cerebellum in this study is similar to what was observed in most of the animal species.

## 1. Introduction

Camel is a domesticated animal whose full agricultural reproductive potentials have not yet been achieved. Originally it has been domesticated for milk and meat since 2500 years ago. Later it becomes synonymous with transport through some of the formidable desert of the world. Today, Once again, we are turning to the camel and it is playing an important role in the socioeconomic status of Africans and other part of the world. It is a good source of meat, milk, skin and other bye products [1]. Camels are increasingly gaining popularity in Africa, and indeed Nigeria where they are used as a source of meat [2] and for transportation. With its increasing popularity it is important to understand its reproductive potentialities and nature of its development. The cerebellum lies caudal to cerebral hemispheres. It is composed of two symmetrical lateral halves, the cerebellar hemispheres and one medial part, the vermis. Fissures of various depths subdivide the entire cerebellar surface into a considerable number of leaf-like lamellae (*Folia cerebellar*). Groups of lamellae are separated by deeper fissures which subdivide the organ into lobes and lobules [3].

The cortex of the cerebellum is seen to consist of three layers. The outer molecular layer which contains relatively few neurons and large numbers of unmyelinated fibres, the inner granular cell layer, which is extremely cellular and between the two is a single layer of huge neurons called Purkinje cells [4]. Cerebellum provides coordination in the animal's movement.

The concept of various foetal tissues competing with one another for nutrients from the dam through the placenta was introduced by Hammond (1944)[5] and that tissues which develop later, such as fat and muscle have a lower growth priority than tissues such as nervous tissue and bone which develop early. The early developing tissues provide ways for estimating developmental age. There is little or no work on the central nervous system development of the camel in the literature. The present study was therefore undertaken to study the morphology and histology of the prenatal camel cerebellum.

## 2. Materials and Methods

### 2.1 Sample collection

A total of 153 camel foetuses were collected from slaughtered pregnant dams at Sokoto abattoir for this study. The foetuses were collected immediately after slaughter from the uteri of the slaughtered dams.

### 2.2 Foetal Age Estimation

The age of the foetuses were estimated using a formula (GA = (CVR +23.99)/0.366) as described by Elwishy *et al.* (1981)[6].

### 2.3 *Method of Dissection of the foetus*

The skin and the muscles of the head of each foetus were incised and removed to expose the skull. The brain was exposed after sawing with a saw through the frontal bones along the supraorbital ridge, the dorsal ridge of the temporal fossa on both sides and through a line joining the lateral cut, then through the supraorbital foramina and the occipital insertion of the ligamentum nuchae. The roof of the cranium was removed using a bone chisel and bone shears. The lateral saw lines were extended with bone shears through the occipital bone which was removed to expose cerebellar dura. The meninges was separated and removed to expose the cerebral hemispheres and the cerebellum. The brain was extracted after rotating the head slowly downwards and severing the cranial nerves. [7]

The cerebellum was photographed after exposure. Specimens from the cerebellum tissue sections were fixed in 10% buffered formalin for a week. They were embedded in paraffin and sectioned at 5micron (μ) with Shandon AS 325 retraction microtome and dried in an oven [8][9][10]. The slides were stained using H & E technique [8] and examined under light microscope at ×4, ×10 and ×40 objectives and appropriate photomicrographs were taken with Olympus VA NOX-T brand research microscope at ×40 ×100 and ×400 magnifications.

## 3. Results

The cerebellum in the early first trimester is smooth but folia started to develop in the late first trimester (Plate I) then second trimester fissures or folia continued to increased in number and size (Plate II) and in the third trimester 350 days old foetus the fissures were more and bigger than in the second trimester (Plate III). In the first trimester (Plate IV) there was clear distinct external granular layer which was thin densely parked with cells, followed by another thin, whitish or a molecular layer with less cell and not so distinct compared to the external granular layer. The molecular layer was followed by a densely cell packed internal granular layer. The purkinje cells were not seen. The white matter was not distinct in the first trimester. The fissures that formed the folia were not very deep and had fewer branches. In the second trimester (Plate V) the external granular layer had become thinner with few cells than in the first trimester, the molecular layer had become wider and few cells than in the first trimester and purkinje cells had started to appear.

The internal granular layer was more distinct with less cell population than the first trimester. The centrally placed white matter had started to appear. The fissure that formed the folia had become deeper and branches had increased. In the cerebellum of the third trimester foetus (Plate VI) the external granular layer had become thinner with few cells, the molecular had became wider, the purkinje cells were clearly seen and formed a demarcation between the molecular layer and internal granular layer. The centrally placed white matter was more distinct, fissures that formed the folia were much deeper and they were bigger with more branches. The cerebellum of the adult camel showed all the layers with the exception of external germinal layer, the outer molecular layer is wider and bigger compared those of the foetuses and the internal granular layer is also much distinct while the purkinje cells were more matured.

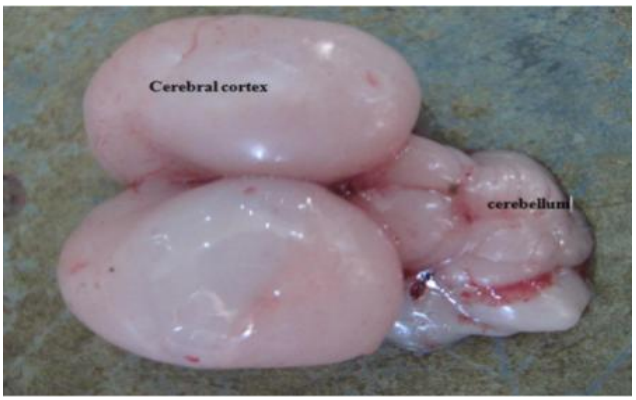


**Plate I: Brain of first trimester (107 days old) camel foetus showing smooth cerebrum (no sulcus or gyri) and cerebellum with**

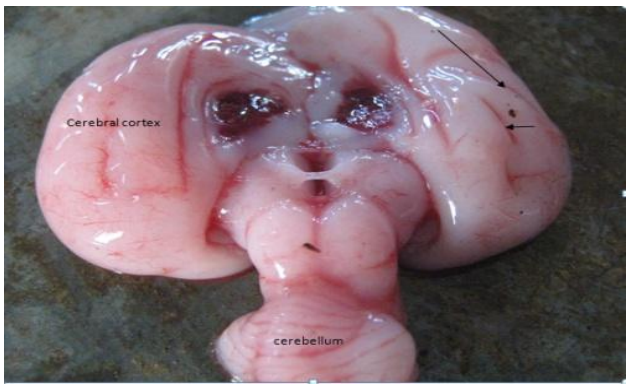


**Plate II: Brain of second trimester (152 days) old camel foetus cerebral cortex and cerebellum with the beginning of the folia starting todevelop appearance of gyrus and sulcus of the cerebrum (arrows)**

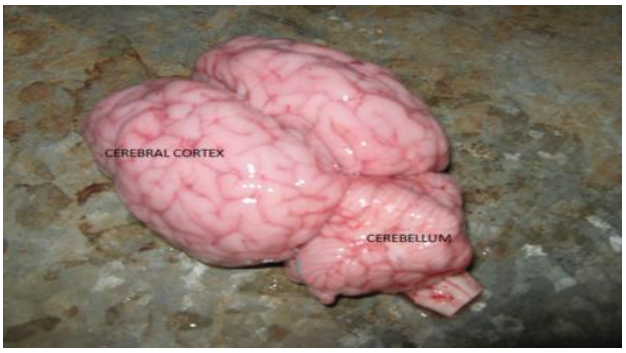


**Plate III: Brain of third trimester (350 days old) camel foetus showing cerebral cortex (with well formed gyri and sulci) and cerebellum (with clearly defined folia).**

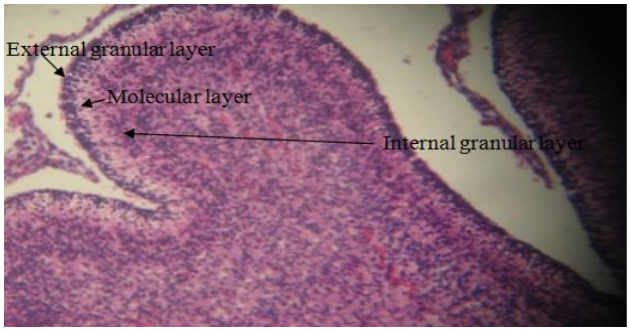


**Plate IV: Photomicrograph L.S. of cerebellum of1st Trimester (107 days old) Camel foetus showing external germinal layer,molecular layer and internal granular layer in the process of development no Purkinje cells were seen at this stage (H & E x 200)**

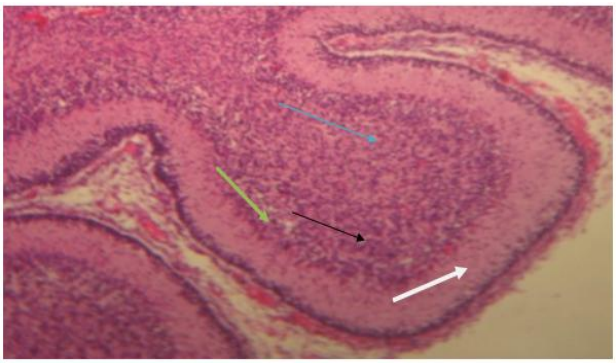

**Plate V: Photomicrograph L.S. of cerebellum of 2nd trimester (147 days old) camel foetus showing internal granular layer(Blue arrow), Purkinje layer (Black arrow), molecular layer (Green arrow)and external germinal layer(White arrow) (H & E ×200)**

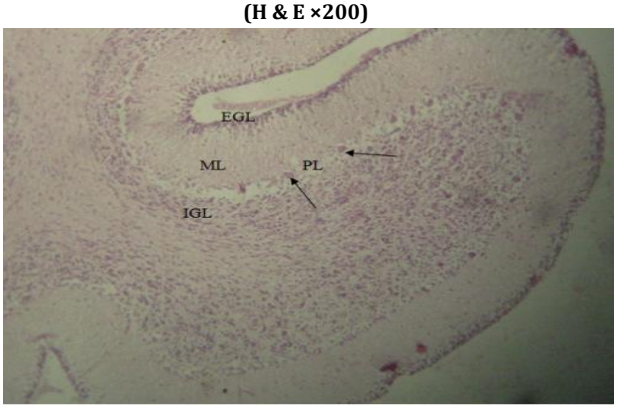


**Plate VI: Photomicrograph of L.S. of cerebellum of 3rd Trimester Camel foetus (350 days old) showing external germinal layer (EGL), molecular layer ML, purkinje layer (PL),with Purkinje cells (arrows) and internal granular layer(IGL) (H & E ×100).**

## 4. Discussion

In this study it was observed that at first trimester there were fewer fissures in the folia which progressively increased towards the third trimester this is similar to what was reported by Mc Geady *et al*. (2006)[11]. It was observed in this study that the cerebellum of first trimester foetus showed clear distinct external granular layer which was thin densely parked with cells which progressively decreases in thickness and amount of cells towards the third trimester, The observation above is contrary to most of the previous works in humans and other species of animals [12][13][14] in which it was reported that the external germinal layer progressively increased until few days after birth when it started decreasing until finally it disappeared, this is in line with the findings of Lavezzi *et al*. (2006)[15]. It was observed that the external granular will be present until after 21 days postnatal in rats [16], when it will totally disappeared.

The external germinal layer persisted for up to 60 to 80 days in the kitten, 75 days in the puppy and 6 month in the calf [17]. The period of greatest development of the external germinal layer varies between species of animals and was closely correlated with the age at which the animal was able to stand and walk in coordinated manner [18]. In calves, foals and other species that walk within an hour after birth the cerebellum was developed much more than in kitten and puppies who do not walk for about 3 weeks post-natally, it was assumed then the development of camel cerebellum is similar to those of calves and foals since it was able to stand within an hour after birth (personal communication). The next layer which was the molecular layer with less cell (stellate and basket) compared to the external germinal layer increases in volume with increases in age i.e. from first to the third trimester this may not be unconnected with reduction of the external germinal layer with increased in age as such the surface area of the next layer which was molecular layer increased, also there was reduction in migrating cells through molecular layer with increased in age of the foetus which was why the molecular become clearer with less cell population as observed by Rakic and Sidman (1970)[12].

The molecular layer was followed by a densely cell (Golgi and granule) packed internal granular layer which progressively increased from first trimester to the third trimester this may be due to the migration of cells from the external granular layer [12][13][15]. In this study the purkinje cells which were in-between molecular and internal granular layer were not seen in the first trimester but were gradually becoming more visible in the subsequent trimesters as it was also observed by Lavezzi *et al*. (2006)[15] in human.

## 5. Conclusion

Base on the above finding, the result shown that the development of cerebellum was found to be in succession i.e from the stages of fissure in the folia undifferentiated zone to the development into differentiated zones of folia, then finally to the developed fissure in the folia, with continous maturity at post-natal stage. These were seen with advancement in gestational age from first trimester through second trimester and to third trimester of age. This study showed that the pattern of cerebellum development is similar to most of the animal species.

## Recommendation

More research needs to be undertaken using different staining techniques and also use of electron microscopy to have clear picture of individual cells of the cerebellum during development.

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