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TRACING THE ORIGIN AND EVOLUTION OF LACTATING CHARACTERISTIC IN MAMMALS

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ABSTRACT

Mammals are morphologically distinct animals with some of the unique features like presence of hairs, mammary glands, heterodont teeth and ear pinnae which are totally lacking in other vertebrates. The origin and evolution of mammary glands have always been a matter of curiosity to resolve. Reptiles being the preceding group of mammals are not known to possess any lactating gland to feed their babies but their specific descendents which were ancestors of mammals might have given rise to this structure. No doubt that the natural selection might have favored this feature in the ensuing mammals making it to be a group characteristic. This article focuses some of the salient points with regard to the origin and evolution of mammary glands that is found invariably in all mammals whether egg laying or viviparous.

KEYWORDS : Mammals, Evolution of mammary glands, Reptilian ancestor

It was Linnaeus who in 1978 first recognized the group of animals characterized with the presence of mammary glands and called them mammals. He grouped four limbed terrestrial mammals with aquatic mammals like whales and dolphins which were earlier considered as fishes. During the course of animal evolution, certain structures originated and diversified in such a way that it poses a challenge to biologist to find out the real organ or tissue of its origin and in what conditions such structures came to existence. Among animal kingdom, mammals are the unique creatures which are characterized with an external glandular structures that secrete milk and use it to feed their young ones. Among birds, evidences are there that shows that some of the birds are able to secrete milk from their crop which they use to feed their newly hatched babies. Since possession of mammary glands is the features of all mammals, one can speculate that even the primitive mammals were capable to lactate. Therefore lactation appears to be an age old reproductive trait that was present in the ancestral mammals (Oftedal, 2002a).

Mammary Glands in Mammals

Existing mammals are distinctly grouped as Prototherians, Marsupials and Eutherians. Prototherians are the primitive mammals that lay eggs. Rest of the mammals like marsupials and eutherian mammals are viviparous i.e. give birth to young ones(McKenna et al. 1997; Nowak, 1999; Springer et al. 2004; Kemp, 2005, 2006; Giallombardo, 2009). Egg laying features and some other primitive characters make prototherians to link its ancestry with reptiles. The surviving prototherians are Duck bill Platypus and Echidna or spiny anteaters. The primitive mammals, also referred as Monotremes have no defined nipples but they do lactate to feed their babies. Milk oozes from their mammary glands via openings in their skin. The babies lick up the milk which is secreted through pores of the skin where it pools up along grooves in the mother's abdomen.

The distribution of mammary glands varies in different groups of mammals in below table. Marsupials may have up to 20 nipples, located in the marsupial pouch that is used to house the young immature babies. Eutherians mammals also possess varying number of nipples in the ventral side of their body. The numbers of teat also vary and may range from 2 to 18. Some of the mammals possess even odd number of glands like Verginia opossum has 13 (Provenzano, et. al. 2008).

Looking on the above table and accumulating more information on the number of teats functionally lactating and the number of offspring born, may give us an idea that animal forms producing more number of litters at a time have more such teats. Rats and pigs produce more than half a dozen of progeny at a time and are expected to feed them unbiased and therefore have evolved more lactating units than those like primates who give birth to one or rarely two.

Although mammary glands are functionally active in lactating mothers only, but in males, like in fruit bats, a functional lactating mammary gland is present. These

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glands in majority of eutherian male mammals are found to show its presence but are rudimentary. In some of the species of mammals, under the influence of hormones even lactation can be induced in the male. Certain males like male mice and horses do not possess mammary glands and nipples (Francis, et al. 1994).

Evolutionary Connections

Homology of organs between or among the organisms is one of the important evidences of evolution. Groups of animals belonging to a single order or family show many features with similar morphological look and form the basis of interpretation of speciation particularly through isolation. Mammals are also good examples where group similarity can be clearly observed. Mammalian distinction from other group of animals for the traits which appear in unique form has always fascinated biologists to accumulate a comparative view on such traits. Convincing evidences with respect to adaptive radiation for specific traits have been put forward. However, appearance of mammary glands in mammals is not an easy issue to be resolved.

Since mammals are the only animals with lactating glands, one can go through their evolutionary lineage to trace the ancient forms with mammary glands. Presently one can scrutinize the fossil forms of ancient mammals to envisage the probable ancestor accomplished with such characters. Mammals are thought to be originated from the Synapsid branch of reptiles. In fact, reptilians have been recognized as Anapsids, Synapsids and Diapsids based on their skull morphology. Traditional classification states that Synapsids include Pelycosaurs and Therapsids which were mammalian ancestors while phylogenetic classification considers that Synapsids gave rise to some reptiles, mammals and birds (Hall and Hallgrimsson, 2008). Early Synapsids were small and slender animals and were prevalent during carboniferous period, which is the time when insects were also evolving on the ground (Grimaldi and Engel, 2005). Fossil biologists have suggested that early forms of Synapsids were insectivorous. Synapsids gave rise to Pelycosaurs and their descendents are Therapsids whose presence could be traced back to Triassic period. During Triassic period a striking diversification of Therapsids occurred and by the beginning of Jurassic/or during Jurassic almost all its lineages had emerged. The fossil forms of ancestral mammal like Dimetrodon has not been useful to trace the presence of lactating glands in it rather it has been used to state the temperature regulating mechanism in such forms due to presence of dorsal sails. Presently we have a number of fossils of Mesozoic mammals and their immediate ancestors. The new molecular techniques have also shed light on some aspects of mammalian evolution by estimating the timing of important divergence points for modern species. Since mammary glands are soft tissues and are not housed in any bony covering, their real presence in fossil remains cannot be traced.

The mammalian ancestors like Therapsids evolved a glandular skin rather than scaled integument. These animals during the long course of adaptive changes accomplished gradual accumulation of all distinct mammalian characters. A number of views have been extended to elucidate origin of the mammary glands and lactation. Although very clear cut, authentic view have not been put forward due to ancestral animals with such features and lack of definite connective links. It seems to happen as a co-evolution because a mother developing such features is ensuring to provide nourishment to new born instantly at birth and at the same time baby has to sense the presence of food nearby and has to show willingness to access to mother to feed. The mammary glands are modified sweat gland that produces milk, a nutritious liquid that helps young mammals to grow.

Some zoologists believe that in ancient forms of premammals/mammals, lactation's original function was to keep eggs moist. Such belief mainly flourishes due to Monotrems which are egg laying mammals (Oftedal, 2002a, b). These mammals do not possess nipples and they secrete milk from a hairy patch on their bellies. During incubation, monotreme eggs are covered in a sticky substance whose origin is not known. The sticky substance may be produced by the mammary glands. Researches indicate that the milk protein, caseins already appeared in the common mammalian ancestor approximately 200–310 million years ago (Borders, and Robertson, 1993). It is

therefore a matter of consideration that the gland secreting substance to keep egg moist attained the function of lactation in ancient mammals. Molecular phylogenetic studies propose that most placental mammals diverged during the Cretaceous period at about 100 to 85 million years ago. However, the existing families mainly diversified during the late Eocene and early Miocene epochs of the Cenozoic era (Bininda-Emonds, et al 2007). Therefore, the initial existing Cenozoic mammals had already possessed lactating glands that modified differently in diverse forms.

All Prototherians show one type of arrangement of mammary glands that differ completely from other mammals. Marsupials have similarity amongst them with respect to organization of mammary glands and lactation. Eutherians with diverse nature of distribution and morphology show varied variation in the structure and distribution of lactating organ. A clear cut explanation for evolution of mammary glands do pose problem to state, particularly for the structural development and variation at the level of sex. Availability of mother close to their new-barns, as a matter of parental care would have been the cause of functional growth of mammary glands in females. The variation in the hormonal secretions in the two sexes with the ability of mother to show lactation would have been a matter of selection of this trait. One theory advocates that the mammary gland is a transformed sweat gland, more closely related to apocrine sweat glands (Oftedal, 2002a, b). Another theory recommends that mammary glands evolved from glands that were used to keep the eggs of early mammals moist, i.e. Lactating on Eggs (Oftedal, 2002a, b). Other theories suggest that early secretions were used directly by hatched young, (Lefevre et. al., 2010) or that the secretions were used by young to help them orient to their mothers (Graves and Duvall, 1983).

Many scientific sources emphasize that mammary glands are modified sweat glands (Moore 2010). Whereas there are certain groups that argue that the mammary glands are sebaceous glands. The evolution of the mammary glands among the mammals has always been a matter of curiosity to comparative biologists. No fossil remains are available in this regard that an authentic link for the evolution of this trait can be formulated. One of the groups of animal that is synapsids are considered to be primogenitors of mammals and can be traced as animals which probably showed such characters. It has been argued that lactation also evolved gradually in early synapsids and that the transformation of proto-lacteal fluid into nutritious milk was correlated with the evolution of other features that descended to modern mammals, such as an elevated metabolic rate, high aerobic capacity, rapid processing of nutrients, and fast growth rates (Oftedal 2002a, b).

Rijnkels (2002) studied the genomic cluster of caseins, the major milk proteins of certain mammals like, humans, cattles and rodents and observed the divergence at the coding level among them. Comparative analysis of genomic sequences harboring the casein gene cluster region of these species shows that the organization and orientation of the genes is highly conserved. The conserved gene structure indicates that the molecular diversity of the casein genes is achieved through variable use of exons in different species and a possible common ancestry for the genes in this region. Kazuhiko Kawasaki et al (2011) investigated exon-intron structures and phylogenetic distributions of casein and other SCPP genes, and based on their findings, they suggested that many slight genetic modifications have created modern caseins, proteins vital to the sustained success of mammals.

CONCLUSION

Mammals are the highest evolved creatures among the animal world. They are hairy animals with profuse power of parental care. They care their babies till the young ones show the ability of independence. One of the features that are feeding babies by mother through her lactating organs is such a unique character that makes these animals fairly distinct from others. A mammary gland is a specific type of apocrine gland which under the influence of hormones manufactures milk to feed babies. The recent developments in the field of development and molecular biology can help to trace the diversification of this organ in different forms of mammals but it still seems to be a challenging task to reveal the real form of animal who for the first time showed a functional lactating organ and could

be considered as a connecting link between reptiles and mammals. Molecular analysis of the milk proteins can also be one of the markers to establish molecular clock of evolution of different mammals as the milk protein/s have accumulated some mutations during the course of evolution. Whatever would have been the reasons for the evolution of this particular trait, it is well understood now that this trait became the group feature only because it ensured the survival of vulnerable kids who keep closeness to the mother for food dependency.

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