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RESEARCH ARTICLE

Bioinformatics field on gene expression during the growth and development of chicken ovarian follicles

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Abstract

Bioinformatics is the acquisition, storage, arrangement, identification, analysis and communication related to biology. It plays a role in the analysis of gene and protein expression. Gene expression is the process by which information from a gene is used in the synthesis of a functional gene product. These products are often proteins, but in non-protein coding genes such as transfer RNA genes, the product is a functional RNA. Main objective of this study was to review the literature on gene expression during the growth and development of chicken ovarian follicles. However, there are few researches have been done on gene expression during the growth and development of chicken ovarian follicle. It is well concluded that the bioinformatics field is very important on gene expression and plays an important role on identifying the functions of different genes which are responsible for growth and development of chicken ovarian follicles.

INTRODUCTION

Bioinformatics is an interdisciplinary area of the science composed of biology, mathematics and computer science (Durbin et al., 2002; Cliford et al., 2004; Xue et al., 2008) and is the application of information technology to manage biological data that helps in decoding organism genomes (Singh et al., 2011). Bioinformatics develops algorithms and suitable data analysis tools to infer the information and create discoveries (Ferrer Costa et al., 2005). Application of various bioinformatics tools in biological research enables storage, retrieval, analysis, annotation and visualization of results and promotes better understanding of biological system in fullness (Durbin et al., 2002). Bioinformatics tools are playing a significant role in providing information about the genes present in the genome species, these tools have also made possible to predict the function of genes and factors affecting these genes (Mooney, 2005). However, gene expression is one of the most important bioinformatics tool (Biggar et al., 2015). According to Shahrezaei and Marquerat, (2015), gene expression is defined as the process by which information from a gene is used in the synthesis of a functional gene product (Durbin et al., 2002). These products are often proteins, but in non-protein coding genes such as transfer RNA genes, the product is a functional RNA (Biggar et al., 2015). The gene expression process plays an important role on identifying the functions of different genes which are responsible for growth and development of chicken ovarian follicles (Shahrezaei and Marquerat, 2015). However, few researches have been done on gene expression during the growth and development of chicken ovarian

follicle. It is very important to know the expression of genes on ovarian follicle during the growth and development. The main objective of this paper was to review literature on gene expression during the growth and development of chicken ovarian follicles.

Gene expression during growth and development of ovarian follicle

General

In all mammals, follicles start to grow from a pool of primordial follicles constituted early in life, continuously throughout the life of the female (Monniaux et al., 1997; Johnson et al., 2015). However, in chickens, it is showing that the primary oocytes enclosed by the vitelline membrane become organized into a primordial follicle following the recruitment of likely granulosa cells (Lei et al., 2014) and the perivitelline membrane is subsequently formed by granulosa cells (Johnson and Woods, 2007). The initiation of primordial follicle growth to the primary follicle stage is associated with the formation of the theca layer which is separated from the granulosa layer by the basal lamina (McLeod et al 2014). Primary follicles range in size from 0.08 to 1 mm in diameter (Monniaux et al., 1997). Further growth to the prehierarchal follicle stage involves the accumulation of lipoprotein-rich, white yolk, plus the differentiation of the theca into internal and external layers (Taniguchi and Watanabe, 2007).

Ovarian follicle development in the chickens

The chickens provide a unique model for the study of the mechanisms involved in follicular development (Zhang et al., 2014). The left ovary contains follicles of various sizes and developmental stages including quiescent primordial follicles, pre-hierarchical growing follicles and large yolk-filled follicles that have been recruited to the well-ordered pre-ovulatory hierarchy. The follicles grow from 3 to 5 mm takes 3 days, from 5 to 8 mm 2 days and from 8 mm to ovulation 6 days with the total time for development from 15 mm to 40 mm being around 17 days (Taniguchi and Watanabe, 2007). As follicles increase in size there is a progressive decrease in the number of follicles in that size class, with the ovary of the laying hen containing 50 follicles between 1 and 8 mm in diameter. The decrease in follicular number is brought about by apoptosis and extensive inter-nucleosomal DNA cleavage has been identified within both granulosa and thecal layers of atretic regressing follicles (McLeod et al., 2014). Characteristically, once follicles grow beyond 9 mm in diameter they are committed to the rapidly growing pre-ovulatory hierarchy and the incidence of atresia is very low (Zhang et al., 2014). The largest follicle designated F1, will ovulate next; upon doing so the second largest follicle (F2) is promoted to this position and will ovulate some 24–26 h later providing the end of an ovulatory 'sequence' has not been reached (Taniguchi and Watanabe, 2007). Following selection into the preovulatory hierarchy, preovulatory follicles quickly grow from 9 mm to 40 mm over the course of days (Johnson and Woods, 2007).

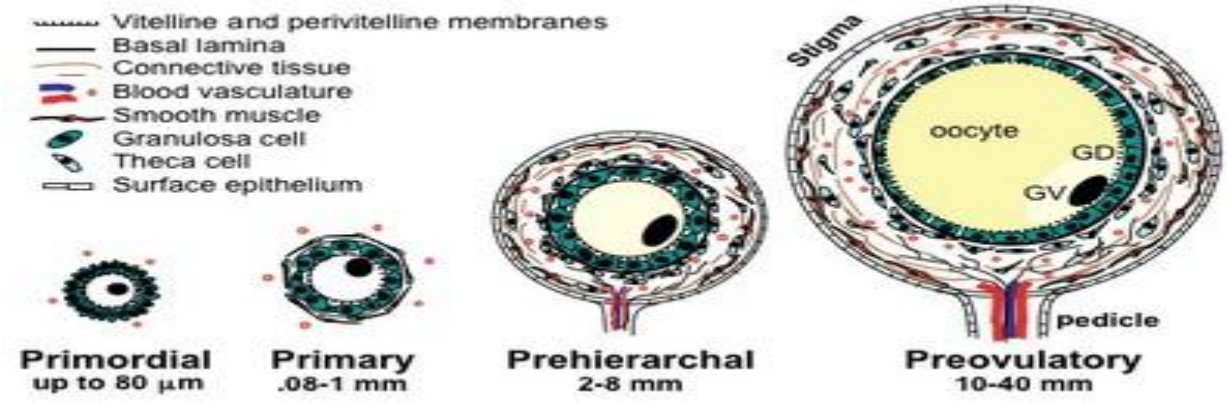

Figure 1: Growth and development of follicles in the chicken ovary (Johnson and Woods, 2007).

2.2 Gene expression on growth and development of chicken ovarian follicles

Many different genes and their functions have been investigated on growth and development of chicken ovarian follicles.

Matrix metalloproteinase (MMP) gene

Matrix metalloproteinase (MMPs) are a specific class of proteolytic enzymes that play critical roles in follicular development and luteinization in mammals. Three MMP genes (MMP1, MMP3, and MMP9) found significantly up-regulated in 23-week-old during egg lay phase of chicken ovaries compared with 6-week-old ovaries (Zhu et al., 2014).

Growth differentiation factor 9 (GDF9) gene

Johnson et al. (2015) conducted a research on domestic chicken: Causes and consequences of an egg a day and indicated that domestic laying chicken has some genes responsible. Growth differentiation factor 9 influences the surrounding cells and follicular development. This gene has been found present in the hen oocyte and influences granulosa cell proliferation. Qin et al. (2015abc) reported that this gene encodes a member of the transforming growth factor-beta superfamily. GDF9 plays an important role in the development of primary follicles in the ovary. It has a critical role in granulosa cell and theca cell growth, as well as in differentiation and maturation of the oocyte. GDF9 has been connected to differences in ovulation rate and in premature cessation of ovary function, therefore has a significant role in fertility. The study concluded that this gene was correlated with heightened hen-housed egg production at 30, 43, 57 and 66 weeks and found that can be associated with hen-housed egg production and egg weight.

Bone morphogenetic factor 15 (BMP15) genes
This gene influences the surrounding cells and follicular development and BMP15 mRNA is most abundant in oocytes of small follicles and stimulates an increase in follicle stimulating hormone (FSH) receptor mRNA in granulosa cells. BMP15 also enhances yolk uptake in growing follicles by decreasing tight junctions between granulosa cells (Johnson et al., 2015).

Leptin receptor (LEPR) gene
Lei et al. (2015) conducted a research on leptin receptor signaling inhibits ovarian follicle development and egg lay in chickens. Their study targeted LEPR by immunizing against its extracellular domain (ECD), and examined the resultant ovarian follicle development and egg-laying rate in chicken hens. This up-regulated apoptotic gene expression in ovarian follicles negatively regulated the expression of genes that promote follicular development and hormone secretion, leading to follicle atresia and interruption of egg lay.

Vacuolar protein sorting 36 (VPS36) and cytoskeleton associated protein 2 genes
According to Xinxing et al. (2014), on the study of expression pattern and regulation of head-to-head genes *Vps36* and *Ckap2* during chicken follicle development reported that these two genes play a vital role. These genes encode a protein that is a subunit of the endosomal sorting complex required for transport II (ESCRT-II). This protein complex functions in sorting of ubiquitin membrane proteins during endocytosis. In this study small white follicles were found to have significantly higher expression of *Vps36* mRNA than any other sized follicles. The expression of *Vps36* mRNA was detected in both granulosa and theca layers of pre-ovulatory follicles. It is concluded that the head-to-head genes of *Vps36* and *Ckap2* exhibit similar expression in chicken follicles and are involved in chicken follicle development.

Fork head box L2 (FOXL2) gene
Qin et al. (2015abc) under the study of association of novel polymorphisms of fork head box L2 and growth differentiation factor 9 genes with egg production and traits in local Chinese Dagu hens. This gene can act as potential genetic markers for egg production in Chinese Dagu chicken breeding and found significantly correlated with a heightened hen-housed egg production at 30, 43, 57 and 66 weeks of age and increased egg weight at 43 week of age.

Conclusion

It is well concluded that the bioinformatics field is very important on gene expression and plays an important role on identifying the functions of different genes which are responsible for growth and development of chicken ovarian follicles. However, many studies need to be been done on gene expression during the growth and development of chicken ovarian follicle. During the growth and development of chicken ovarian follicles the knowledge of gene expression is very important.

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