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Study Progress of Intergeneric Hybridization between Chicken and Quail

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Abstract

In the present paper, we reviewed intergeneric hybridization between chicken and quail from four aspects, such as morphology, molecular genetics, sex identification of earlier embryos and prospects, summarized the recent research progress from the scholars at home or abroad, and aimed to attract more and more attention to intergeneric hybridization between chicken and quail, offer more space and room for other researchers to consider and develop, and lay a foundation for the exploitation, protection and utilization of China genetic resources.

Keywords: Chicken, Quail, Intergeneric hybridization

1. Introduction

Protein human being need principally came from products of meat, eggs, milk and so on, and poultry meat topped the list of domestic meat. Along with economic globalization and market economization, poultry meat has attracted more and more attention. Cases that new products obtained by distant hybridization have been used for produce and life are not seldom. There are not only precedents of offspring between horse and donkey, namely mule in the earlier stage, but also new strains of liger with scientific and ornamental values at present.

Intergeneric hybridization between chicken and quail had been tested successfully in USA (Hua, 1983, PP. 35-36), Japanese (Ahmad, 1989, PP. 2-5) and Malaysia (Liu, 1986, PP. 101-108) successively, and A successful straight crossing test was performed (chicken ♂× quail ♀ hybridization) in experimental station of Shihezi University in China on Oct. 1992, which filled a domestic gap in this field (Wang, 1979, PP. 1-5). Through distant hybridization approach, hybrids combined with excellent characteristics from parents, such as better suitability, and some biological functions for growth, development, propagation and so on. Hybrids not only possessed the characteristics of rapid growth and large body type of male parent, but also early maturity and delicious flesh of female parent. Therefore, it was a perfect flesh product over parents. Accordingly, research and development on hybrids of poultry would be of profound scientific significance with market prospects.

2. Morphology studies

Chen et al(2005, PP. 36-37) have measured body size and carcass traits of adult quail, layers, black-bone chicken and

hybrids, and applied one-way analysis of variance to reveal that hybrids were different from both of chicken and quail, and were intergeneric hybrids between those two. Through SSR multiple comparative law, it was revealed that each characteristic of hybrids was more similar to female parent of quail. Differences between the same samples resulted from excessive variance which enveloped the variance between hybrids and quail due to multiple comparison. According to the calculation methods of Qiu, each adulthood poultry habitus index, namely the percentage of organ weight to live weight or carcass weight was measured, indicated their carrying genetic and biological information, in agreement with the result of Zhao et al(2005, PP. 22-23) using one-factor analysis of variance, which fully reflected hybridization efficiency.

Yu et al(2003, PP. 25-28) had assayed the weight, relative growth speed, absolute growth speed, accumulative growth speed of quail, layer, black-bone chicken and hybrid ranged from 1 to 10 weeks. Results showed that growth-development law of hybrids possessed not only the rapid growing of male parent, but also early maturity of female parent, exceeding both parents, which was in agreement with the results of Zhao et al(2005, PP. 22-23) and Liao et al(2006, PP. 4634-4636).

F. Minvielle have investigated plumage color heredity of hybrids, and found that plumage color of hybrids integrated the color of parents when plumage color of parents was dominant inheritance while didn't express recessive plumage color when plumage color of parents was recessive inheritance. Research of Li et al (2003, PP. 11-13) showed that hybrids between chicken and quail inherited principal characters of parents in body size, and also showed some novel properties. Plumage color of hybrids between chicken and quail was mostly white or reddish brown. When black-bone chicken used as male parent, plumage and bone color of hybrid offspring showed a uniform variation, viz. dark brown plumage black shank, and black and white plumage yellow shank. Therefore, solid foundation could be established for poultry identification through positioning control of plumage color genes.

3. Molecular genetics studies

Hybrids chromosome number was 2n=78, and its sex determination were ZZ(♂) and ZW(♀). As for sex determination of silkworm, male was ZZ, and female was ZW, with balanced sex linked lethal. If hybrid poultry had lethal genes in Z chromosome, it would be responsible for female embryo death, which was not yet convinced at present.

Yoshihiro(1982, PP. 53-54) reported that embryos of fertilized eggs died after 3-5 days, and died totally after 5-8 days, which revealed that combination with different sperm eggs couldn't obtain rational incubation, and could possibly result in hybrid sterility or unisexual sterility due to chromosome recombination and partnership of different poultry. Zhao et al (2005, PP. 10-15) had found that most hybrid embryos died during the early stage of growth, and death period centralized after 2.8 to 4 days. Among them, majority was female with less death during the late stage.

Straight crossing combination has been made successfully between mountain dark-bone chicken black plumage lines(♂), or parents of Hongbao yellow plumage broiler and quail(♀) in Sichuan Agriculture University. Combination between new roman layers (♂) and Japanes(♀), silky black-bone chicken(♂) and quail(♀) successfully had their hybrids respectively in the experimental station of Shihezi University in Sep. 1999. Results convinced the feasibility of straight crossing among these five poultry species.

Until now, reports of reverse crossing combination (quail ♂× chicken ♀) were not documented yet. Zhao et al(2003, PP. 13-15) had studied the genital tracts of female layers and quails, and results showed that structure, pH value, conductance and internal secretion of female chicken genital were different from quail's, but this difference had no affection on the performance and survival of sperms. Less time for the combination of heterogeneous germ cells was one of the causes for reverse crossing failure. Whether for straight crossing or reverse crossing, germ cells among different genus could all combine, but female genital tract didn't block completely the passing and capacitating of sperms in heterogeneous poultry.

Song found that the karyotype of No.1 and No.2 chromosome in muscovy duck and domestic duck was responsible for hybrid sterility. Sun et al(2007, PP. 4152-4153) had studied the morphology of hybrid chromosome, and found that discrepancy among No.1, No.4, No.6, and No.8 chromosomes could possibly lead to sterility resulting from the failure of good match during the period of chromosome meiosis. Phenomena, namely robertsonian ectopia and closely related interspecific karyotype inversion were quite universal in bird chromosomes. Stock considered that inversion could prevent abroad interspecific hybridization, which might be responsible for sterility.

Liao et al (2006, PP. 4634-4636) had calculated mitochondrial DNA (mtDNA) size of each poultry by using Lab Works TM Software. For instance, chicken was 19.1 kb, quail was 16.9 kb and hybrid was 16.9 kb. Li et al (2003, PP. 185-189) have analyzed the mtDNA of chicken, black chicken, quail and their hybrids, and their genetic effect, and results indicated that mtDNA of hybrids was completely identical to their female parents, and quite different from their male parents. All these results suggested that extranuclear genomes of hybrids and male quail showed a high consistence-maternal inheritance.

Differentiation of bird embryo gonads was affected by sex hormones at the early stage. Estrogen was associated with

ovary differentiation, genital tracts feminization and external genital organs. Jane (1997, PP. 182-190) reported that estrogen receptor(ER) expression was earlier than gonad differentiation, and estrogen played a permanent role in bird gender differentiation. Aromatase was expressed during the process of bird gonad differentiation, and gonads at both sides could respond to estrogen before sex differentiation. ER expression of female embryos was higher than that of male ones in sex differentiation, and remained such situation after differentiation period. Gonads distributed in both sides of female and male embryos with more in the left sides. All the facts indicated that estrogen expression was mediated and regulated by ER. Research of Tang had detected ER related antigen mRNA expression, and this gene expressed ER protein. Craig(1997, PP. 295-302) had found that ER expression site was only limited to gonads within 5.5 days of chicken embryo growth, and ER expression level was higher in female embryo than in male one during the sex differentiation period (5.5-6.5days). Taken together, according to incubation period, it could be speculated that hybrid sex differentiation occurred in 3-5days or so of incubating, in line with the time of embryo early death, namely that early embryo death was associated with its sex differentiation and ER expression level. Study of Li et al(2007, PP. 1311-1315) indicated that hybrid sex differentiation occurred approximately in 2.75-3.50days, which was in agreement with the results of Liao et al and Yu et al.

Qiao et al and Liao et al(2008, PP. 1311-1315; 2008, PP. 907-912) had investigated Bcl-2 and P53 expression in early embryos, examined the early growth of male and female hybrid embryos at different time points, and results showed that there was no statistical difference among different days. It suggested that Bcl-2 and P53 played a significant role in the growth and development of chicken early embryos, in line with Tang's observations that embryo death peak occurred after 69-72h. As seen from his research, it might be related to the disorders appeared in the cell apoptosis signal transduction pathway. All these researches laid a solid foundation for searching cell apoptosis causation during embryo period.

4. Studies of early embryo sex identification

Intergeneric hybridization between chicken and quail, similar to other distant hybridizations, also faced the issues such as heterogeneous germ cell incompatibility, hybrid offspring sterility and so on. Yoshihiro (1982, PP. 53-54) had found the first filial generation brood embryo after 3-5 days' incubation had males and females, while the following embryos were totally males through cytologic examination at the subsequent stages and females all died in his investigation of sexual proportion among hybrids between chicken and quail, which was in agreement with the reports of many researchers in China.

With the rapid development of functional genomic technology, it was possible to reveal embryo early death mechanism resulted from intergeneric hybridization incompatibility between chicken and quail from the angel of gene. Before seeking for approaches to reveal the real causation for early embryo death, it was very important to figure out the gender of early embryo hybrid. In order to overcome the hybridization incompatibility between chicken and quail, discovering lethal gene became one of the premises for important studies.

Currently, excellent effects have been acquired using repeats, SRY, ZFX, ZFY and so on in mammalian Y gene to undertaken sex identification. Ogawa had cloned a section of non-repeated DNA fragment (EE0.6) from chicken W chromosome gene pool. Ellergren have separated chicken highly conservative CHD-W gene which could be used as an extensive genetic marker to identify all non ratites.

Hori had found Wpkci/ASW gene located in the end of W chromosome which was highly conservative in the evolution of non ratites, highly expressed in the female embryo of early growth, and had a 65% homology with ckPKCI gene located in acrocen-tric long arm of chromosome Z. Study of Shunsuke indicated that Wpkci and ckPKCI formed heterodimer, and inhibited biological function of chPKCI in vitro, which confirmed the deduction of Hori-Wpkci gene could possibly play a special role in deciding the gender of non ratites.

In order to establish a simple, rapid, reliable and stable method to identify the gender of hybrid early embryo, Liu et al(2007, PP. 9-12) selected embryos during the period of centralized death (2.50-5.00d) as samples, using RT-PCR, and preliminarily estimated that hybrid embryo with two particular bands was female while male with no bands. CDNA fragments of double genes, viz. Wpkci and β-actin were amplified from unknown gender hybrids between chicken and quail. Three bands of 490bp, 402bp and 296bp displayed female while one band of 490bp displayed male. In order to validate its reliability and stability, further experiment using single Wpkci gene to identify the gender of hybrid embryo was performed, and results were in agreement with previous investigation.

Qiao et al (2008, PP. 1311-1315) further validated the investigation results, and first used single Wpkci gene to identify the gender of hybrids between chicken and quail. After χ^2 test, the proportion of male and female embryos was unbalanced, and male was significantly more than female. Mortality of early male was greatly significantly higher than that of female, in line with previous studies.

5. Prospects

Intergeneric hybridization between chicken and quail was the typical representative of animal distant hybridization, and

its hybrids integrated their parents' characteristics such as body form, meat-producing, flesh and so on. In the present trail of intergeneric straight crossing between chicken and quail, fertilization and hatching rate was low, and hybrids obtained were all male of unisexual sterility. Sperm egg of reverse crossing combination could fused, but until now no reports on their hybrids was available, which was the inhibitory factors for people to understand, develop scientific research, and implement large extension and production.

Mechanism investigation of hybrids during the period of embryo and early fertilization would be the critical procedure to solve those issues. If successful, it could offer important theory basis and excellent animal model for the researches of animal distant hybridization.

References

Ahmad, M. (1989). Hybrids between chicken and quail. *Animal Science Abroad-Pigs and Poultry*, 5(2):2-5.

Chen, H., Zhao, Z.S., & Jiao, L.P., et al. (2005). Body size and carcass traits measurement for chicken(♂) quail((*)) and their hybrids. *Heilongjiang Animal Science and Veterinary Medicine*, (4):36-37.

Craig, A.S., Jane, E.A., & Andrew, H.S. (1997). Gonadal sex differentiation in chicken embryos; expression of estrogen receptor and aromatase genes. *Journal of Steroid Biochem Molec Bio*, 60(5-6):295-302.

Hua, G.X. (1983). Sexual proportion among hybrids between chicken and quail. *Animal Science Abroad-Pigs and Poultry*, 1(6):35-36.

Jane, E.A., Craig, A.S., & Andrew, H.S. (1997). Sites of estrogen receptor and aromatase expression in the chicken embryo. *General and Comparative Endocrinolog*, 108:182-190.

Li, D.Q., Zhao, Z.S., & Liao, H.R., et al. (2003). Studies on generic hybrids of chicken-quail. In Chen, Y.S. (Eds), *Advances on animal genetic and breeding researches in China-the 12th national animal genetic and breeding conference proceedings*. Beijing: Chinese Agricultural Science Press, PP. 185-189.

Li, Y., Qiao, A.J., & Ma, W.X., et al. (2007). Effect and different expression of ER gene in early embryos of generic hybrids of chicken-quail. *Chinese Journal of Animal and Veterinary Sciences*, 38(12):1311-1315.

Li, Y., Zhao, Z.S., & Sun, J., et al. (2003). Observation on the biological character in chicken-quail hybrids. *Heilongjiang Animal Science and Veterinary Medicine*, 11:11-13.

Liao, H.R., Li, Y., & Guo, X.L., et al. (2008). Expression of ER, bcl-2, and p53 mRNA in early hybrid embryos of chicken-quail. *Hereditas*, 30(7):907-912.

Liao, H.R., Zhao, Z.S., & Li, Y., et al. (2006). Study on genetic effect of chicken-quail hybrids. *Journal of Anhui Agricultural Sciences*, 34(18):4634-4636.

Liu, G.L., Qiao, A.J., & Ma, W.X., et al. (2007). Establishment and optimization of sexual identification system of early-stage embryos from generic hybridization between chicken and quail. *China Poultry*, 29(6):9-12.

Liu, J., & Zhou, G.J. (1986). Cytological study on the gonadal development of F1 hybrid produced by crossing *Carassius auraturs L.* (♀) with *Cyprinus carpio*(■). *Acta Hydrobiologica Sinica*, 10(2):101-108.

Qiao, A.J., Ma, W.X., & Li, D.Q., et al. (2008). Identification of sex earlier embryos from generic hybrids of chicken-quail using gene wpkci. *Scienctia Agricultura Sinica*, 38(12):1311-1315.

Sun, Y.Q., Zhao, Z.S., & Meng, Q.M., et al. (2007). Karyotype analysis of chicken-quail hybrids. *Journal of Anhui Agriculture Sciences*, 35(14):4152-4153.

Wang, C.Y. (1979). Achievements of Chinese animal genetics for 30 years. *Hereditas*, 1(6):1-5.

Yoshihiro, T. (1982). The sex ratio of chicken quail hybrids. *Japanese Poultry Science*, 19(1):53-54.

Yu, C.M., Zhao, Z.S., & Li, Y., et al. (2003). Early growth performance measurement for chicken(♂) quail((*)) and their hybrids. *Journal of Shihezi University (Natural Science)*, 7(1):25-28.

Zhao, Z.S., Li, D.Q., & Jiao, L.P., et al. (2005). Determination of body size and meat traits of poultry generic hybrid progeny and their parents. *Chinese Journal of Animal Science*, 41(2):22-23.

Zhao, Z.S., Li, D.Q., & Sun, J., et al. (2005). Studies on the cross experiment and the mtDNA genetic polymorphism in chicken-quail hybrids. *Chinese Journal of Animal and Veterinary Sciences*, 36(1):10-15.

Zhao, Z.S., Li, D.Q., & Yu, C.M., et al. (2003). Studies on operating and survival time of sperm in other female interliner poultry genital tract. *Heilongjiang Animal Science and Veterinary Medicine*, 11:13-15.