Immunocompetence index selection of broiler chicken lines for disease resistance and their impact on survival rate

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Abstract

Aim: This study was aimed to develop the disease resistance broiler chicken lines over two generations (G_0, G_1 and G_2) of selection for immunocompetence (IC) index by targeting all the facets of immune response traits viz., humoral response (HR) to Sheep red blood cells (SRBC), cell mediated immune response (CMI) to phytohaeagglutination- P mitogen (PHA-P), levels of serum serum immunoglobin- G (IgG) and serum lysozyme (LZM) level.

Materials and Methods: The SDL Synthetic Dam Line (SDL) broiler line consisting of 303, 204 and 300 birds in G_0, G_1 and G_2 generations, respectively were screened for immunocompetence traits such as humoral response to SRBCs, cell mediated immune response to PHA-P and levels of serum lysozyme by Lysoplate assay and IgG by SRID method, and ranked based on their IC index values.

Results: The percent survival rate up to 6 weeks of age in SDL broiler chicken lines were selected for high immuno-competence index (HIC) and low immunocompetence index values (LIC) over two generations (G_0, G_1 and G_2) of selection and observed that significant differences (P< 0.05) in percent survival pattern in the base population (n= 303) with the highest survivability of 100.00% was observed in 5-6 weeks of age followed by 99.37% and 97.23% in 4-5 and 0-4 weeks of age respectively. In the G_1 generation, significant differences (P<0.01) was noticed in the selected high and low index lines up to 6 weeks of age with the overall survival rate lower in high index lines (93.10%) as compared to the low index lines (97.62%). Whereas the reverse trend was observed in the G_2 generation that the high index line had significantly (P<0.05) higher survival percent (98.62%) as compared to the low index lines (97.93%). Moreover, the overall survival rate was better substantially over the two generations of divergent immunocompetent index selection of SDL broiler chicken lines. The present investigation revealed that breeding for better immunocompetence status by selection index could lead to better health status in term of improved survival rate in broiler chicken over the generation of selection and further suggested that index selection for more number of generations coupled with economic traits would seem to be a viable option for development of disease resistant chicken lines.

Conclusion: Breeding for overall genetic improvement of immunocompetence status by index selection with all the facets of immune system could lead to better survival rate and development of disease resistant chicken.

Keywords: breeding, immunocompetence, index slection, survival rate

Introduction

Mortality has always been a great concern in poultry flocks. Re-emergence of the poultry diseases cause huge losses to the poultry industry. It is desirable to have disease resistant strains having better genetic combination in association with beneficial traits, for increased fitness to the subsequent generations. In case of natural selection, genetic improvement is slow but constant; whereas in artificial selection, the genetic improvement for single or more traits will bring about noticeable improvement in few or more generations [1-2]. Immunity for disease resistance is a complex genetic trait that is multifaceted [3]. Selection based on an index, combining several immunocom-petence traits seems a viable preposition [4-5]. The modern broiler breeding programme therefore should give due consideration to the general health status of the birds. Conventional vaccination program coupled with the modern managemental practices strive to protect the birds from many pathogens. However, the lapses at various levels and/ or the change in pathogenicity of causative agents, development of resistant strains of pathogens, medicinal treatments are often ineffective causing severe economic losses, which necessitate the need for improving the genetic resistance [6]. Genetic variability exists in chickens for immune response to specific antigens [7-8], allowing for moderate genetic response to selection for both increased and decreased titer [9-10] and considerable evidence of polygenic inheritance of humoral and cellular immunity in responses to selection for antibody response to various antigens. Multiple genetic factors have been found to affect the immune response and disease resistance in chicken [11]. Hassan *et al* [12] compared the effects of

infection with Newcastle disease virus and infectious bursal disease virus on four Egyptian chicken breeds and found that Mandarah chickens showed less susceptibility than the other breeds to both diseases, indicated by significantly lower mortality rates following artificial infection. Survival rate under selection for improvement of an immunocompetence status in broiler chicken lines are not well studied and very scanty information is available using immuno-competence index selection.

Keeping the above in view, the present investigation is aimed to fill this gap in knowledge by studying the overall natural survival patterns of the divergently selected broiler chicken lines for improved immunocompetence status over two generations.

Materials and Methods

Ethical approval: The present study was approved by the Animal Ethics Committee of the IVRI, Izatnagar. UP, India.

A Synthetic Dam Line (SDL) of broiler chicken, evolved by crossing of pure lines viz., White Plymouth Rock, White Cornish, maintained as closed flock with 30 sire base at Experimental Broiler Farm, Central Avian Research Institute, Izatnagar, (U.P), India were utilized in the present study. A base population of 303 birds, consisting of 183 females and 120 males were screened for various immunocompetence traits, using protocols reported earlier [5]. All the birds were ranked on the basis of IC index constructed by combining these traits by giving equal economic weightage to all these traits. About 5-6 males and 30-36 females at the high and low index values birds were chosen as parents of G_1 high immunocompetence index (HIC) and low immunocompetence index values (LIC) index lines, respectively. The selected high and low lines were bred within the lines by artificial insemination and produced first generation (G_1) offspring. In G_1 generation, 92 chicks in high and 112 in low IC index lines were obtained. Similarly, parents of G_2 generation were selected in the respective lines and 152 and 148 chicks of high and low IC-index lines, respectively were obtained in G_2 generations for this study. Details on incubation and hatching, vaccination, management and feeding etc. are reported previously [5].

Recording of survival rate: Mortality rate was recorded on a daily basis in base population as well as in divergent IC-index lines in G_1 and G_2 generations up to 6 weeks of age. Post Mortem inspection was conducted at Veterinary Pathology Department, Indian Veterinary Research Institute, Izatnagar, UP to find the cause of the death. The survival rate of the healthy population was also recorded for the developed lines without killing the birds.

Statistical analysis: The survival rate in each line was recorded and presented as percentage. The comparison between groups was done by Chi square test.

Results and Discussion

The percent survival rates of SDL broiler chicken lines up to the market age (6 weeks) were selected for high and low immunocompetence index by combining HMI, CMI, IgG and LZM traits over two generations (G_0, G_1 and G_2) of selection are presented in table 1. Significant differences at 5% (P<0.05) in percent survival pattern was observed between the ages at 0-4, 4-5 and 5-6 weeks of age with 97.23%, 99.37% and 100% respectively, thus indicating that the survival rate is influenced by different genetic and environmental factors such as feed, water, vaccination, exposure and or outbreak of diseases, stress and genotype x pheno-type interactions etc [13]. Moreover, the higher survival rate was noticed in the market age at 5-6 weeks of age as compared to the initial period, indicating that the immunity development is not fully developed in very young chicks [14].

HIC and LIC lines of G_1 generation had significantly better survival rate in all weeks of age. Comparatively, the low lines (97.62%) had better survival rate as compared to the high lines (93.10%). A significant difference (P<0.05%) was observed between high and low IC-index lines only at 4-5 weeks of age in G_2 generation wherein the high lines had better survival rate (98.71%) as compared to the low lines (97.93%). Moreover, the overall increase in the survivability of the selected lines over two generations of divergent selection at all the weeks of age showed a positive correlation with the direction of selection in favor of high IC- index lines as compared to the low lines. As per the expectation, the present findings also revealed that the higher immunocompetent status chicken lines show better survivability as compared to the lower lines and had almost more than 99.00% survival rate was observed from 5 weeks of age indicating that the possibility of passive development of immunity begins after 4 weeks of age coupled with maternal antibodies [14]. Similar to the present study, previously studies have been reported for long-term selection experiments to single antigen such as Sheep RBC (SRBC) [4], for immune response to IBDV vaccine [15], for immune response New Castle Disease vaccine [5] and for Marek's Disease Virus [16] and for immune response E.coli [17], that had resulted in significant differences in immune responses and viability between the selected lines. Similarly, Hassan et al., [16] compared the effects of infection with Newcastle disease virus and infectious bursal disease virus on four Egyptian chicken breeds, and found that Mandarah chickens (a dual purpose breed developed through cross-breeding) showed less susceptibility than the other breeds to both diseases, indicating significantly higher survival rates following artificial infection.

The present investigation showed that the overall survival rate was improved after two generation of selection in both the lines (from 93.1 to 98.71 and from 97.62 to 97.93 in high and low lines, respectively)

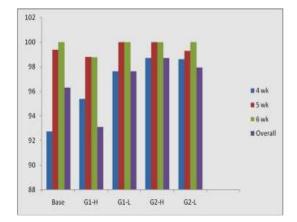Figure-1. Survival patterns of SDL broiler lines over two generations immunocompetence index selection

Table-1. Percent survival rate in SDL of broiler chicken up to 6 weeks of age in base population and high and low IC-index lines over two generations of divergent selection based on IC-index

Generations	Lines	Period			Overall (0-6 weeks)
		0-4 weeks	4-5 weeks	5-6 weeks	
Base (n= 303)		97.23[a]	99.37[b]	0.0[c]	96.31
G1 Generation	High IC-Index line (n= 92)	95.40[A]	98.80[A]	98.78[A]	93.1[A]
	Low IC-Index line (n= 112)	97.62[B]	100.00[B]	100.00[B]	97.62[B]
G2 Generation	High IC-Index line (n= 152)	98.71	100.00[B]	100.00	98.71[B]
	Low IC-Index line (n= 152)	98.62	99.30[A]	100.00	97.93[A]

Comparisons were made among periods in base population, between lines within each period as well as in overall in each generation. Means bearing common superscript do not differ significantly (P<0.05)

(Figure-1). These results were in agreement with earlier report [18] that reportedan increase in the general survivability of the chick's belonging to high humoral response line as compared to low line based on antibody response to *E.coli* response. Also it was found that a line of birds selected for low immune response was more susceptible to infections from endemic bacteria and external parasites when placed in a low stress environment, but the high line in a high stress environment was more susceptible to viral infections [19].

Moreover, some researchers [2,20-21] also suggested that selection for identification of candidate genes related to desirable physical or behavioral characteristics and biological traits will lead to high production efficiency and optimal welfare of the birds. The present study revealed a positive correlation for immunocompetence index selection for overall increases in the percent survival rate of the HIC lines and further suggested that to include all the facets of immune system without compromising production traits for more numbers of generations would lead to better well-being/ survivability of the chicken lines.

Conclusion

The present investigation revealed a better survival rate in both the HIC (98.71%) and LIC lines (97.93%) over the two generations of selection as compared to the G_1 (93.10 in HIC and 97.62% in LIC) and G_0 population (96.31%), indicating that the breeding for better immunocompetence status by combined selection index that includes almost all the facets of

immune system such as HMI, CMI, serum IgG and lysozyme levels, could lead to better health status in term of survivability in SDL broiler chicken lines. Further, the immunocompetence selection index would be a viable option for the development of disease resistant chicken lines, keeping in view of the economic traits.

Authors' contributions

SK conceptualized and designed the PhD dissertation work of GKS. GKS has carried out the research work. SG and GKS drafted and approved the final manuscript. Both author read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

References

1. Christina, L. S., Pevzner, I. Y., He, H., Genovese, K. J., Nisbet, D. J., Kaiser, P. and Kogut M. H. (2009) Selection of broilers with improved innate immune responsiveness to reduce on-farm Infection by foodborne pathogens- A Review, *Foodborne Pathogens and Disease, 6*(7): 777- 783. DOI: 10.1089=fpd.2009.0307.
2. Cheng, H. W. (2010) Breeding of tomorrow's chickens to

improve well-being- A Review, *Poult. Sci,* 89: 805– 813. doi: 10.3382/ps.2009-00361.

3. Bolhuis, J. E., Ellen, E. D., Van Reenen, C. G., De Groot, J., Ten Napel, J., Koopmanschap, R., De Vries-Reilingh, G., Uitdehaag, K. A., Kemp, B. and Rodenburg T. B. (2009) Effects of genetic group selection against mortality on behaviour and peripheral serotonin in domestic laying hens with trimmed and intact beaks- A Review, *Physiol. Behav.,* 97: 470– 475.

4. Sivaraman, G. K., Kumar, S., Saxena, V.K., Singh, N.S. and Shivakumar, B. M. (2005) Genetics of immunocompetent traits in broiler chicken. *Bri. Poult. Sci,* 46 (2): 169- 74.

5. Sivaraman, G.K. and Kumar, S. (2010) Kinetics of antibody response to NDV vaccine in specialized broiler chicken lines divergently selected for immunocompetence index. *J. of Appl. Ani. Res,* 37: 167- 169.

6. Sudheesh, P. S., Ghabshi, A. A., Mazrooei, N. A. and Habsi, S. A. (2012) Comparative Pathogenomics of Bacteria Causing Infectious Diseases in Fish- A Review, *J. of Evol. Biol,* Volume 2012, Article ID 457264, 16 pages doi:10.1155 /2012/457264.

7. Wijga, S., Parmentier, H. K., Nieuwland, M. G. and Bovenhuis, H. (2009) Genetic parameters for levels of natural antibodies in chicken lines divergently selected for specific antibody response. *Poult. Sci,* 88(9): 1805- 1810. doi: 10.3382/ps.2009-00064.

8. Kaiser, P. (2010) Advances in avian immunology-prospects for disease. *Avi. Path,* 39(5): 309- 324.

9. Zhao, X. L., Honaker, C. F. and Siegel, P. B. (2012) Phenotypic responses of chickens to long-term selection for high or low antibody titers to sheep red blood cells. *Poult. Sci,* 91(5): 1047- 56. doi: 10.3382/ps.2011-01892.

10. Hu, Y. D., Wen, J., Zheng, M. Q., Liu, R. R., Chen, J. L., Zhu, Q. and Zhao, G.P. (2012) Correlated responses to bi-directional selection for sheep red blood cells titer in White Leghorns. *J. of Ani. and Vet. Adv,* 11(6): 2879- 2884.

11. Jie, H. and Liu, Y. P. (2011) Breeding for disease resistance in poultry: Opportunities with challenges- A Review, *World's Poultry Science Journal,* 67 (04): 687- 696. DOI: http://dx. doi.org/10.1017/S0043933911000766.

12. Hassan, M. K., Afify, M. A. and Aly, M. M. (2004) Genetic resistance of Egyptian chickens *to infectious bursal disease* and *Newcastle disease. Tropical Animal Health and Production,* 36(1): 1– 9.

13. Hamal, K. R., Burgess, S. C., Pevzner, I. Y. and Erf, G. F. (2006) Maternal Antibody Transfer from Dams to Their Egg Yolks, Egg Whites, and Chicks in Meat Lines of Chickens. *Poult. Sci,* 85: 1364– 1372.

14. Staszewski, V. and Siitari, H. (2010) Antibody injection in the egg yolk: maternal antibodies affect humoral immune response of the offspring. *Functional Ecology,* 24: 1333-1341.

15. Sivaraman, G.K and Kumar S. (2006) Immunoresponsive-ness to IBDV vaccine in SDL broiler chicken lines divergently selected for Immunocompetence index. *Ind. J. of Poult. Sci,* 41(1): 21- 25.

16. Gimeno, I. M. (2008) Marek's disease vaccines: a solution for today but a worry for tomorrow? - A Review, *Vaccine,* 26(S3): C31- C41.

17. Parmentier, H. K., Walraven, M. and Nieuwland, M. G. B. (1998) Antibody response and body weights of chicken lines selected for high and low humoral responsiveness to sheep red blood cells. 1. Effect of *E.coli* lipopolysaccharide. *Poult. Sci,* 27: 248- 58.

18. Sivaraman, G.K and Kumar, S. (2012) Genetic selection of broiler chicken lines for disease resistance and their impact on health conditions. In: *XXIX Annual Conference and National Symposium of Indian Poultry Science Association,* Hyderabad, India, pp.19.

19. Kim, C. D., Lamont, S. J. and Rothschild, M. F. (1987) Genetic association of body weight and immune reponse with major histocompatibility complex in White Leghorn chicks. *Poult. Sci,* 66: 1258- 1263.

20. Ellen, E. D., Visscher. J., Van Arendonk, J. A. M. and Bijma, P. (2008) Survival of laying hens: Genetic parameters for direct and associative effects in three purebred layer lines. *Poult. Sci,* 87: 233- 239.

21. Laible, G. (2009) Enhancing livestock through genetic engineering—Recent advances and future prospects- A Review, *Comp. Immunol. Microbiol.,* 32: 123–137.

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