Biotechnology in Animal Husbandry 30 (2), p 303-311, 2014
Publisher: Institute for Animal Husbandry, Belgrade-Zemun
ISSN 1450-9156
UDC 636.5
DOI: 10.2298/BAH1402303H

HETEROSIS EFFECT IN HYBRID LAYING HENS

P. Hristakieva, M. Oblakova, M. Lalev, N. Mincheva

Agricultural institute - Stara Zagora,6000, Bulgaria
Corresponding author: pavlinahristakieva@abv.bg
Original scientific paper

Abstract: The new original egg laying lines T, P and N selected at the Institute of Agriculture – Stara Zagora were used. Hybrid T♂ × P♀, P♂ × T♀ crosses were obtained and used for paternal line. Thereafter, the following breeding schedule of paternal and maternal lines was applied: Group I – (P♂×T♀)♂ ×N♀; group II – (T♂×P♀)♂ ×N♀; group III – T♂×N♀; and group IV – P♂×N♀. The production traits of original and hybrid birds were recorded: live weight at the age of 8 and 18 weeks, age of sexual maturity in days, 150 days egg production, average egg weight – at 2-week intervals until end of lay; livability, heterosis effect. The live weights of hybrids at 8 and 18 weeks of age were statistically significantly lower compared to original lines. The values of heterosis for this parameter were negative for all four hybrid combinations. The earliest beginning of egg lay occurred in (T♂×P♀) ♂ ×N♀ (162.08 days of age) and P♂×N♀ (163.11 days of age). The relative (%) heterosis for age of sexual maturity of studied hybrid combinations had moderate to low negative values. Average egg weights of hybrids were higher and the values of heterosis – positive for all four groups varying from 0.97% to 1.63%. The average 150 days egg production was lower in purebred lines compared to hybrids. The highest average 150 days egg production was determined in P♂×N♀ hybrids – 142 eggs. The heterosis effect for egg production in hybrids was significant.

Key words: crossbreeding, laying hens, heterosis, egg production

Introduction

The production of hybrid birds is essential for attaining high productivity from modern egg laying hens. Several crossbreeding methods are used for production of hybrids: between breeds, between strains (two-line, three-line and four-line) and combined crossbreeding, which results in heterosis.

Heterosis is a complex biological event, usually seen in first-generation crosses (F_1) and is characterised by increased livability and productivity (*Belorechkov, 2004, Szwaczkowski et al., 2003).*

The effect of heterosis is generally higher for reproduction traits than for growth potential *(Fairfull, 1990)* and is influence by the maternal side and nutrition *(Liu et al., 1995)*.

Singh et al. (1992), Chaubal et al. (1994), Minvielle et al. (2000) and Khalil et al. (2004) reported a lower egg production of original purebred chicken lines compared to their crosses. A mild positive heterosis effect from 0 to 5% for egg weight in produced crosses has been observed by *Fairfull et al. (1987), Fairfull (1990)* and *Groen et al. (1998*). *Khalil et al. (1999)* and *Sabri et al. (2000)* detected a significant maternal effect on the live weight of offspring at an early age (0 – 8 weeks of age), and according to *Prado-Gonzalez et al. (2003*) the maternal influence was manifested from hatching to 4 weeks of age.

The monitoring and comparison of production traits of original lines and their crossbred hybrids aimed to establish the best heterosis effect on the commercial product.

Materials and Methods

The experiment was performed in the Poultry Breeding Unit at the Institute of Agriculture, Stara Zagora, in 2009-2012. The newly selected egg laying lines T, P and N were used for production of hybrid birds.

Line T has red feathering, brown eggshell and is characterized with optimal live body weight and low feed consumption per one egg produced.

Line P has red feathering and high egg weight.

Line N has white feathering, used as maternal line for production of feather-autosexing egg-laying hybrids. It has been selected for high egg production and good hatching traits.

Hybrid two-line birds for the paternal line were T♂ × P♀, P♂ × T♀ crosses 2009/2010. This reciprocal crossbreeding aimed to obtain the best two-line paternal combination which should be bred to the maternal N line to produce the three-line stock hybrids.

The last stage was the crossbreeding of paternal and maternal lines: Group I – (P♂×T♀) ♂ ×N♀; group II – (T♂×P♀)♂ ×N♀; group III – T♂×N♀; and group IV – P♂×N♀.

In 2011/2012, the following traits of layers from original and hybrid lines produced by the aforementioned schedule were monitored:

- Live weight – at 8 and 18 weeks of age (g)
- Age of sexual maturity in days – at attaining 50 percent production for each group.
- Egg production – daily over a 150-day period (number of eggs)
- Average egg weight – at 2-week intervals until the end of lay (g)

- Livability – in percentage as ratio between the number of birds at a specified age and the number of hatchlings (%)
- The heterosis effect was calculated according to the formula *(Fairfull, 1990)*:

$$H\% = [F_1-(P_1+P_2)/2] / [(P_1+P_2)/2] \times 100,$$

where: H% – heterosis (%)
F_1 – average values of traits of hybrid lines
$P_{1,2}$ – average values of traits of original lines

Original lines and hybrids were divided in groups, according to the crossing schedule. They were housed in separate 20 boxes at 10 hens with 1 cock in the same premise on deep litter and fed rations respective to their age ad libitum.

Data were processed with Excel 2003-ANOVA using the Descriptive Statistics and F-Test Two-Sample for Variances procedures *(Zhelyazkov and Tsvetanova, 2002)*.

Results and Discussion

Table 1 presents production traits of pure and hybrid chicken lines. With regard to the live body weight at 8 weeks of age, hybrids were statistically significantly lighter than chickens from the original lines.

Table 1. Production traits of pure and hybrid chicken lines

Parameters	Parental line			Crosses			
	T♂ x T ♀	P♂ x P♀	N♂ x N♀	(P♂ x T♀)♂xN♀ Group I	(T♂x P♀)♂xN♀ Group II	T♂ x N♀ Group III	P♂ x N♀ Group IV
Body weight(g) age 8 wks	538.8±4.97cd	521.40±4.79c b	577.17±4.47c	495.95±5.62a	491.12±6.36a	509.67±6.36b	492.31±6.69a
age 18 wks	1472.1±18.4c	1444.26±14.08a	1490.99±10.25cd	1421.80±9.01a	1392.28±9.01b	1431.69±8.86a	1396.91±9.23b
Age of sexual maturity (days)	173.68±1.09a	178.5±2.47b	168.76±1.83c	168.12±2.33c	162.08±2.40d	169.03±1.67ce	163.11±1.07d
Average egg weight (g)	60.25±1.85a	60.65±1.17a	60.86±1.78a	61.58±0.64a	61.32±0.53a	61.15±0.56a	61.57±0.91a
Egg production for 150 days	102.63±3.61a	100.76±6.53a	111.36±5.03b	132.03±4.61c	139.60±3.33c	125.61±4.21d	142.42±4.67c
Livability (%)	95.83±1.44a	98.05±0.88a	91.67±2.02b	97.74±0.48a	97.59±0.72a	96.69±1.03a	95.58±1.41a

* different letters within a row indicate statistically significant differences

The lowest body weight at 8 weeks of age was determined in birds from group II – 491.97 g, followed by birds from group IV (492.31 g), group I (495.95 g) and the heaviest hybrids were from group III (509.67 g). Purebred lines were significantly superior to hybrids as body weight was concerned. There were no considerable differences between the weights of paternal and maternal lines.

At 18 weeks of age, chickens from the pure lines N and T have attained the highest body weights – 1490.99 g and 1472.10 g, respectively, while birds from line P were the lightest (1444.26 g), but these average weights were statistically significantly higher than live weights of hybrid combinations. Within the hybrids, the lowest weight was that of group II (1392.28 g), which was significantly lower only vs group IV.

The earliest beginning of lay was observed in birds from group II - 162.08 days of age, followed by group IV (163 days of age), with insignificant differences. The sexual maturity was attained at a statistically significantly later age in groups I (168 days) and II (169 days).

Lines T and P, used as paternal lines in the breeding plan for production of hybrids, attained sexual maturity at 173.68 and 178.5 days of age ($p \leq 0.05$). The

beginning of lay of the maternal line N (168 days) was the lowest compared to paternal lines T and P. In general, hybrid forms were statistically significantly superior to purebred paternal lines and were comparable to the maternal line with regard to the age of sexual maturity. This is in agreement with the data of *Chaubal et al. (1994)* and *Kicka (1997*) about earlier onset of sexual maturity in crosses of purebred lines. In this study, similar to what was reported by *El-Salamony et al. (2002)* there were no statistically significant differences in age of sexual maturity among original lines and hybrid combinations. *Lumatauw et al. (2002)* established that the age of sexual maturity varied from 150 days (Paraoakan) to 177 days (Bolinao).

The average weight of eggs produced from studied pure line and hybrid hens over the control period varied within a narrow range - 60.27 g, 60.65 g and 60.85 g for lines T, P and N; 61.15 g, 61.32 g, 61.57 g and 60.58 g за for groups III, II, IV and I respectively. Although the differences were not statistically significant, the average hybrid egg weights were higher.

The egg production of hens is influenced by numerous factors, particularly by the genotype and the production system *(Gerzilov et al., 2012)*. The established average 150 days egg production was lower in purebred lines compared to hybrid combinations. The highest average 150 days egg production was determined in hens from hybrid group IV – 142 eggs, followed by 139 eggs laid for 150 days by group II, 132 eggs (group I) and 125 eggs (Group III). The purebred maternal line produced the highest number of eggs – 111, for 150 days. The high production of eggs by hybrid combinations compared to pure lines corresponds to data reported by other authors *(Yahaya et al., 2009)*.

The livability of all studied hens was within the reference range. The lowest livability was recorded in line N (91.67%; $p<0.001$). Hybrid combinations and other purebred lines did not differ substantially with regard to this trait.

Table 2 presents the percent values of heterosis effect on production traits of hybrids. Heterosis for live body weight at 8 and 18 weeks of age ranged from high to low negative percentages – from minus10.37 to minus 3.22 for all hybrid combinations. This is in agreement with the findings of *Williams et al. (2002)* about a negative heterosis effect for live weight, increasing with age in the offspring of two White Plymouth Rock lines with high and low live weights.

Table 2 Heterosis effect (%)

Traits	(P♂ x T♀)♂xN♀ Group I	(T♂ x P♀)♂xN♀ Group II	T♂ x N♀ Group III	P♂ x N♀ Group IV
Body weight (g) 8 weeks of age	-9.62	-10.00	-8.65	-10.37
18 weeks of age	-3.22	-5.22	-3.36	-5.02
Age of sexual maturity (days)	-3.24	-6.70	-1.29	-6.05
Average egg weight (g)	1.63	1.20	0.97	1.34
Egg production for 150 days	31.56	33.06	17.40	34.28
Livability (%)	2.68	-7.97	3.13	0.75

After breeding local hens with Lohmann Brown and Leghorn, a number of researchers found out that the heterosis percentage for age of sexual maturity varied from –25% to 11.5% (*Singh et al., 1983; Fairfull et al., 1987; Bordas et al., 1996; Gavora et al., 1996; Mohammed 1997; Williams et al., 2002)*. *Lumatauw et al. (2002)* reported that the heterosis for age of sexual maturity in the offspring of Paraoakan x Banaba was 6.24%. In our experiment, the heterosis for age of sexual maturity had moderate to low negative values. The highest negative heterosis percentage was observed for group II (6.7%) followed by group IV (6.05%). The lay in birds from those groups began at the earliest age, followed by birds from groups I and III.

The heterosis for average egg weight was positive in all four hybrid groups and varied from 0.97% to 1.63%. This supported the superiority of hybrids over original breeder lines with regard to egg weight.

As egg production was concerned, the effect of heterosis on hybrids was high. The calculated percentages were from 17.40% (group III) to 34.28% (group IV). The positive high heterosis values confirmed that the offspring of original egg laying lines produced more eggs than purebred birds. This was also related to the age of sexual maturity, which occurred earlier in hybrid hens than in original lines. *Abou El-Ghar et al. (2012)* concluded that this could be attributed to increased number of produced eggs together with the lower age of sexual maturity.

The calculated heterosis for the other controlled trait – livability percentage, exhibited negative value only for hybrids from group II – minus 7.97%, whereas it was positive for the other two two-line combinations: 0.75% for group IV and 3.13% for group III. The three-line combination from group I had a heterosis percentage for livability of 2.68%. The data confirmed that only birds from group II were with lower livability compared to original breeder lines.

Conclusion

The heterosis percentage for live body weights at 8 and 18 weeks of age for all four studied hybrid groups had high to low negative values.

The heterosis effect for average egg weight was positive and ranged within 0.97% to 1.63%. This confirmed the superiority of hybrids over original breeder lines.

The positive heterosis values for egg production confirmed the high efficacy of crossbreeding for production of commercial egg laying hybrid birds.

Heterozis efekat u meleza kokoši nosilja

P. Hristakieva, M. Oblakova, M. Lalev, N. Mincheva

Rezime

Nove originalne linije kokoši nosilja T, P i N stvorene u Institutu za poljoprivredu - Stara Zagora su korišćene u ovom istraživanju. Hibridni meleziT ♂ × R ♀ , R ♂ × T ♀ su dobijeni i korišćeni za očinske linije. Nakon toga, primenjen je sledeći raspored očinskih i majčinskih linija: grupa I - (R♂×T♀)♂ ×N♀; grupa II - (T♂×R♀)♂ ×N♀; grupa III - T T♂×N♀; i grupa IV - R♂×N♀. Proizvodne osobine originalnih i hibridnih grla su evidentirane: živa masa u uzrastu od 8 i 18 nedelja, starost seksualne zrelosti u danima, 150-dnevna proizvodnja jaja, prosečna težina jaja – u intervalima od 2 nedelje do kraja nošenja; preživljavanje, heterozis efekat.

Mase živih grla hibrida u uzrastu od 8 i 18 nedelja starosti bile su statistički značajno niže u odnosu na originalne linije. Vrednosti heterozisa za ovaj parametar su bile negativne za sva četiri kombinacije meleza. Najraniji početak nošenja jaja zabeležen je kod (T♂×R♀)♂ ×N♀ (162,08 dana starosti) i R♂×N♀ (163,11 dana starosti). Relativni (%) heterozis za uzrast seksualne zrelosti ispitivanih kombinacija meleza imao je umerene do niske negativne vrednosti. Prosečne težine jaja meleza bile su veće i vrednosti heterozisa - pozitivne za sve četiri grupe i variraju od 0,97% do 1,63%. Prosečna 150-dnevna proizvodnja jaja je niža kod čistokrvnih linija u odnosu na meleze. Najveća prosečna 150 dnevna proizvodnja jaja je utvrđena za R♂×N♀ - 142 jaja. Efekat heterozisa na proizvodnju jaja u meleza je bio značajan.

References

ABOU EL-GHAR, R. SH., HANAN H. GHANEM, HEDAIA M. SHALAN and O.M.ALY. (2012): Heterosis from Crossing Some Local Strains With Two Commercial Lines Of Laying Hens. Egypt. Poult. Sci. Vol (32) (III): 515-529

BELORECHKOV, D. (2004): Modern views on hybridisation in poultry breeding. Poultry v Breeding, 6 : 13 – 15.

BORDAS, A., MERAT, P., MINVIELE, F. (1996): Heterosis in egg- laying lines under divergent selection for residual feed consumption. Poult. Sci., 75:20- 24.

CHAUBAL, D.V., SOLANSKI, J.V; SHUKAI, R.K, RANK, D.N, MISHRA, R.K, KHAMAK. (1994): Performance of White Leghorn pullets under reciprocal recurrent selection for tw ogeneration. Indian J. Poult. Sci. 29 (3): 211- 217

EL-SALAMONY, A.I., ABOU-ASHOUR, A.M; EZZELDIN, Z.A. (2002): A study of heterosis in some egg production traits in Norfa layers. Egypt. J. Agric Res. 80(3): 1337-1352.

FAIRFULL R.W., GOWE, R. S., NAGAL, J. (1987): Dominance and epistatis in heterosis of White Leghorn strain crosses. Canadian J. of Anim. Sci. 67: 663-680

FAIRFULL, R. W. (1990): Heterosis. Pages 913–934 in Poultry Breeding and Genetics. R. D. Crawford, ed. Elsevier Science, Amsterdam.

GAVORA, J. S., FAIRFULL, R. W., BENKEL, B. F., CANTWELL, W. J., CHAMBERS, J. R., (1996): Prediction of heterosis from DNA fingerprints in chickens. Genetics 144: 777-784. (October, 1996).

GERZILOV, V., V. DATKOVA, S. MIHAYLOVA, BOZAKOVA, N. (2012): Effect of poultry housing systems on egg production. Bulg. J. Agric. Sci., 18: 953-957

GROEN, A.F; HEELSUM A.V; KIMANI, C.W., VAN DRUNCU, C.P. (1998): Heterosis and reciprocal effects for egg laying traits estimated from a full dialed cross with six commercial White Leghorn lines, using mixed model analysis. Arch Geflugelk 62 (3): 115-120.

KHALIL, M. K., HERMES I. M., AL- HOMIDAN, A. H. (1999): Estimation of heterotic components for growth and livability traits in a crossbreeding experiment of Saudi chickens with White Leghorn. Egypt. Poultry Sci., 19 (3): 491 – 507.

KHALIL, M.K., AL-HOMIDAN, A. H., HERMES H.I. (2004): Crossbreeding components in age at first egg and egg production for crossing Saudi chickens with White Leghorn. Livestock Research for Rural Development 16 (1). 10pp

KICKA, M.A.M; STINO, F.K.R, KAMAR, G.A.R. (1997): Genetic studies on some economical traits of chickens in subtropics. Egypt. J. Anim. Prod.11 (1): 41-46.

LIU, G., E.A.DUNNINGTON, P. B. SIEGEL. (1993): Maternal effects and heterosis for growth in reciprocal cross populations of chickens. J. Anim. Breed. Genet. 110:423–428.
LUMATAUW, S., ANGEL L. LAMBIO, CELICIO R. ARBOLEDA, CL.T.DAGAAS. (2002): Heterosis and Combining Abilities in Crosses among Three Genetic Groups of Philippine Native Chickens (*Gallus gallus domesticus*, Linn.). Philippine Journal of Veterinary and Animal SciencesVol 28, No 1(abstr.)
MINVIELLE, F. MONVOISIN, J. I. COSTA, J. MAEDA Y. (2000): Long term egg production and heterosis in quail lines after within line or reciprocal recurrent selection for high early egg production. British Poult. Sci. 41 : 150- 157.
MOHAMMED, K. A. H. (1997): Improvement of some Egyptian strains of chickens by crossing with egg- type commercial breeds. Second Hungarian Egyptian Poultry Conference, 16- 19 September 1997. Godollo, Hungary.
PRADO – GONZALES, E. A., RAMIREZ AVILA, L., SEGURA –PREISINGER, R.(2003): Internationalization of breeding programs – breeding egg type chickens for a global market, 6th World Congress on Genetics Applied to Livestock Production, 26, 135 – 142;
Anim. Genetics and Breeding Unit, Univ. of New England, Armidale, Australia.
SABRI, H. M., HENRY, R. W., ROBERT, H. H., CHARLES, J. W. (1999): Genetic parameters for egg and related characteristics of White Leghorne hens in a subtropical environment. Genetics and Molecular Biology, 22 (2): 183 – 186.
SINGH, P., SINGH, R. V., CHANDARY, R. P., VIKRAM SINGH (1983): Diallel crossing for estimation of G. C. A., S. C. A., heterosis and other genetic effects for various economic traits in White Leghorn. Indian Vet. J., 60:384- 389.
SINGH, P., CHAUDHARY, M.L., BRAH, G.S and SANDHU, J.S. (1992): Evaluation of two White Leghorn strains and their reciprocal crosses for part year productivity. Indian J. Of Poult. Sci. 27(3): 139-143.
SZWACZKOWSKI, T., CYWA - BENKO, K., WEZYK, ST. (2003): A note on in breeding effect on productive and reproductive traits in laying hens. Anim. Sci. papers and Reports, 21(2): 121 – 129
WILLIAMS, S.M., S.E. PRICE, SIEGE, P.B. (2002): Heterosis of Growth and Reproductive Traits in Fowl. Poultry Science 81:1109–1112
YAHAYA, K.H., O. O.ONI, G. N. AKPA, ADEYNIKA, I. A. (2009): Evaluation Of Layer Type Chickens Under Reciprocal Recurrent Selection. Bayern Journal of Pure and Applied Sciences, 2(1):177 - 182
ZHELYAZKOV, E., TSVETANOVA, Y. (2002): Manual of Genetics. Stara Zagora, 2002:175-195

Received 20 March 2014; accepted for publication 6 June 2014