Ann. Anim. Sci., Vol. 10, No. 1 (2010) 49–55

RELIABILITY OF BREEDING VALUE ESTIMATION OF LAYING HENS FOR HATCHING CHARACTERISTICS*

Iwona Rozempolska-Rucińska

Department of Biological Bases of Animal Production, University of Life Sciences in Lublin, Akademicka 13, 20-950 Lublin, Poland

Abstract

The aim of this study was to assess consistency of ranking laying hens for breeding value when selecting birds for a selection flock and after acquisition of hatching results. The consistency of these assessments is related to efficiency of breeding work and improvement of hatching characteristics. In this case, knowledge of rank correlations could facilitate selection. This study was performed with a population of laying hens using performance data on 14326 birds. BLUP estimates were obtained using a multitrait animal model. Two data variants were used in the analyses: for known hatching performance of the generation under selection and when these data were unknown. Close agreement between predicted and actual breeding values of hens (about 0.9) was found. For cocks, the consistency of ranking was only about 0.4.

Key words: laying hens, BLUP estimates, hatching characteristics, breeding ranking

Improvement of reproductive traits is critical to every production type of poultry, including broilers and layers. At the same time, breeding efforts to improve these traits are hindered by their low heritability (Szwaczkowski et al., 2000; Zięba et al., 2003; Sapp et al., 2004, 2005; Rozempolska-Rucińska et al., 2007). Additional difficulties may arise due to the fact that selection of birds for the breeding flock takes place when data on animal performance are incomplete. Previous analyses showed that the accuracy of BLUP estimates in birds is also related to pedigree depth and inclusion of traits correlated with hatchability (Rozempolska-Rucińska et al., 2008). The accuracy of estimates determines the efficiency of breeding work on the one hand, but on the other it may vary between males and females because of the specificity of reproductive traits. When selecting birds for the selection flock, the assessment of males based solely on the relationship matrix and no individual

*This study was financed from research fund for 2008–2011 as research project No. N N311 364435.

performance testing may differ from the assessment of females. This issue may be of special importance because of the number of offspring derived from one sire and cock selection intensity. In this situation, males exert a greater effect on the breeding value of the next generation. On the other hand, reproductive performance of hens also remains unknown.

It is interesting to ask about reliability of the breeding ranking of cocks and hens in terms of reproductive traits when birds are selected for the breeding flock and their performance is not known. Will the breeding ranking of birds remain the same and if not, how will it change once their reproductive results are known? In this case, knowledge of rank correlations could facilitate breeding work.

Material and methods

Three generations of Rhode Island White laying hens of the maternal strain, raised in a commercial pedigree farm in 2006–2008, were investigated. Individual performance test of the experimental flock included the following parameters: body weight at 18 weeks of age (BW), sexual maturity – number of days between hatching and first oviposition (SM), initial egg production rate – number of eggs laid during the first 15 weeks of egg production (IEPR), average weight of eggs collected for 7 days from 34-week-old layers (WE). The experimental flock consisted of all maternal strain birds used on the farm. Based on breeding value estimation, birds intended for reproduction are chosen from the experimental flock as next generation parents. This group is referred to as breeding flock. In the flock of breeder chickens, the following parameters were individually tested: number of fertilized eggs (FE), number of chicks hatched from set eggs (CSE) and number of chicks hatched from fertilized eggs (CFE). These traits were analysed over 3 years for 4 successive hatches. Breeding flocks contained about 530 females and 43 males. During the years analysed, selection intensity did not change considerably and was 1.7±0.2 for females and 2.7±0.1 for males. Table 1 presents the level of production traits in the population of Rhode Island White hens under study.

Table 1. Level of production traits in the maternal strain

Trait (unit)	x	sd
Body weight (g)	1568	141
Sexual maturity (days)	151	25
Initial egg production rate (pcs.)	82	19
Egg weight (g)	56.4	16.8
Fertilization percentage	90.2	9.6
Percentage of chicks hatched from set eggs	74.2	16.4
Percentage of chicks hatched from fertilized eggs	81.04	18.83

Note: x – mean value of trait, sd – standard deviation.

The significance of factors included in estimation of (co)variance components was verified by multifactorial analysis of variance using the least squares method. Variance and covariance components, estimated using models including factors presented in Table 2, served to determine the breeding value of animals with the BLUP method (Madsen and Jensen, 2000).

Table 2. List of factors in computational models for different traits

Trait factor	Type[a]	BW, SM, IEPR, WE	FE, CSE	CFE
Year of hatch (origin) × hatch	F	x		
Year of reproduction	F		x	x
No. of set eggs	C		x	
No. of fertilized eggs	C			x
Additive effect of bird	A	x	x	x

x – presence of factor in the model for analysed trait,
Type[a] of factor: A – random, related to relationship matrix, F – fixed, C – covariance variable.

Productive traits (BW, SM, IEPR, WE) did not undergo further analysis and were included in the model due to relationships between productive and reproductive traits. The use of multitrait model allows for more detailed assessment of reproductive traits, for which information is inadequate (Rozempolska-Rucińska et al., 2008).

BLUP estimates were obtained using two data variants described in detail in Table 3. Differences between them only concerned the information about reproductive results of the last generation, referred to as the generation under selection. In variant I, breeding value of birds was estimated without knowledge of the reproductive results of this generation, and in variant II birds completed their hatching period and reproductive results were also known for the generation under selection.

Table 3. Characteristic of variants used to estimate the breeding value of birds

Characteristic	Variants	
	I	II
No. of generations	3	3
No. of generations that completed their reproductive period	2	3
Reproductive results of generation under selection	no	yes
No. of birds from experimental flocks	14326	14326
No. of hens with known reproductive performance	1037	1569
No. of animals in pedigree	14837	14837

BLUP estimates were used to calculate rank correlations between the breeding value of offspring and the breeding value of parents for different hatching characteristics. In this case, the total breeding value of sire and dam was the combined additive value of parents. The analyses were performed when reproductive performance of the generation under selection was known (variant II) and when this information was not available (variant I). Variant II is labour-consuming and for this reason it is difficult to apply in breeding practice, but BLUP estimates obtained for known reproductive performance of the generation under selection were used as a model to which estimates obtained in variant I were related. This is why the breeding value obtained in variant II was designated as "actual" genetic value compared to "predicted" genetic value for breeding value estimated when reproductive performance of the generation under selection was unknown.

Rank correlations were also estimated between "actual" and "predicted" breeding of the generation under selection.

Results

Table 4 presents the consistency of ranking offspring and parents for breeding value estimated when reproductive performance of all birds was known (variant II) and when no information on reproduction of the last generation was available (variant I).

Table 4. Rank correlations between the breeding value of parents and offspring

Trait* variant	Dam		Sire		Total	
	I	II	I	II	I	II
FE	0.68	0.69	0.25	0.72	0.66	0.96
CSE	0.58	0.64	0.20	0.69	0.57	0.92
CFE	0.44	0.58	0.29	0.69	0.51	0.89

* FE – No. of fertilized eggs, CSE – No. of chicks hatched from set eggs, CFE – No. of chicks hatched from fertilized eggs.

Rank correlations between BLUP estimates of parents and offspring were in the 20–90% range. The considerable discrepancy resulted from the data variant used. The sex of parents also had some effect. Higher correlation values were obtained between dams and offspring and when breeding value was estimated for known reproductive performance of the birds (variant II).

The agreement between actual and predicted breeding value was also related to the sex of birds (Table 5).

Table 5. Rank correlations between actual and predicted breeding value

Trait** sex	FE	CSE	CFE
Female	0.93	0.92	0.89
Male	0.40	0.34	0.42
Total*	0.69	0.64	0.62

* without consideration of sex; ** FE – No. of fertilized eggs, CSE – No. of chicks hatched from set eggs, CFE – No. of chicks hatched from fertilized eggs.

Rank correlations for hens were high (about 0.9) for each trait analysed. In the case of cocks, the consistency of ranking proved very low (30–40%).

Discussion

The ranking between the total breeding value of parents and offspring, estimated when performance of the generation under selection was known (variant II), is self-explanatory. The high consistency results from the definition of breeding value itself. The rank correlations are much lower for variant I, which is applied in practical breeding. This result is definitely affected by low consistency of BLUP estimates found between cocks and their offspring. This situation would indicate that the estimates of breeding value obtained for offspring result mainly from the breeding value of the dams. The consistency of ranking between offspring and dams is close to the ranking involving both parents. At the same time, rank correlations between offspring and dams, obtained under variants I and II, are identical. This shows that the breeding value estimation of females was affected by reproductive data on their offspring to a small extent. Clear differences occurred for cocks. The inclusion of reproductive data on offspring in the analyses increased the consistency of the sire-offspring breeding ranking by almost 50%. This can be attributed to the fact that for animals with known performance and unknown offspring data, the accuracy of estimation is dependent on the size of age mate groups (Tosh and Witton, 1994). The specificity of poultry breeding and the high polygamy rate result in large groups of female age mates and much smaller groups of male age mates, which affects the reliability of BLUP estimates. A considerable increase in the consistency of the breeding ranking between offspring and sires, after accounting for data, is regrettably of small practical value because of the specific nature of poultry breeding. Two-year-old cocks are usually not used for reproduction.

The problem with breeding value estimation of reproductive traits in cocks is confirmed by the present results given in Table 5. It turned out that for 60% of the evaluated males, the rank in the breeding ranking will change after inclusion of data on the hatchability of related females. Thus, when selecting cocks for the selection flock we may make a considerable mistake of not choosing birds with the highest additive value. This situation is particularly unfavourable, because due to the high polygamy rate, males determine the breeding value of offspring. Reducing the discrepancy between breeding value estimated when selecting cocks for the selection flock and their actual value could increase genetic progress for hatching characteristics. It seems necessary to find additional methods for estimating the breeding value of cocks. In practical farming it is a frequent practice that selected cocks originate from families with the highest hatchability. The results obtained suggest that two-stage selection could be appropriate for cocks, but it should be modified to include genetic rather than phenotypic value of families. Higher ranking consistency was found between the breeding value of offspring and their parents (Table 4) than between predicted and actual breeding value of cocks (Table 5). In this situation, it may be more effective to select cocks based on the BLUP estimates of parents followed by individual performance tests.

The present data conclusively show that inclusion of information on reproductive results of the generation under selection had little effect on the estimation and ranking of hen breeding value. This may be because the genetic analyses used a multitrait model accounting for other production traits correlated with hatchability (Rozempolska-Rucińska et al., 2007; Zięba et al., 2003). The multitrait model allows for more accurate estimation of genetic variation of a trait for which little or no information is available (van Arendonk et al., 1993). It was found for hatching characteristics that inclusion of data on correlated traits is important for BLUP estimates (Rozempolska-Rucińska et al., 2008). On the other hand, this approach proved rather inefficient for cocks, but out of four additional traits included in the analyses (BW, WE, IEPR, SM) only body weight was measured directly in males. Just as hatchability, the other traits concerned females. In this situation, when out of seven estimated traits only one was directly related to cocks, the estimation of the other traits based only on the relationship matrix was not very efficient. Considering earlier analyses (Rozempolska-Rucińska et al., 2010), it appears that greater consistency of the cocks' breeding ranking can be obtained if a greater number of generations is considered. When using information on performance of a 5-generational population, the consistency of ranking between actual and predicted breeding value of the birds was 0.92 (Rozempolska-Rucińska et al., 2010). This result was much more beneficial compared to about 60% consistency obtained in the present study (Table 4). Despite research findings that the use of data on correlated traits has a greater effect on BLUP estimates than pedigree depth (Rozempolska-Rucińska et al., 2008), this conclusion does not apply to estimation of cocks.

In conclusion, when selecting birds for the selection flock we can be certain that about 90% of the hens will maintain their rank after reproduction data become available. This fact should facilitate breeding work, especially selection. Unfortunately, very low agreement between actual and predicted breeding value was obtained for cocks, which may reduce breeding progress in terms of hatching characteristics. The rank in the breeding ranking will change for as much as 60% of the cocks after inclusion of hatching data.

The assessment methods need to be modified to increase the agreement between "actual" and "predicted" value when selecting cocks for breeding flocks. Possible solutions are to include a greater number of generations in the analyses, to find correlated traits that can be measured in males, or to develop more complex methods of cockerel selection.

References

Rozempolska-Rucińska I., Zięba G., Twardowska M., Łukaszewicz M., Witkowski A. (2007). Relationships between hatchability and routine selection criterion in laying hens. Proc. XIX International Poultry Symposium PB WPSA, Olsztyn, 10–12.09.2008, ss. 45–48

Rozempolska-Rucińska I., Twardowska M., Zięba G., Łukaszewicz M., Witkowski A. (2008). Our knowledge of hens' reproductive breeding value is limited upon selecting birds for flock reproduction. Anim. Sci. Pap. Rep., 1, 26: 79–84.

Rozempolska-Rucińska I., Zięba G., Łukaszewicz M., Ciechońska M. (2010). Hatchability as modelled with or without bird's permanent environment effect due to hatch in laying hens. Arch. Geflugelk., 74, 1: 58–61.

Sapp R.L., Rekaya R., Misztal I., Wing T. (2004). Male and female fertility and hatchability in chickens: A longitudinal mixed model approach. Poultry Sci., 83: 1253–1259.

Sapp R.L., Rekaya R., Misztal I., Wing T. (2005). Longitudinal multiple-trait versus cumulative single-trait analysis of male and female fertility and hatchability in chickens. Poultry Sci., 84: 1010–1014.

Szwaczkowski T., Wężyk S., Piotrowski P., Cywa-Benko K. (2000). Direct and maternal genetic and environmental effects for fertility and hatchability in laying hens. Arch. Geflugelk., 64: 115–120.

Tosh J.J., Witton J.W. (1994). Effects of data structure on variance of prediction error and accuracy of genetic evaluation. J. Anim. Sci., 72: 2568–2577.

Van Arendonk J., Van der Werf J., Groen A., Bink M. (1993). Mixed models in animal breeding. Notes of courses at Department of Genetic and Animal Breeding, Academy of Agriculture, Poznań.

Zięba G., Łukaszewicz M., Twardowska M., Witkowski A. (2003). Genetic trends of laying merit in paternal and maternal strains of hens. Anim. Sci. Pap. Rep., 4, 21: 241–249.

Accepted for printing 24 II 2010

IWONA ROZEMPOLSKA-RUCIŃSKA

Wiarygodność oceny wartości hodowlanej kur nieśnych pod względem cech wylęgowych

STRESZCZENIE

Celem pracy była ocena zgodności uszeregowania kur nieśnych pod względem wartości hodowlanej w momencie wyboru ptaków do stada selekcyjnego i po uzyskaniu informacji o wynikach lęgów. Zgodność tych ocen jest związana z efektywnością pracy hodowlanej i doskonalenia cech wylęgowych.

Znajomość korelacji rangowych mogłaby w tym przypadku ułatwić prowadzenie selekcji. Badania prowadzono w populacji kur nieśnych, wykorzystując informacje o użytkowości 14326 ptaków. Szacunki BLUP uzyskano stosując wielocechowy model osobniczy. W analizach wykorzystano dwa warianty danych: przy znanej użytkowości wylęgowej pokolenia selekcjonowanego i przy braku tych informacji. Stwierdzono wysoką zgodność pomiędzy rzeczywistą i przewidywaną wartością hodowlaną kur, wynoszącą około 0,9. W przypadku kogutów zgodność rankingu wynosiła zaledwie około 0,4.