

## **Service cock only indirectly affects hatchability in laying hens\***

**Iwona Rozempolska-Rucińska<sup>1</sup>, Grzegorz Zięba<sup>1</sup>, Marek Łukaszewicz<sup>2\*\*</sup>**

<sup>1</sup> Chair for Biological Bases of Animal Production,  
University of Life Sciences in Lublin,  
Akademicka 13, 20-950 Lublin, Poland

<sup>2</sup> Polish Academy of Sciences, Institute of Genetics and Animal Breeding,  
Jastrzębiec, 05-552 Wólka Kosowska, Poland

*(Received July 7, 2009; accepted April 13, 2010)*

The purpose of the study was to investigate the effect of service sire on fertilization rate and losses during hatching as a way of increasing the accuracy of breeding value estimation of layers for hatchability. Layers from five generations of two breeds – Rhode Island White and Rhode Island Red – were individually recorded for fertilization rate, percentage of chicks hatched from eggs laid, set, and fertilized. Two statistical models, both fitting random animal additive genetic and permanent environment effects along with fixed joint effect of hatch-year  $\times$  hatch-number, differed with regard to presence or absence of random effect of service sire. Of the traits studied fertilization rate is least influenced by service sire which can be neglected when evaluating fertilization. Although service sire effect is small, both absolutely and relatively, failing to account for it in a model evaluating number of chicks hatched may result in substantial overestimation of heritability. Service sire effect accounted for in the model can also add to the accuracy of the hens' proofs for hatchability. Correlation between direct additive and service sire effects may be dependent on the population it is estimated in.

**KEY WORDS:** hatchability / laying hens / service sire / variance components

---

\*Academic study financed from the research fund for 2008-2011, as research project no. N N311 364435.

\*\*Corresponding author: m.lukaszewicz@ighz.pl

Statistical classifications employed for variance components' estimation and breeding value evaluation may greatly influence the outcome, causing suboptimal selection decisions if they are inadequate. In hens, as in other species, reproduction (and other complexes of functional traits) has recently gained importance it deserves, as an element of the overall breeding objective. This is the reason why many research teams [e.g. Szwaczkowski *et al.* 2000, Akbas *et al.* 2002, Sapp *et al.* 2004, 2005, Wolc *et al.* 2005, 2007, Bennewitz *et al.* 2007, Rozempolska-Rucińska *et al.* 2009, 2010] studied different models of evaluation of hatchability, for which both sexes are selected without own record. In particular the correlation between rankings of sires and their female progenies may account to as low as 0.5 to 0.6, for this trait [Rozempolska-Rucińska 2010]. The cocks lack their own laying production record which in hens elevates the rank correlation between their hatchability breeding values and that of their progenies to around 0.9, in multiple-trait models [ibid]. Further development of statistical description of hatchability may help to improve the sire-progeny correlation.

Upon breeding value estimation of hens for hatchability the effect of a cock as a sire is accounted for via the numerator relationship matrix whereas cock's effect as a mate is routinely neglected. In the majority of studies on swine [Van der Lende *et al.* 1999, Serenius *et al.* 2003, Chen *et al.* 2003] the effect of service sire was found to be low although selection for this effect was possible [Hamann *et al.* 2004]. In birds significant service sire effect on hatchability was reported in ostriches, even in artificial incubation circumstances [Cloete *et al.* 2006]. In commercial laying flocks the hens themselves are deprived of the possibility of expressing their maternal abilities as sitters and the sitting instinct is directly selected against. Moreover, exploitation of the DNA marker information to improve accuracy of modelling of hatchability is not promising as no DNA regions responsible for hatchability have yet been identified [Hocking 2005] and marker assisted selection may be ineffective in selection for polygenic traits [Boruszewska *et al.* 2009].

Accounting for the effect of service sire thus seems the only remaining way of removing some unexplained variation linked to hatchability breeding value estimation, and feasibility of exploitation of that effect was the purpose of the current study.

## **Material and methods**

The data were collected from a commercial farm and comprised hatching performance records on 9827 hatches from 2852 hens of a Rhode Island White (RIW) and on 5572 hatches from 1943 layers of a Rhode Island Red (RIR) flocks, across five generations. Individual recording included the number of fertilised eggs (FE) as proportion of set eggs, proportion of chicks hatched from eggs laid (eggs set plus eggs discarded) during the setting season (CHL), proportion of chicks hatched from eggs set (CHS), and proportion of chicks hatched from fertilised eggs (CHF), in 4 hatches each generation.

The studied traits are described in Table 1, separately for each breed. Before the statistical analysis the data were transformed with the Bliss transformation ( $\sqrt{\% \text{trait}}$ ).

**Table 1.** Means and standard deviations (SD) of hatchability traits

Trait*	Rhode Island White		Rhode Island Red	
	mean	SD	mean	SD
FE	89.6	12.5	92.3	11.6
CHL	69.1	21.2	73.4	20.6
CHS	73.2	20.5	77.7	19.5
CHF	81.0	18.8	83.5	17.3

\*FE – fertilization rate; CHL – % chicks hatched from eggs laid; CHS – % chicks hatched from eggs set; CHF – % chicks hatched from eggs fertilized.

**Table 2.** Factors accounted for in the models

Factor / Type*	Traits**	FE, CHL, CHS, CHF
Year-of-hatch*hatch-number-within-year / F		M1 M2
Additive individual effect of a layer / A		M1 M2
Service sire / A		M1
Permanent environment due to hatch / D		M1 M2

\*A – random, linked to relationship matrix; D – random, diagonal; F – fixed.

\*\*FE – fertilization rate; CHL – % chicks hatched from eggs laid; CHS – % chicks hatched from eggs set; CHF – % chicks hatched from eggs fertilized.

M1 – factor present in model 1; M2 – factor present in model 2.

The pedigrees included 31025 and 15275 birds in RIW and RIR, respectively.

The (co)variance components were estimated with multiple-trait, repeatability animal models and the REML method, using the software of Madsen and Jansen [2000]. The models for each trait are presented in Table 2.

Results obtained with model M1, including all the effects, were compared with the results obtained with model M2, in which the service sire effect was neglected.

Following the variance components estimation BLUP rankings computed with the models studied were rank-correlated to verify the possible impact of service sire presence in the model on reliability of the proofs.

## Results and discussion

Both models yield the same residual (and virtually the same phenotypic) variance of a trait within breed and eventual shifts in magnitude regard the additive, service sire and permanent environment components (Tab. 3). Accounting for service sire in a model results predominantly in modifying the variance components' ratios for the genetic additive and permanent environment effects (Tab. 4). Regardless small magnitude of the service sire component itself, both absolute and relative, the changes of the genetic additive and permanent environment parameters can be substantial.

While failure to fit the service sire in a model consequently results in overestimation of the genetic additive component, regardless of the breed, the environmental components change in opposite directions, in the breeds of interest. Apparently, the permanent environment aspect of service sire (service sire is common to all the hatches) changes with certain circumstances (most likely the breeding objective itself) accompanying the selection process – correlation between genetic additive and service sire effects for hatchability can be either positive (Tab. 4; RIR) or zero to negative (RIW).

**Table 3.** Variance components by trait, breed, and model

Trait*	(Co)variance	Rhode Island White		Rhode Island Red	
		M1**	M2	M1	M2
FE	additive	0.0063	0.0072	0.0074	0.0076
	service sire	0.0005	-	0.0013	-
	permanent environment	0.0080	0.0075	0.0032	0.0041
	residual	0.0363	0.0363	0.0316	0.0316
	phenotypic	0.0511	0.0510	0.0435	0.433
CHL	additive	0.0097	0.0180	0.0174	0.0178
	service sire	0.0011	-	0.0021	-
	permanent environment	0.0212	0.0149	0.0108	0.0119
	residual	0.0384	0.0385	0.0413	0.0414
	phenotypic	0.0704	0.0714	0.0716	0.0711
CHS	additive	0.0092	0.0167	0.0182	0.0195
	service sire	0.0009	-	0.0023	-
	permanent environment	0.0198	0.0140	0.0060	0.0067
	residual	0.0417	0.0417	0.0441	0.0441
	phenotypic	0.0716	0.0724	0.0706	0.0703
CHF	additive	0.0051	0.0134	0.0183	0.0188
	service sire	0.0009	-	0.0013	-
	permanent environment	0.0205	0.0142	0.0045	0.0051
	residual	0.0506	0.0507	0.0493	0.0493
	phenotypic	0.0771	0.0783	0.0734	0.0732

\*FE – fertilization rate; CHL – % chicks hatched from eggs laid; CHS – % chicks hatched from eggs set; CHF – % chicks hatched from eggs fertilized.

\*\*M1 – service sire fitted; M2 – service sire neglected.

**Table 4.** Ratios\* of (co)variance components by trait, breed, and model

Trait**	Ratio***	Rhode Island White		Rhode Island Red	
		M1****	M2	M1	M2
FE	$h^2$	0.12	0.14	0.17	0.17
	$s^2$	0.01	-	0.03	-
	r	0.28	0.29	0.24	0.27
	$r_{as}$	0.07	-	0.25	-
CHL	$h^2$	0.14	0.25	0.21	0.25
	$s^2$	0.02	-	0.03	-
	r	0.43	0.46	0.35	0.42
	$r_{as}$	-0.21	-	0.31	-
CHS	$h^2$	0.13	0.23	0.22	0.28
	$s^2$	0.01	-	0.03	-
	r	0.40	0.42	0.29	0.37
	$r_{as}$	-0.14	-	0.37	-
CHF	$h^2$	0.07	0.17	0.22	0.26
	$s^2$	0.01	-	0.02	-
	r	0.33	0.35	0.28	0.33
	$r_{as}$	-0.06	-	0.42	-

\*Standard errors of the ratios range from 0.01 ( $s^2$ ) to 0.05.

\*\*FE – fertilization rate; CHL – % chicks hatched from eggs laid; CHS – % chicks hatched from eggs set; CHF – % chicks hatched from eggs fertilized.

\*\*\* $h^2$  – direct heritability coefficient;  $s^2$  – service sire heritability; r – repeatability;  $r_{as}$  – correlation between additive and service sire effects.

\*\*\*\*M1 – service sire fitted; M2 – service sire neglected.

Nonetheless, although the permanent environment component changes in opposite directions, due to big enough changes of the additive component, repeatability stays a little overestimated when service sire is absent in the model, no matter what the breed is (Tab. 4). The positive correlations between direct additive and service sire effects in RIR are of moderate magnitude and of small standard errors indicating feasibility of simultaneous improvement of both qualities in RIR, for all the hatchability traits. In RIW, however, the correlations are predominantly small and negative but relatively high standard errors suggest the studied qualities are not correlated. It is solely CHL which may cause problems from the simultaneous improvement of the direct additive and the service sire qualities point of view. Similar dependence of the relation between service sire and other variance components on the population in which it had been studied, was also reported in swine [Serenius *et al.* 2003].

It would be extremely difficult to obtain any significant response to selection for service sire qualities given the current service sire heritability estimates (0.01-0.03). In fact, it were only the reports of Hamann *et al.* [2004] in swine and of Cloete *et al.* [2006] in ostriches that concluded feasibility of selection for those qualities, in the surveyed literature. Following the present results, though, neglecting the service sire effect in a

model for hatchability causes substantial overestimation of the direct heritability (Tab. 4) and overestimated expectations concerning the selection effectiveness may follow, for all the hatching output traits (CHL, CHS, CHF). Fertilization rate, however, is not affected, neither directly nor indirectly, by service cock.

Besides more accurate direct  $h^2$  estimates some gain in accuracy of breeding value evaluation can also be achieved by accounting for the service sire effect. Although the rank correlation between BLUP rankings obtained with either model are as high as 0.91 for FE to 0.98 for CHL in RIR and 0.90 for FE to 0.93 for CHF in RIW, they are not ones. The exhaustion of other sources of information on hatchability for the breeding value evaluation purposes was discussed in the introduction.

In spite of small magnitude of service cock variance component itself, for all the investigated hatch output traits (CHL, CHS, CHF), presence of this factor in the statistical model helps distribute the direct genetic additive and permanent environment variances in a way that reduces the otherwise apparently overestimated direct heritability estimates. Service cock effect accounted for in the model can also add to the accuracy of the hens' proofs for hatchability. Correlation between direct additive and service cock effects may be dependent on the population it is estimated in. Fertilization rate is unaffected by service sire.

#### REFERENCES

1. AKBAS Y., ÜNVER Y., OGUZ I., ALTAN O., 2002 – Comparison of different variance component estimation methods for genetic parameters of clutch pattern in laying hens. *Archiv für Geflügelkunde* 5, 66, 232–236.
2. BENNEWITZ J., MORGADES O., PREISINGER R., THALLER G., KALM E., 2007 – Variance Component and Breeding Value Estimation for Reproductive Traits in Laying Hens Using a Bayesian Threshold Model. *Poultry Science* 86, 823-828.
3. BORUSZEWSKA K., ŁUKASZEWICZ M., ZIĘBA G., WITKOWSKI A., HORBAŃCZUK J., JASZCZAK K., 2009, Microsatellite markers may be ineffective in selection of laying hens for polygenic production traits. *Poultry Science*, 88, 932-937.
4. CHEN P., BAAS T.J., MABRY J.W., KOEHLER K.J., DEKKERS J.C.M., 2003 – Genetic parameters and trends for litter traits in U.S. Yorkshire, Duroc, Hampshire, and Landrace pigs. *Journal of Animal Science* 81, 46-53.
5. CLOETE S.W.P., BUNTER K.L., LAMBRECHTS H., BRAND Z., SWART D., GREYLING J.P.C., 2006 – Variance components for live weight, body measurements and reproductive traits of pair-mated ostrich females. *British Poultry Science* 47, 2, 147-158.
6. HAMANN H., STEINHEUER R., DISTL O., 2004 – Estimation of genetic parameters for litter size as a sow and boar trait in German herdbook Landrace and Pietrain swine. *Livestock Production Science* 85, 2-3, 201-207.
7. HOCKING P.M., 2005 – Review of QTL mapping results in chickens. *World's Poultry Science Journal* 61, 215-226.
8. VAN DER LENDE T., WILLEMSSEN M. H. A., VAN ARENDONK J. A. M. VAN HAANDEL E. B. P. G., 1999 – Genetic analysis of the service sire effect on litter size in swine. *Livestock Production Science* 58, 91-94.
9. MADSEN P., JENSEN J., 2000 – DMU. A package for the analysing multivariate mixed models. Version 6, release 4.

10. ROZEMPOLSKA-RUCIŃSKA ZIĘBA G., ŁUKASZEWICZ M., 2009 – Hatchability traits as selection criteria in breeding of laying hens. *Archiv für Geflügelkunde* 4, 73, 263-267.
11. ROZEMPOLSKA-RUCIŃSKA I., 2010 – Reliability of breeding value estimation of laying hens for hatching characteristics. *Annals of Animal Science* 10, 1, 49-55.
12. 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. *Archiv für Geflügelkunde* 1, 74, 58-61.
13. SAPP R.L., REKAYA R., MISZTAL I., WING T., 2004 – Male and Female Fertility and Hatchability in Chickens: A Longitudinal Mixed Model Approach. *Poultry Science* 83, 1253-1259.
14. 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 Science* 84, 1010-1014.
15. SERENIUS T., SEVON-AIMONEN M.-L., MANTYSAARI E.A., 2003 – Effect of service sire and validity of repeatability model in litter size and farrowing interval of Finnish Landrace and Large White populations. *Livestock Production Science* 81, 213-222.
16. SZWACZKOWSKI T., WĘŻYK S., PIOTROWSKI P., CYWA-BENKO K., 2000 – Direct and maternal genetic and environmental effects for fertility and hatchability in laying hens. *Archiv für Geflügelkunde* 64, 115-120.
17. WOLC A., TWARDOWSKA M., SZWACZKOWSKI T., 2005 – Analyse des Knickeieranteils bei Legehennen als lineares und als Schwellenmerkmal mittels Tiermodell. *Archiv für Geflügelkunde* 69, 181-184.
18. WOLC A., LISOWSKI M., SZWACZKOWSKI T., 2007 – Heritability of egg production in laying hens under cumulative, multitrait and repeated measurement animal models. *Czech Journal of Animal Science* 52, 8, 254-259.

Iwona Rozempolska-Rucińska, Grzegorz Zięba, Marek Łukaszewicz

## Kogut wykorzystany do kojarzeń tylko pośrednio wpływa na wyniki lęgów u kur nieśnych

### Streszczenie

Celem badań była ocena wpływu kryjącego samca na procent zapłodnienia i wylęgowość piskląt z punktu widzenia zwiększenia dokładności szacunków wartości hodowlanej kur nieśnych pod względem cech wylęgowych. W badaniach uwzględniono 5 pokoleń rasy Rhode Island White i Rhode Island Red, dla których prowadzono indywidualną kontrolę procentu zapłodnienia, procentu piskląt wyklutych z jaj zniesionych, nałożonych i zapłodnionych. Zastosowano dwa modele, uwzględniające losowy addytywny wpływ genetyczny osobnika, losowy wpływ specyficznego środowiska kury oraz stały wpływ interakcji rok wylęgu-numer wylęgu. Różnica między modelami polegała na obecności lub braku losowego wpływu kryjącego koguta. Wpływ samca był najmniejszy w przypadku procentu zapłodnienia i może zostać pominięty przy ocenie tej cechy. Chociaż wpływ samca był niewielki, zarówno absolutnie jak i względnie, to jednak nieuwzględnienie tego czynnika w modelu oceniającym wyniki lęgów prowadzi do zasadniczego przeszacowania wskaźnika odziedziczalności. Uwzględnienie wpływu samca w modelu może dodatkowo zwiększyć dokładność przewidywanych wartości hodowlanych niosek pod względem cech wylęgowości. Wielkość współczynników korelacji pomiędzy bezpośrednim, addytywnym wpływem genetycznym a wpływem samca może być uzależniona od populacji, w których były oceniane.

