*Review*

# Study on performance traits of laying hens with crossing the White Leghorn and the Rhode Island breeds

## Erik GARAMVÖLGYI[1*], Zoltán SÜTŐ [1]

[1] Hungarian University of Agriculture and Life Sciences (MATE), Kaposvár Campus, Kaposvár

**ABSTRACT** - The current steady increase in the global population is accompanied by a dramatic growth in demand for food, whose satisfaction relies heavily on animal protein sources. Poultry farming is already mankind's key source of protein. Changes in consumer habits combined with the negative impacts of climate change are posing new challenges to poultry breeding companies today. Certain traits properties relating to egg production among offspring groups resulting from the crossing of the White Leghorn and the Rhode Island breeds show improvements relative to the corresponding properties of pure-bred offspring. This literature review is aimed at summing up experiments focusing on White Leghorn and Rhode Island crosses in terms of the main traits properties relating to egg production. Experiments involving the crossing of the White Leghorn and Rhode Island breeds tend to occur mainly during pure-bred poultry breeding. Studies discussing the performance of groups of offspring of White Leghorn (WL) and Rhode Island (RI) breeds, without analysing physiological types of experiments, have been few and far between in the past 20 years. Most of the few such studies originate from countries of the third world focusing in most cases on matters of feeding. This is explained, for the most part, by the fact that in the current period of modern poultry farming, only the world's top breeding companies are in possession of high performance Leghorn and Rhode lines and they seldom ever publish scientific papers allowing glimpse into breeders' development or strategic activities of breeders.

**Keywords**: laying hen, egg, White Leghorn, Rhode Island, cross-breeding

## INTRODUCTION

The global population has doubled in the past fifty years, having reached 7.8 billion by now (*UN*, 2021). Projections show that the total population on Earth will grow to reach 9.8 billion by 2050 (*UN*, 2017). The ongoing population increase and the rise of living standards is accompanied by a like increase in demand for food, the satisfaction of which relies heavily on animal protein sources. In Addition to these, the climate change will affect agriculture through higher temperatures, elevated carbon dioxide ($CO_2$) concentration, precipitation changes, increased weeds, pests and disease pressure. Global mean surface temperature is projected to rise in a range from 1.8°C to 4.0°C by 2100. Such changes will have more or less severe impacts on all components of food security: food production and availability, stability of food supplies, access to food and food utilization (*FAO*, 2009).

*CORRESPONDING AUTHOR

*Magyar Agrár- és Élettudományi Egyetem (MATE), Kaposvári Campus*
✉ *7400 Kaposvár, Guba Sándor u. 40.,* ☎ *82/505-800*
*E-mail: garamvolgyi.erik@phd.uni-mate.hu*

Poultry farming is already the single most important source of protein for people; in the form of the highly popular poultry meat, of which a total of 112.99 million tonnes, and table eggs, of which 69.79 million tonnes (that is, 1320 billion eggs) was produced in 2014 (*Witzke et al.,* 2017**,** *Windhorst,* 2018).

The favourable biological properties chicken as a species have contributed to the increase in the consumption of poultry meat and eggs, as detailed below: *(1)* high reproduction rate; *(2)* short generation interval; *(3)* excellent nutrient transformation; *(4)* highly effective adaptability; *(5)* genetic properties enabling the production of hybrids; *(6)* cheap transportation of hatching eggs and day-old-chicks; *(7)* excellent utilisation of space etc. (*Horn*, 2000).

## THE CURRENT SITUATION IN TERMS OF TABLE EGG PRODUCTION

The importance of chicken egg production and consumption is clearly indicated by an *FAO* (2010) forecast of a 1.1% annual growth rate for the period between 2010 and 2020, in view of which the global chicken egg output is likely to exceed 70 million a year by 2020. This output volume has already been reached, as according to the latest – June 2021 – FAO data the world's total egg production was up at 83.5 million tonnes (or some 1579 billion eggs) in 2019 already.

The total global demand for protein of animal origin is expected (*Mulder,* 2018) to increase between 2017 and 2037 by some 35%, of which the global egg production will increase by 1.6% per year.

The current approx. 77 million tonnes global chicken egg production can be examined in essentially two categories: half of the total output comes from light-bodied Leghorn type hybrids producing white-shelled eggs, while the other half is produced by medium-heavy hybrids laying brown-shelled eggs. Breeder companies in Europe (including Hungary), Africa and the Far-East prefer the breeding of hybrids laying brown-shelled eggs to cater for consumer demand, their share equalling up to 80% (*Cavero et al.,* 2012).

*Preisinger* (2016) argues that this is a definite disadvantage in Europe because Leghorn hens laying white-shelled eggs perform better in non-caged farming than breeds laying brown-shelled eggs. Demand for brown coloured eggs has been changing in Europe as well recently, in response to which traders are increasingly looking for typically "tint" or "tinted" (or "cream" and "beige") coloured eggs. From a professional perspective this is all the more exciting, since the four wild chicken (junglefowl) species lay cream or Isabel colour eggs, which is starkly different from the deep brown colour which is generally held to be the ancient "natural" egg colour (*Sütő and Szász*, 2013). A

number of major traditional breeder companies (e.g. Babcock, Shaver, Tokai) had hybrids laying cream coloured eggs already back in the 1970s and 1980s, but now demand for this kind of colour seems to be reviving and on the increase again, because Hungarian TETRA's competitors have been coming out with such genotypes one after another (e.g.: H&N, CORAL Tinted Eggs Layers, Hy-Line Sonia, Dominant Tinted, etc.).
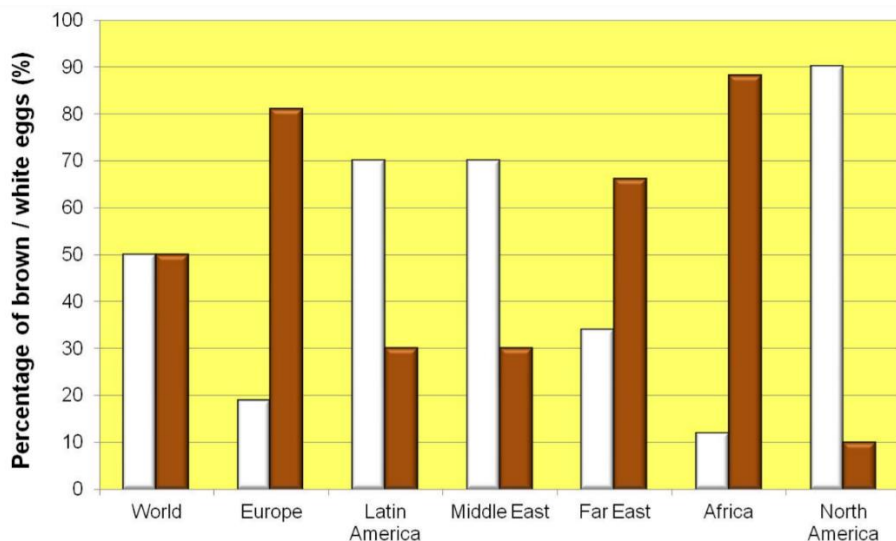


**Figure 1:** Estimated percentage of brown and white eggs worldwide
(Source: Attractive Eggshell Color as a Breeding Goal, *Link*)

## THE TWO INITIAL TYPES

The Leghorn breed was created back in the first half of the 19th century in the United States of America, by cross-breeding the Italian unimproved chicken with the Wyandotte and Minorca breeds. Its name came from the name of the Italian town of Livorno where the majority of the birds transported to America were loaded on ships in around 1835. The Leghorn was the first chicken breed selected exclusively for maximising its egg production capacity, neglecting a variety of appearance related features of lesser importance for production. This breed comes in more than twenty varieties, each having the same type of build, except for the colour of the plumage and the form of the comb. The most economically important of these is the White Leghorn (WL) with a single comb

because each of the Leghorn type hybrids – laying white-shelled eggs – has been bred from this breed through heterosis breeding (*Sütő and Szász*, 2013).

The Rhode Island breed was created in the mid-19th century, also in the United States of America. Its breeding started from a red-coloured unimproved chicken variety living on Rhode Island which was then cross-bred with a number of other varieties (Cochin, Red Malay and Yellow Shanghae) to improve its meat forms. Later on, brown Leghorn roosters were used for cross-breeding in order to increase their egg production. Breeders gave preference to bright cherry-red (that is, dark red) coloured specimens, significantly impeding, particularly in Europe, the progress of improvement in terms of the most important traits. Two colour variants of the breed are of relevance today the red (genetically: gold) Rhode Island Red (RIR) and the white-plumed (genetically: silver) Rhode Island White (RIW) types. The breed's economic significance lies primarily in the fact that breeders use many different lines of the breed for breeding medium-heavy bodied laying hybrids producing brown-shelled eggs (*Sütő and Szász*, 2013), though there is less and less reason for referring to them as "medium-heavy bodied".

## A DISCUSSION OF THE CROSSING OF WHITE LEGHORN WITH RHODE ISLAND

The White Leghorn and the Rhode Island lines are commercially used in layer production worldwide. The two basic layer breeds differ from another in many of their properties, which was also the basis of the distinction between the two large groups of layer hybrids. It is clear however, that consumer markets were divided definitely in terms of their preferences regarding the eggshell colour (white or brown), and therefore it is rather only in the pure breeding phase that one can find cross-bred types created for experimental purposes. The idea is justified by considerations such as size of bodyweight that cross-breeding enables a reduction in the live weight of layer hens in comparison to Rhode type hybrids, along with an improvement in the feed conversion ratio, which improves the chances – in regions where brown-shelled eggs are preferred (such as in Europe) – for mitigating the adverse effects of today's global trend of climate change (including better heat tolerance, smaller environmental footprint). Crosses between RIR and WL produce tint eggs, which constitute higher and higher market shares in parts of Asia, and especially China. According to the statistics of China Animal Agriculture Association, tint eggs constitutes averagely 61% of the eggs from domestic breeds and 24% from the imported breeds in recent 4 year (*Adamu et. al.,* 2020).

*Sexual maturity*

The laying hens are sensitive to light and changes in day length. When hens are reared only under natural light conditions, they reach sexual maturity at different ages depending on latitude and season. Age at sexual maturity has a direct influence on laying performance. One of the factors contributing to the differences in egg production. The age at first egg used as a measure of age at sexual maturity. The two pure breeds differed widely with respect to this characteristic. For the White Leghorns the average age at first egg was between 172.4-188 days and for the Rhode Island Reds 247.6-255 days (*Warren,* 1930; *Glazener et al.* (1952). *Warren* (1930) reported that WL♂ x RIR♀ offspring reached sexual maturity than reciprocal-crossed ones (175.9 days), and nearly at the same age as pure breed, the White Leghorn birds. The number of days to sexual maturity was largest in the case of the Rhode Island Red pure breed. *Knox and Olsen* (1938) found during their experiments that the WL♂ x RIR♀ offspring underperformed the control pure breed specimens at age of sexual maturity. Because the pure-bred White Leghorn (WL) breed reached earlier (192 days) the sexual maturity than WL♂ x RIR♀ cross-breeds (211 days). *Dudley* (1944) got similar results as Warren. In his studies compared the performances of the White Leghorn (WL) and Rhode Island Red (RIR) breeds as well as their cross-bred and reciprocal cross-bred offspring. The crossbred hens reached more quickly sexual maturity than pure breeds. The pure-breed Rhode Island Reds breed took longer to mature than any other type of progeny (211.9 days). The WL♂ x RIR♀ reached the sexual maturity the earliest (186.1 days), earlier than pure-breed WL♂ x WL♀ (190,4 days) and RIR♂ x WL♀ (199.3). *Podchalwar et al.* (2013) found too that the RIR♂ x WL♀ offspring reached sexual maturity in less time.

*Crossbreeding for egg production*

The improvement in poultry performance for egg production during the last three-quarters of the 20th century has been tremendous: from 176 eggs per hen per year in 1925 to 309 eggs per hen per year in 1998 (*Decuypere et al.,* 2003).

   *Warren* (1930) found that the hybrids from the cross WL♂ x RIR♀, were the best producers. This crossbred reached more eggs (214.6 eggs) than purebred White Leghorn (211.6 eggs). The hybrids from the reciprocal cross, RIR♂ x WL♀ cross had an average production of 13 fewer eggs (198.7 eggs) than the White Leghorns. The Rhode Island Reds were the lowest producers (168.9

eggs). *Te Hennepe* (1937) reported that in the Lancashire International Laying-hen Test in 1936-1937 among various cross-breeds the WL x RIR offspring produced nearly twenty eggs less than White Leghorn and Rhode Island Red. *Knox and Olsen* (1938) crossed White Leghorn (WL) roosters with Rhode Island Red (RIR) hens and compared this crossbred for example single comb White Leghorn. They found that the crossbred offspring had fewer eggs (145.4 eggs) than the control pure-bred Single Combs White Leghorns (201.3 eggs). *Knox* (1939) reported one year later that the performance of cross-bred lines fell short of pure-breeds in terms of egg production and other growth parameters. *Dudley* (1944) reported in his studies that the averages of annual egg production for the cross-breeds were slightly higher than those for the pure-breds. Also the hybrids from the cross WL♂ x RIR♀ produced the most of eggs (204.5 eggs). Then the RIR♂ x WL♀ reciprocal crossbreds reached more eggs (197 eggs) than purebred White Leghorn (194.4 eggs) and Rhode Island Red (196.8 eggs). *Ambar et al.* (1999) compared offspring produced by the crossing of birds native to tropical climates and exotic breeds. In terms of egg production WL♂ x RIR♀ came in 3th 54.71 % eggs production), while the RIR♂ x WL♀ cross-breed took the 5th position (57.89% eggs production). *Adamu et al.* (2020) in their study, resource populations of Rhode Island Red (RIR) and White Leghorn (WL) pure-bred chickens were reciprocally crossed to generate 4 distinct groups. They reported that White Leghorn and the hybrids commenced laying earlier than RIR pullets and egg production traits were favorable in the crossbreds compared with purebreds.

*Egg weight*

The egg weight is one of the important performance traits. There are several factors what influencing the resulting egg weight: genetics, health conditions and nutrition. An important factor is the genetics. By the egg size and weight are different the two main types. White Leghorn hens produce leighter egg than Rhode Island hens. The weight of the egg can be further increased by crossing. That reported *Warren* (1930) in his studies. *Warren* (1930) crossed White Leghorn (WL) roosters with Rhode Island Red (RIR) hens and compared this crossbred with purebred White Leghorn and Rhode Island, where the average egg-weight of the offspring of both cross-breeds was identical to those of the two pure-line breeds. *Knox and Olsen* (1938) found the WL x RIR cross-bred had a better average egg weight than the purebred White Leghorn. *Ambar et al.* (1999) reported too that by the crossing increased weight of the egg.

*Adamu et al.* (2020) reported that heterosis for egg number and clutch size was moderate in WL♂ × RIR♀ but low in RIR♂ × WL♀ hens.

**Table 1:** Comparing the traits of different laying hens lines

| Genotypes (Male x Female) | Age at sexual maturity (days) | Egg weight (g) | Egg production (egg, %*) | References |
|---|---|---|---|---|
| RIR x RIR | 247.6 | 54.3 | 168.9 | |
| WL x RIR | 175.9 | 54.6 | 214.6 | *Warren, D. C.* |
| RIR x WL | 206.4 | 54.4 | 198.7 | *(1930)* |
| WL x WL | 172.4 | 51.2 | 211.6 | |
| RIR x RIR | - | - | - | |
| WL x RIR | 211.0 | 56.4 | 145.4 | *Knox, C. W. - Olsen, M. W.* |
| RIR x WL | - | - | - | *(1938)* |
| WL x WL | 192.0 | 54.7 | 201.3 | |
| RIR x RIR | 210.9 | - | 196.8 | |
| WL x RIR | 186.1 | - | 204.5 | *Dudley, F. J.* |
| RIR x WL | 199.3 | - | 197.0 | *(1944)* |
| WL x WL | 190.4 | - | 194.4 | |
| RIR x RIR | 255.0 | 59.2 | 130 (six months) | |
| WL x RIR | - | - | - | *Glazener et al.* |
| RIR x WL | - | - | - | *(1952)* |
| WL x WL | 188.0 | 57.5 | 112 (six months) | |
| RIR x RIR | - | - | - | |
| WL x RIR | - | 55.1 | 54.71* | *Ambar et al.* |
| RIR x WL | - | 57.9 | 57.89* | *(1999)* |
| WL x WL | - | - | - | |

WL = White Leghorn; WL♂ x RIR♀ = White Leghorn male by Rhode Island Red female; RIR = Rhode Island Red; RIR♂ x WL♀ = Rhode Island Red male by White Leghorn female

## CONCLUSIONS

The conclusion we have drawn from literature is that in addition to meeting consumer demand (for creme-coloured eggs), the crossing of the White Leghorn (WL) and the Rhode Island Red (RIR) lines produced favourable results in a number of traits. The WL x RIR offspring took less time to reach sexual maturity and in several studies the egg production of the offspring exceeded that of the pure line groups. The cross-bred combinations outperformed the parents in terms of lower mortality rates as well. Crossing did not have much of an impact on egg quality parameters. Broodiness, however, were found to increase in cross-bred groups relative to pure line offspring groups. Examples of cross-breeding with White Leghorn (WL) and Rhode Island (RI) breeds for purposes of experiments were found only in the pure-breeding stage and there is only a very limited number of publications in the past 20 years covering such

tests for experimental purposes. Studying such types of cross-breeding combinations, however, have become topical, and professionally exciting, again with the aim of mitigating the current climate change effects and in order to fully satisfy consumer demand.

We are confident that there will be significant professional interest in the new experimental report on the characteristics of the offspring produced by crossing the Leghorn and Rhode lines in different housing systems.

## REFERENCES

Adamu M.Isa, Yanyan Sun, Lei Shi, Linlin Jiang, Yunlei Li, Jing Fan, Panlin Wang, Aixin Ni, Ziyan Huang, Hui Ma, Dongli Li, Jilan Chen (2020). Hybrids generated by crossing elite laying chickens exhibited heterosis for clutch and egg quality traits. British Poult. Sci., 99(12), 6332-6340. DOI: *10.1016/j.psj.2020.08.056*

Ambar, M.A.J., Bhuiyan, A.K.F.H., Hoque, M.A., Amin, M.R. (1999). Ranking of some pure and crossbred chicken using scoring indices. Indian Journal of Poultry Science, 34, 140-146.

Cavero, D., Schmutz, M., Icken, W., Preisinger, R. (2012). Attractive eggshell colour as a breeding goal. Lohmann Information, 47(2) 15-21.

Cavero, D., Schmutz, M., Preisinger, R. (2010). Genetic evaluation of pure-line and cross-line performance in layers. Lohmann Information, 45(2), 18-21.

Decuypere, E., Bruggeman, V., Barbato, G.F., Buyse, G. (2003). Growth and Reproduction Problems Associated with Selection for Increased Broiler Meat Production, In: Poultry Genetics Breeding and Biotechnology USA, 13-28.

Dudley, F. J. (1944). Results of crossing the Rhode Island Red and White Leghorn breeds of poultry. The Journal of Agricultural Science, 34(2), 76-81. DOI: *10.1017/S0021859600019754*

Faostat (2009). *Link*

Faostat (2010, 2020). *Link*

Glazener, E. W., Comstock, R. E., Blow, W. L., Dearstyne R. S., Bostian, C. H. (1952). Crossbreeding for egg production. Poultry Sci., 31, 1078-1083. DOI: *10.3382/ps.0311078*

Horn P. (Szerk.) (2000). Állattenyésztés 2. - Baromfi, haszongalamb. 1-428.p. Mezőgazda Kiadó, Budapest.

Knox, C. K. (1939). Crossbreeding in the domestic fowl. Proceedings Seventh World's Poultry Congress, 58-61.

Knox, C. W., Olsen, M. W. (1938). A test of crossbred chickens, single comb White Leghorns and Rhode Island Reds. Poultry Sci., 17, 193-199. DOI: *10.3382/ps.0170193*

Mulder, N. D. (2018). Global and EU Poultry Outlook 2025 (Baromfi Világnap, 2018. május 10. Budapest, Vajdahunyad Vára)

Podchalwar, K. S., Savaliya, F. P., Patel, A. B., Joshi, R. S., Hirani, N. D., Qadri, F. S. (2013). Studies on performance of three crossbred chickens suitable for rural farming. Indian Journal of Poultry Science. 48(2), 215-218.

Preisinger, R. (2016). EU layer breeders adapting hens for cage free conditions. Downloaded: *Link* (Last downlod: 22.06.2020.)

Sütő, Z., Szász, S. (2013). Az étkezési tojástermelés biológiai alapjai (In: Pupos T., Sütő Z., Szőllősi L. (szerk.): Versenyképes tojástermelés. pp. 97-109. Szaktudás Kiadó Ház Zrt. Nemzeti Agrárgazdasági Kamara, Budapest. (Profimax sorozat) (ISBN 978-615-5224-42-3)

Te Hennepe, B. J. C. (1937). Lancashire International Egg-Laying Test, 1936-37. The Lancashire Utility Poultry Society's Report, Vol. 11, 1937, No. 12. (Intemational Review of Poultry Science, Official Organ of The World's Poultry Science Association, TOME X, No. 4)

United Nations (2017). World Population Prospects 2017, UN DESA/Population Division. *Link*

United Nations (2020). World Population Prospects 2019, UN DESA/Population Division. *Link*

Warren, D. C. (1930). Crossbred poultry. In: Kansas State Agriculture Experiment Station Bulletin 252: 1-54.

Windhorst, H.-W. (2018). Contours of change – global egg and poultry meat production in retrospect. Zootecnica International. Downloded: *Link* (Last download: 22.06.2020.)

Witzke, von H., Windhorst, H-W., Noleppa, S. (2017). Societal benefits of modern poultry meat production in Germany and the EU. An economic and environmental analysis. HFFA Research GmbH, Paper 08/217. Berlin. Downloded: *Link* (Last download: 22.06.2020.)

Zelleke, G., Moudgal, R. P., Asmare, A. (2005). Fertility and hatchability in RIR and WL breeds as functionally modified by crossing them in alternate sex combinations (Gallus domesticus). British Poult. Sci., 46(1), 119-123. DOI: *10.1080/00071660400023961*