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Recent contributions to the scientific substantiation of the gene theory of sexuality in Galinaceae

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Abstract. The genetic determinism of sex and the equal male to female ratio in chicken was explained in literature by the existence of the male sex, homogametic ZZ, and of the female sex, heterogametic ZW, as well as by the existence of genes in chromosome Z, however, with no corresponding genes of it in chromosome W. This paper presents experiments of genetic recombination which allows the identification in generation F1 of the dominant sex gene linked to the gene that determines the monitored colour phenotype. In the same generation the recessive sex allele was identified in chromosome Z. In generation F2, males and females are in equal ratio in every category of genotypes. Three categories of feather colour genotypes were produced: dominant homozygous, heterozygous and recessive homozygous. The experimental results show the presence of two genes in chromosome W, the dominant sex gene and the gene transmitting the colour of the feathers, contrary to the hemizygotic theory of Morgan.

Keywords: genetic recombination; feather colour; day-old chicks sex screening.

Introduction. The determinism of the two phenotypes in Galinaceae, the sex and the colour of the feathers, was explained so far only by using two different levels of organization of the genetic material: the chromosomal level and the gene level. The gene determinism starts form the assumption that the genes responsible for feathers colour inheritance are located in chromosome Z and that they do not have any correspondent genes in chromosome W (Morgan 1919). The chromosomal theory of sex determination by heterosomes is still cited, mainly because of the lack of new investigations on this topic. Reputed scientists in poultry genetics always start their studies from the conclusion of the previously mentioned theory (Romanov et al 2004; Berlin & Ellegren 2004; Dorshorst & Ashwell 2009).

The investigation to be presented in this paper was conducted due to the existence of major discrepancies between the experimental data from own research and the chromosomal theory of sex determination by heterosomes (see also Pricop 2006, 2009), which is why this paper relates to the paper of Morgan. The cross of red Rhode Island males with white Rhode Island females produced in generation F1 heterozygous gold females and heterozygous silver males. The feathers of the heterozygous gold females differ both from the feathers of the parents and from the feathers of the heterozygous silver males from the same generation.

The results of our research are contradicting the hemizygotic mechanism which requires the revision and amendment of Morgan’s conclusions.

The use of proper crosses (recessive homozygous male, genotype ss × dominant homozygous female, genotype SS / heterozygous female, genotype Ss) allows the production of hybrid day-old chicks which can be sexed by the juvenile feathers colour. Consequently, our experimental results open new research perspectives in the field of molecular genetics with the purpose to determine the particular way of action of the genes in chromosome W of the poultry genome.

Material and Method. We used the method of the direct and reciprocal cross using two different breeds in order to monitor the phenotypic expression of the heterosomal genes responsible for the genetic determinism of the juvenile feathers' colour and of the sex in gallinaceae. The cross of the parental males and females produced generation F1, and the cross of the F1males and females produced generation F2.

The parents originate from pure homozygous lines for the silver (S) and gold (s) heterosomal genes which are responsible for the juvenile feathers colour inheritance. The parents belonged to the following breeds: white Rhode-Island and red Rhode-Island characterized as follows: phenotypically, the white Rhode-Island birds have white feathers and their genotype is homozygous dominant (SS) for the silver gene (S); phenotypically, the red Rhode-Island birds have red feathers and their genotype is homozygous recessive (ss) for the gold gene (s).

The experimental groups consisted of over 1700 individuals which were evaluated in generation F1 whereas over 1600 individuals were evaluated in generation F2. The technological male to female ratio in the parent groups was 1:10. The macroscopic examination of the feathers color and of the sex of the individuals was conducted twice, once for day-old and the second for birds at the age of 18 weeks.

Direct cross in Galinaceae: white Rhode Island male × red Rhode-Island female. The cross of white Rhode Island males with red Rhode-Island females produced in generation F1 day-old genetic recombinants that were sexed using the cloacal method. The generation F1 contained heterozygous silver males and heterozygous silver females (Figure 1). Table 1 shows F1 statistics.

The hatch produced 1,780 genetic recombinants classified by the sex and colour of the juvenile feathers as follows:

- 42.7% heterozygous silver males with white juvenile feathers
- 1.7% heterozygous silver males with white juvenile feathers, brown spot on the head and three dark-brown stripes on the back
- 4.9% heterozygous silver males with white juvenile feathers and red spot on the back
- 50.7% heterozygous silver females with white juvenile feathers

The hatch produced 49.3% heterozygous silver males, genotype Ss and 50.7% heterozygous silver females, genotype Ss.

At the age of 18 weeks, 1,460 birds were examined macroscopically by the colour of the feathers as follows:

- 42.7% heterozygous silver males with white feathers
- 6.6% heterozygous silver males with red feathers among the preponderantly white feathers
- 50.4% heterozygous silver females with white feathers
- 0.3% heterozygous silver females with red feathers among the preponderantly white feathers

The red feathers among the preponderantly white feathers of the heterozygous silver females (Ss) are accounted by the presence of the hypostatic gold gene in chromosome W (Figure 1). Epistasis is revealed by the phenotype with red feathers among the preponderantly white feathers and by the difference of frequency between the heterozygous silver males (6.6%) and the heterozygous silver females (0.3%). The 6.3% difference in the frequency (6.6% - 0.3%) of the two sexes observed in the described phenotype is explained by the allelic interaction which is unmodified in the males and modified in the females by the epistatic action of the dominant sex gene over the gold gene in chromosome W.

The production of the two categories of phenotypes of feather colour in F1 males is explained by the incomplete dominance of the silver gene over the gold gene and by the fact that the recessive sex allele has no epistatic action over the silver and gold genes in the linkage group Z.

Table 1

Feather colour by sex in F1 day-old and 18-week old genetic recombinants (♂ white Rhode-Island × ♀ red Rhode-Island)

Day-old			***Sex***	***18 Week-old***		
Phenotype and genotype	birds	%		Phenotype and genotype	birds	%
Heterozygous silver, with white juvenile feathers (Ss)	760	42.7	**MALE**	Heterozygous silver, with white feathers (Ss)	624	42.7
Heterozygous silver, with white juvenile feathers, brown spot on the head and three dark-brown stripes on the back (Ss)	30	1.7		Heterozygous silver, with red feathers among the preponderantly white feathers (Ss)	96	6.6
Heterozygous silver, with white juvenile feathers and red spot on the back (Ss)	88	4.9				
Heterozygous silver, with white juvenile feathers (Ss)	902	50.7	**FEMALE**	Heterozygous silver, with white feathers (Ss)	735	50.4
				Heterozygous silver, with red feathers among the preponderantly white feathers (Ss)	5	0.3
Total males and females	**1,780**	**100**		**Total males and females**	**1,460**	**100**

Together with chromosome Z the heterozygous silver males also receive from the father the recessive sex allele (sdw) linked to the silver gene (S) and together with chromosome Z from the mother they also receive the recessive sex allele (sdw) linked to the gold gene (s). The homozygous recessive genotype sdwsdw determines the male sex, while the heterozygous genotype Ss determines the colour of the feathers.

Together with chromosome Z the heterozygous silver females also received from the father the recessive sex allele (sdw) linked to the silver gene (S) and together with chromosome W from the mother they also receive the dominant sex gene (SDW) linked to the gold gene (s). The heterozygous genotype sdwSDW determines the female sex while the heterozygous genotype Ss determines the colour of the feathers.

When the F1 genetic recombinants reached sexual maturity they were crossed between them and produced generation F2 (see Table 2).

Table 2

Feather colour by sex in F2 day-old and 18-week old genetic recombinants (♂ heterozygous silver × ♀ heterozygous silver)

Day-old			***18 Week-old***		
Sex, phenotype and genotype	birds	%	Sex, phenotype and genotype	birds	%
Homozygous silver (SS) and heterozygous (Ss)* silver males and females with white juvenile feathers	1251	74.9	Homozygous (SS) * silver males and females with white feathers	335	24.8
			Heterozygous (Ss)* silver males and females with red feathers among the preponderantly white feathers	676	50.0
Homozygous (ss) * gold males and females with red juvenile feathers	419	25.1	Homozygous (bb) * gold males and females with red feathers	341	25.2
Total males and females	**1,670**	**100**	**Total males and females**	**1,352**	**100**

* The males and females accounted for equal shares in each phenotypic category

Subsequent to the sex chromosomes segregation in F1 genetic recombinants we would have expected four categories of genotypes in generation F2, differing by sex and by the colour of the feathers as follows: a) homozygous silver males (sdwsdw SS), heterozygous silver males (sdwsdw Ss), heterozygous silver females (sdwSDW Ss) and homozygous gold females (sdwSDW ss).

The experimental data on generation F2 (Figure 1) show that besides the expected four categories of genotypes there are two more genotypes, which is a novelty: homozygous silver females (sdwSDW SS) and homozygous gold males (sdwsdw ss).

The features observed in the inheritance of feathers colour show that the last two categories of genotypes that were detected should have not appeared since they do not observe the pattern of sex chromosomes segregation in the genetic recombinants of generation F1 and of their recombination in generation F2.

In a previous experiment (Ministry of Agriculture, Fisheries and Food, 1966) all F2 males had white feathers, half of the females had white feathers and the other half red feathers.

The three categories of genotypes from generation F2 and the equal share of males and females in each genotype category reveal the following:

- in generation F1 the gold gene is located in chromosome W of the heterozygous silver females (Ss); it determines genetically the red feathers among the preponderantly white feathers on the body in 0.3% of the heterozygous silver females and represents a particular way of action of this gene in chromosome W;
- the silver gene is located in chromosome Z of all F1 subjects and is inherited by the progeny as any dominant autosomal gene;
- the cross of F1 heterozygous silver males with F1 heterozygous silver females shows that feathers colour inheritance in generation F2 by the heterosomal genes is similar to the inheritance of the traits determined by genes located in a single autosomal locus;
- the existence of 24.8% dominant homozygous females and males, of 50.0% heterozygous females and males and of 25.2% recessive homozygous females and males clearly shows that the F1 females are heterozygous rather than hemizygous.

Reciprocal cross: red Rhode-Island male × white Rhode-Island female. Analogously, we conducted the reciprocal cross between red Rhode-Island males and white Rhode-Island females. F1 day-old genetic recombinant chicks were sex screened by the colour of the juvenile feathers (Fig. 2). F1 generation included heterozygous silver males, genotype Ss and heterozygous gold females, genotype sS. Table 3 shows F1 statistics.

The hatch produced 1,980 genetic recombinants (Table 3) classified by the sex and colour of the juvenile feathers as follows:

- 43.3% heterozygous silver males with white juvenile feathers;
- 1.7% heterozygous silver males with white juvenile feathers, brown spot on the head and three dark-brown stripes on the back;
- 5.1% heterozygous silver males with white juvenile feathers and red spot on the back;
- 45.2% heterozygous gold females with reddish-white juvenile feathers, red feathers on the head and two red stripes on the back;
- 1.2% heterozygous gold females with reddish-white juvenile feathers and red feathers on the head;
- 0.7% heterozygous gold females with red juvenile feathers, brown spot on the head and three dark-brown stripes on the back;
- 2.8% heterozygous gold females with red juvenile feathers.

The hatch produced 50.1% heterozygous silver males, genotype Ss and 49.9% heterozygous gold females (trademark Roso SL-2000), genotype sS.

Day-old chicks sex screening by the colour of the juvenile feathers is explained by the allelic interaction between the gold and silver genes, modified by epistasis (E) in the females and unmodified in the males (Figure 2).

Table 3

Feather colour by sex in F1 day-old and 18-week old genetic recombinants
(♂ red Rhode-Island × ♀ white Rhode-Island)

Day-old			***Sex***	***18 Week-old***		
Phenotype and genotype	birds	%		Phenotype and genotype	birds	%
Heterozygous silver, with white juvenile feathers (Ss)	857	43.3	**MALE**	Heterozygous silver, with white feathers (Ss)	713	43.4
Heterozygous silver, with white juvenile feathers, brown spot on the head and three dark-brown stripes on the back (Ss)	34	1.7		Heterozygous silver, with red feathers among the preponderantly white feathers (Ss)	109	6.7
Heterozygous silver, with white juvenile feathers and red spot on the back (Ss)	101	5.1				
Heterozygous gold, with reddish-white juvenile feathers, red feathers on the head and two red stripes on the back (sS)	895	45.2	**FEMALE**	Heterozygous gold, with white feathers among the preponderantly red feathers (sS)	818	49.9
Heterozygous gold, with reddish-white juvenile feathers and red feathers on the head (sS)	24	1.2				
Heterozygous gold, with red juvenile feathers, brown spot on the head and three dark-brown stripes on the back (sS)	14	0.7				
Heterozygous gold, with red juvenile feathers (sS)	55	2.8				
Total males and females	**1,980**	**100**		**Total males and females**	**1,640**	**100**

The accuracy of day-old chicks sex screening by the colour of the juvenile feathers was supported by their cloacal sex screening.

At the age of 18 weeks, 1,640 birds were examined for the colour of the feathers as follows (Table 3):

- 43.4% heterozygous silver males with white feathers;
- 6.7% heterozygous silver males with red feathers among the preponderantly white feathers;
- 49.9% heterozygous gold females with white feathers among the preponderantly red feathers.

The results of feathers colour inheritance in the 18 week-old heterozygous gold females reveal the existence of just one phenotypic category. Their phenotype is different from that of their parents and from that of the heterozygous silver males from the same generation (Figure 2). Based on the macroscopic examination Pricop (2005) reasoned that the heterosomal gene noticed previously within the chromosome W is the dominant sex gene (SDW) which plays two roles:

- a) as a dominant sex gene in relation to its recessive allele, sdw, located in chromosome Z; the heterozygous genotype sdwSDW determines the female sex;
- b) as an epistatic gene that interacts with the gene determining the plumage colour, located within the chromosome W.

The non-allelic interaction (E) of the dominant sex gene on the silver gene in the heterozygous gold females occurs only in the W linkage group and it modifies the allelic interaction between the gold and silver genes from the heterozygous genotype sS that determines the colour of the feathers. The colour of feathers of the F1 heterozygous gold females was the phenotypic marker that allowed the identification of the dominant sex gene.

The colour of heterozygous silver males feathers, genotype Ss, is white in 43.3% in the chicks and has red feathers in the preponderantly white feathers in 6.7% of the chicks (Table 3). The production of the two categories of phenotypes of feather colour in the males is explained by the incomplete dominance of the silver gene over the gold gene and by the fact that the recessive sex allele (sdw) has no epistatic action over them. The recessive sex allele is present in the two Z chromosomes and forms the recessive homozygous genotype sdwsdw that determined the male sex.

The cross of a male of recessive homozygous genotype (sdwsdw) with a female of heterozygous genotype (sdwSDW) produces 50% males of recessive homozygous genotype (sdwsdw) and 50% females of heterozygous genotype (sdwSDW). This explains the gene determinism of the sex and the production of equal ratios of males and females. Together with chromosome Z the heterozygous silver males also receive from the father the recessive sex allele (sdw) linked to the gold gene (s) and together with chromosome Z from the mother they also receive the recessive sex allele (sdw) linked to the silver gene (S). The homozygous recessive genotype sdwsdw determines the male sex, while the heterozygous genotype Ss determines the colour of the feathers.

Together with chromosome Z the heterozygous gold females also received from the father the recessive sex allele (sdw) linked to the gold gene (s) and together with chromosome W from the mother they also receive the dominant sex gene (SDW) linked to the silver gene (S). The heterozygous genotype sdwSDW determines the female sex while the heterozygous genotype sS determines the colour of the feathers.

The cross of heterozygous silver males (Ss) with heterozygous gold female (sS) produced generation F2 (see Table 4).

Table 4

Feather colour by sex in F2 day-old and 18-week old genetic recombinants
(♂ heterozygous silver × ♀ heterozygous gold)

Day-old			***18 Week-old***		
Sex, phenotype and genotype	birds	%	Sex, phenotype and genotype	birds	%
Homozygous silver (SS) and heterozygous (Ss)* silver males and females with white juvenile feathers.	934	50.2	Homozygous (SS) * silver males and females with white feathers.	376	25.0
			Heterozygous (Ss)* silver males and females with red feathers among the preponderantly white feathers.	376	25.0
Heterozygous (sS)* gold males and females with reddish-white juvenile feathers, red feathers on the head and two red stripes on the back.	460	24.7	Heterozygous (sS)* gold males and females with white feathers among the preponderantly red feathers.	374	24.9
Homozygous (ss)* gold males and females with red juvenile feathers.	468	25.1	Homozygous (ss) * gold males and females with red feathers.	378	25.1
Total males and females	**1,862**	**100**	**Total males and females**	**1,504**	**100**

* The males and females accounted for equal shares in each phenotypic category.

Subsequent to the sex chromosomes segregation in F1 genetic recombinants we would have expected four categories of genotypes in generation F2 (Fig. 2), differing by sex and by the colour of the feathers as follows: a) homozygous silver females (sdwSDW SS), b) heterozygous silver males (sdwsdw Ss), c) heterozygous gold females (sdwSDW sS), d) homozygous gold males (sdwsdw ss).

Comparing to the experimental data on generation F2 (Fig. 2) one can observe that besides the expected four categories of genotypes there are four more genotypes, which is a novelty: a) homozygous silver males (sdwsdw SS); b) heterozygous silver females (sdwSDW Ss); c) heterozygous gold males (sdwsdw sS); d) homozygous gold females (sdwSDW ss).

The features observed in the inheritance of feathers colour show that the last four categories of genotypes that were detected should have not appeared since they do not observe the pattern of sex chromosomes segregation in the genetic recombinants of generation F1 and of their recombination in generation F2.

Compared to the results obtained in a previous experiment (Ministry of Agriculture, Fisheries and Food, 1966) we crossed F1 offspring produced from red Rhode-Island males and white Rhode-Island females and F2 progeny displayed two phenotypes: 50% silver males and females and 50% gold males and females.

In our experiments we obtained in generation F2 four categories of phenotypes and the three categories of genotypes which, together with the ratio males: females equal to one for each category of genotypes, reveal the following:

- in generation F1 the silver gene is located in chromosome W of the heterozygous gold females (sS); it determines genetically the white feathers among the preponderantly red feathers and represents a particular way of action of this gene in chromosome W;
- the gold gene is located in chromosome Z of all F1 subjects and is inherited by the progeny as any recessive autosomal gene; the progeny has red feathers on the body with few white feathers due to the modified allelic interaction between the gold gene and the hypostatic silver gene located in chromosome W;
- the cross of F1 heterozygous silver males with F1 heterozygous gold females shows that feathers colour inheritance in generation F2 by the heterosomal genes is similar to the one observed in the autosomal genes except for the fact that the heterozygous are represented by two categories of phenotypes of the colour of feathers that form together 49.9% of the progeny, consisting of: 25.0% heterozygous silver males and females and 24.9% heterozygous gold males and females;
- F2 generation included 25% dominant homozygous females and males, 49.9% heterozygous females and males and 25.1% recessive homozygous females and males, which clearly shows that the F1 females are heterozygous rather than hemizygous.

The direct cross produced in generation F1 two categories of phenotypes of the colour of feathers in the heterozygous silver females genotype Ss (Figure 1), while the reciprocal cross in the same generation produced just one phenotype category of the colour of feathers in the heterozygous gold females genotype sS (Figure 2).

A careful analysis of the two situations reveals an epistasis effect with different phenotypic results determined by the epistatic action of the dominant sex gene (SDW) on the gold gene (s) in the first situation and on the silver gene (S) in the second situation. When the recessive gold gene is located in chromosome W and the dominant silver gene is located in chromosome Z two phenotype categories result for the heterozygous silver females (Ss), while when the two gene change locations (gold gene in chromosome Z and silver gene in chromosome W) just one phenotype category results for the heterozygous gold females (sS), different from those of the heterozygous silver females.

The existence of the unexpected categories in generation F2, both for the direct and for the reciprocal cross, might be partly explained by the presence of a pseudoautosomal region, suggested by Berlin & Ellegren (2004), similar to those observed in XY chromosomal systems of mammals (Henke et al 1993; Das et al 2009; Flaquer et al 2009) and fish (Traut & Winking 2001; Petrescu-Mag & Bourne 2008; Petrescu-Mag 2009), where the genes determining the plumage colour inheritance are located. In that pseudoautosomal region the genes are recombining by crossing-over just like in the autosomal regions, although this area is located in the heterosomes.

The cross of red Rhode-Island males with heterozygous silver female. The generation F1 heterozygous silver females produced in the direct cross (Figure 1) were crossed with red Rhode-Island males and produced genetic recombinants that can be sexed when day-old by the colour of the juvenile feathers. Table 5 shows F1 results.

The hatch produced 3,150 genetic recombinants (Table 5) classified by the sex and colour of the juvenile feathers as follows:

- 43.1% heterozygous silver males with white juvenile feathers;
- 1.8% heterozygous silver males with white juvenile feathers, brown spot on the head and three dark-brown stripes on the back;

- 5% heterozygous silver males with white juvenile feathers and red spot on the back;
- 50.1% homozygous gold females with red juvenile feathers.

Table 5

Feather colour by sex in F1 day-old and 18-week old genetic recombinants
(♂ red Rhode-Island × ♀ heterozygous silver)

Day-old			***Sex***	***18 Week-old***		
Phenotype and genotype	birds	%		Phenotype and genotype	birds	%
Heterozygous silver, with white juvenile feathers (Ss)	1,358	43.1	**MALE**	Heterozygous silver, with white feathers (Ss)	1,127	43.1
Heterozygous silver, with white juvenile feathers, brown spot on the head and three dark-brown stripes on the back (Ss)	57	1.8		Heterozygous silver, with red feathers among the preponderantly white feathers (Ss)	179	6.8
Heterozygous silver, with white juvenile feathers and red spot on the back (Ss)	158	5.0				
Homozygous gold, with red juvenile feathers (ss)	1,577	50.1	**FEMALE**	Homozygous gold with red feathers (ss)	1,310	50.1
Total males and females	**3,150**	**100**		**Total males and females**	**2,616**	**100**

The hatch produced 49.9% heterozygous silver males and 50.1% homozygous gold females (trademark Roso SL-93).

The heterozygous silver males had white juvenile feathers when day-old as determined by the action of the silver and gold genes of the heterozygous genotype Ss.

The gold homozygous (ss) females had red juvenile feathers when day-old due to the gold gene (s) located both in chromosome Z and in chromosome W.

Day-old sex screening by the colour of the feathers is allowed by the allelic interaction between the silver and gold genes in the heterozygous silver males. The recessive homozygous genotype (ss) determined the red colour of the juvenile feathers in the homozygous gold females that can be easily screened off from the males.

Conclusions. The identification of the gene that determines the colour of the feathers linked to the dominant sex gene (SDW) in chromosome W and of the recessive sex allele (sdw) in chromosome Z allowed, for the first time, a gene approach of sex inheritance and the development of a new theory, the "The gene theory of sexuality". Our results are supported by molecular data of Pace & Brenner (2003), where Asw-Hint heterodimer is used to present a model for avian sex determination (see also Smith 2007).

Based on our experimental results we propose to amend the heterosome map modified by Hutt (1936; see also Hutt - cited by Ministry of Agriculture, Fisheries and Food, 1966), by introducing, both in chromosome Z and in chromosome W, the locus for the two genes that determine sex inheritance as follows: the dominant sex gene (SDW) in chromosome W and its recessive allele (sdw) in chromosome Z. Following our investigations we identified the gold and silver genes in chromosome W in a locus corresponding to the one existing in chromosome Z.

According to the new theory it results that: **a)** the gene determinism of sex inheritance is explained by the cross of a male of recessive homozygous genotype sdwsdw with a female of heterozygous genotype sdwSDW which produces 50% males of the recessive homozygous genotype sdwsdw and 50% females of the heterozygous genotype sdwSDW; **b)** the inheritance of the juvenile feathers colour by F1 day-old hybrid chicks is explained by the presence of the heterosomal genes silver and gold in a heterozygous genotype, both in the males (Ss) and in the females (sS); **c)** F1 day-old hybrid chicks sex screening by the colour of the juvenile feathers is determined by the allelic interaction, which is modified in the females by the epistatic (E) action of the dominant sex gene (SDW) on the silver gene that turns hypostatic, while and the allelic interaction remains unmodified in the males; **d)** the presence of the three categories of genotypes in generation F2 reveals both the universal character of the homo- and heterozygotic mechanisms to the detriment of the hemizygotic mechanism and the autosomal origin of the heterosomes. **e)** the introduction in the heterosome map, both in chromosome Z and in chromosome W, of the locus for the sex inheritance genes.

Completely different from the *Chromosomal theory of sex inheritance by heterosomes* substantiated by the school of Morgan (1919) in his book "The Physical Basis of Heredity" that explains sex inheritance at the chromosome level, "The gene theory of sexuality" explains the gene determinism of sex inheritance and the equal male to female ratio at the gene level, as result of the crossing between a recessive homozygous (sdw sdw) organism and a heterozygous (sdw SDW) one.

The four phenotypic categories of the colour of the feathers, observed in day-old heterozygous gold females, represent four different levels of epistatic action of the sex dominant gene upon silver gene.

This study enclose a cycle of qualitative genetics and further studies, at molecular level, are necessary in order to explain in detail the presence of the unexpected subjects in F2 generation, both in direct cross and reciprocal cross.

Briefly, our results reveal the universality of chromosomal theory of heredity (Pricop 2009). The new theory is supported by the following practical applications (Pricop & Pricop 2010): Thesis and antithesis of creation of new poultry breeds; Explanation of hermaphroditism in gallinaceae; Solutions to the litigious disputes between customers and suppliers of hybrid chickens, when the genetic formula for commercial layer production was not followed; Method to stop plumage discoloration and improvement of this trait in the commercial layer hybrids obtained by crossing red Rhode-Island males with white Rhode-Island females; Hybridization design for sexing day-old hybrid chicks by the down colour using heterozygous barred females and heterozygous silver females.

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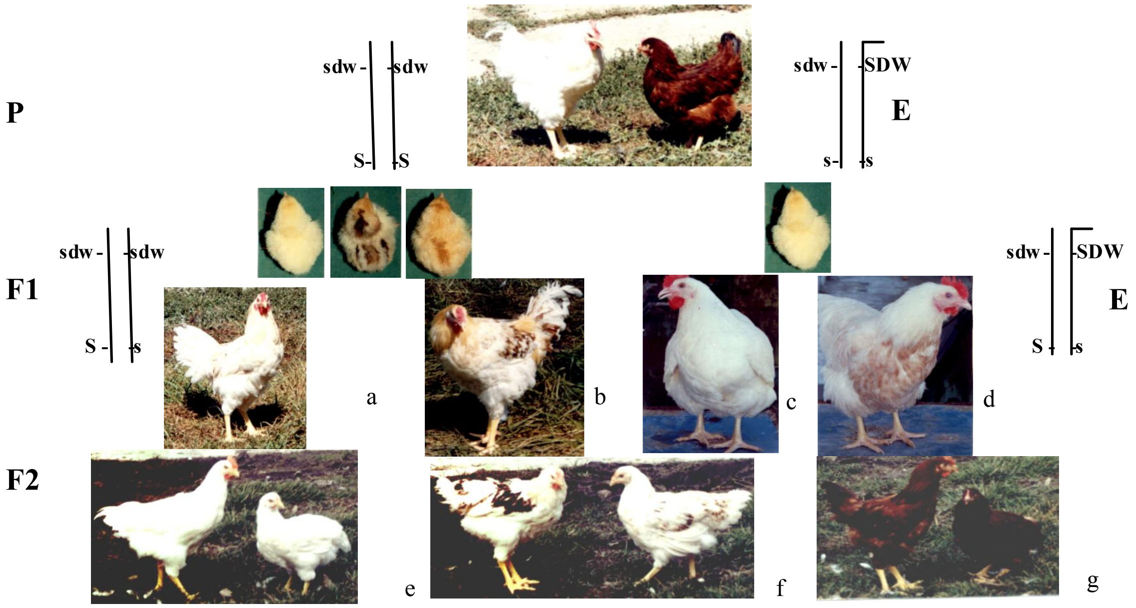

Genotype:	**sdwsdw SS**	**sdwSDW SS***	**sdwsdw Ss**	**sdwSDW Ss**	**sdwsdw ss***	**sdwSDW ss**
Frequency (%):	**24.8**		**50.0**		**25.2**	

Legend:

P = parental generation
F1 = progeny generation 1
F2 = progeny generation 2

a and b = heterozygous silver males
c and d = heterozygous silver females
e = homozygous silver females and males
f = heterozygous silver females and males
g = homozygous gold females and male

SDW = dominant sex gene
sdw = recessive sex allele
S = silver gene
s = gold gene
E = epistasis

* unexpected subject in generation F2

Figure 1. Progeny of generations F1 and F2 at the age of 18 weeks; cross of white Rhode-Island males and red Rhode-Island females (Pricop 2003)

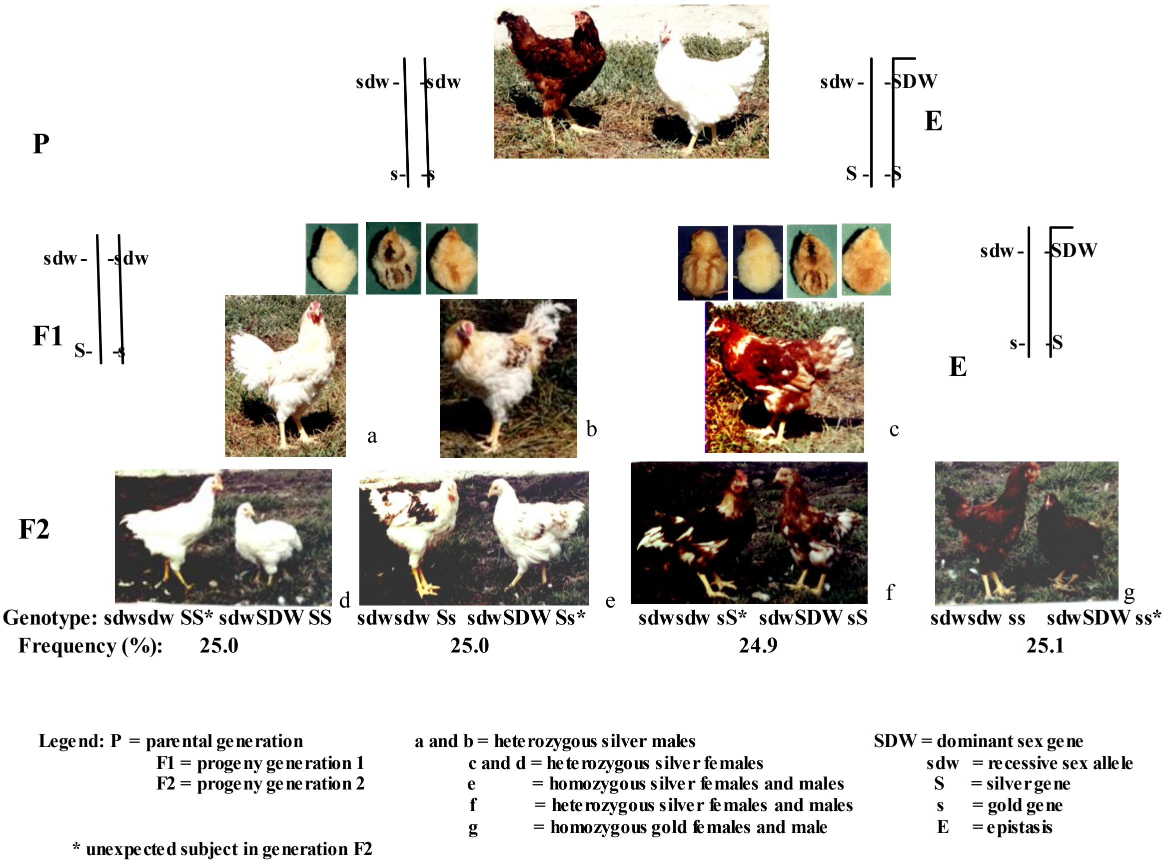

Figure 2. Progeny of generations F1 and F2 at the age of 18 weeks; cross of red Rhode-Island males and white Rhode-Island females (Pricop 2003)

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