

# The Poltava chicken breed of Ukraine: its history, characterization and conservation

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## Summary

Poltava chickens are native to Ukraine, with a remarkable history, genetics and economic traits. They include three varieties: Clay, Cuckoo and Black. The Poltava Clay variety exemplifies what can be achieved by thorough selection in transforming a local, low production chicken population into an established breed with high performance characteristics and selected line structure. Two other varieties, the Cuckoo and Black, are extinct but plans for their restoration are underway.

## Resumen

Las aves Poltava son originarias de Ucrania y poseen unos rasgos genéticos y económicos y una historia importante. Incluyen tres líneas: Clay, Cuckoo y Black. La línea Poltava Clay es un ejemplo de lo que se puede conseguir a través de la selección transformando una población local de aves de baja producción en una línea estable con características de alto rendimiento y estructura selecta. Las otras dos variedades, Cuckoo y Black, se han extinguido pero existen planes actualmente para su recuperación.

**Keywords:** Characterization, Chicken, Conservation, History, Poltava, Ukraine.

## Introduction

The name of the Poltava chickens of Ukraine is derived from the name of Poltava city and region. This is one of the central, long-established regions

of Ukraine, which retains the old traditions of livestock breeding and farming. The breed used to include three varieties: the Clay, Cuckoo, and Black. They were registered as local populations during an expeditionary poultry survey in the 1920's (Ferdinandov, 1948), however, breed founders had already been exhibited at a poultry exhibition in Poltava in 1895. The selection of Poltava chickens for improved performance and reproduction was initiated in 1912 at the Poltava Experiment Station. At that time, their yearly egg production was 70, average egg weight was 50 g, and body weight 2.1 to 4 kg (Ivanova and Kovalenko, 2003; Mosyakina *et al.*, 2005).

At the first and second all-Ukrainian egg production competitions in 1928-1929, the Poltava chickens demonstrated an extraordinary production of 100 eggs per hen, with the best layers having produced 164-169 eggs in the 259 days of the test (Romanov and Bondarenko, 1994). However, in the following years (1930-1941) most collective farms switched to breeding White Leghorns and other standard breeds. During World War II and the post-war years, changes in agriculture policies induced by the deleterious innovations of the Lysenko and Khrushchev parties, the transition to industrial poultry production and other state measures resulted in the continued decline of native breeds. To propagate and preserve native chicken populations, eggs of

**Dedication:** The authors dedicate this paper to the memory of their senior colleague and teacher Vera Dmitrievna Lukyanova (1927-2006), the former Director of the Poultry Research Institute (UAAS), Borky, who contributed to the breeding and selection improvement of the Poltava Clay chickens in the 1960s-1990s.

Poltava chickens were imported to the Ukrainian Poultry Experiment Station (now the Poultry Research Institute, PRI) in Borky, Kharkiv Region, from the Poltava Region in 1948-1949. Before 1953, this core breeding flock was subject to mass selection coupled with individual selection. Later on, more intense selection was undertaken to improve the Poltava breed including all three varieties (Clay, Black and Cuckoo), which was supported by a special decree by the Ukraine Ministry of Agriculture (Len', 1959; Ivanova and Kovalenko, 2003; Mosyakina *et al.*, 2005).

## Poltava Clay

The Clay variety is presumed to have been known in Poltava Province from the mid 19th century. It was derived from local fowls crossed with Buff Orpingtons (Savelyev, 1953; Romanov and Bondarenko, 1994) or other exotic breeds such as New Hampshire, Wyandotte, etc. (Mosyakina *et al.*, 2005). From 1951 an improvement of the Clay variety was begun. In 1965, worthwhile strains were chosen and selection, combined with progeny testing of sires, commenced. Since 1970, these selected strains have been tested for general and

specific combining abilities (Lukyanova and Kovalenko, 1979).

By January 1, 1985, there were 714 385 Poltava Clays at the collective and state farms of the former USSR. However, since 1991 there has been a significant decline in livestock and poultry production and an overall gene pool loss, factors that also affected the state of the Poltava chicken breed. By 1994, a total of 3 300 purebred Clay chickens remained (Romanov and Bondarenko, 1994). In 2003, the Borky farm as an accredited Poltava Clay breeding centre and primary producer had 6 000 individuals. In addition, five more primary and secondary producers supplied this breed to state and private farms in Ukraine (Ivanova and Kovalenko, 2003; Mosyakina *et al.*, 2005). Information about Poltava Clays was incorporated into the FAO DAD-IS Breeds Database (FAO, 1996) and the World Watch List for Domestic Animal Diversity (Scherf, 1995, 2000).

Clay chickens are not particularly large birds, with a horizontal posture and legs of medium length and yellow colour (gene  $ID^*ID$ ) (Figure 1). Their comb is rose ( $R^*R$ ) or less frequently single ( $R^*N$ ). Their plumage colour ranges from buff to dark buff (genes of wheaten colouration  $MC1R^*WH$ ,  $MC1R^*Y$ ,  $MH^*MH$ ,  $DI^*DI$ ,  $CB^*CB$ , and of gold  $S^*N$ ),



Figure 1. A cock of the Poltava Clay variety.



Figure 2. A hen of the Poltava Clay variety.

and is of a "black-tailed" Columbian type ( $CO^*CO$ ). Clay chickens are somewhat larger than the Cuckoos and Blacks (Len', 1961).

The Poltava Clay has been subject to morphotypological characterisation (Nikiforov *et al.*, 1998) and assessment for blood groups (Podstreshny, 1980; Gintovt *et al.*, 1984), and blood serum and egg white proteins (Bondarenko, 1976; Moiseyeva *et al.*, 1989). As a result of these studies, Poltava chickens were found to be closer to breeds of Asian origin including dual-purpose breeds from Russia and China. Romanov and Weigend (2001) included two Poltava Clay strains, P6 and P14, in a microsatellite diversity study of 20 populations. Both Poltava strains were clustered together with commercial and other strains derived from Rhode Island Reds and New Hampshires (Figure 2). In a large-scale survey (AVIANDIV, 2001), estimation of polymorphism degree for 25 microsatellite markers resulted in somewhat greater values in the Poltava breed in comparison with the "world" gene pool.

Clay chickens are well adapted to local conditions, can forage effectively and are undemanding feeders. They have broodiness and an overall calm demeanour and can be reared both on floors and in cage batteries of various types

including individual cages for artificial insemination. The Poltava Clay is a dual-purpose breed, but some strains were selected with a bias towards egg or meat productivity. In strains selected for body weight, the cocks weigh up to 3.2 kg, and the hens 2.2 kg. Strains selected for egg production produce 210-240 eggs in 72 weeks. The breed is subject to continuous selection for increased viability, resistance to stress, neoplasms and Marek disease. Eggshell colour is brown (Ivanova and Kovalenko, 2003; Mosyakina *et al.*, 2005). Chicks are early feathering (gene  $K^*N$ ) and fast growing (Bondarenko, 1995). Clay fowls are more resistant to Rous sarcoma virus and neoplasms as compared to White Leghorns and White Russians (Stolyarenko, 1970; Kovalenko and Stolyarenko, 1982).

Poltava Clays are used as a dam strain in crossing with White Leghorns. Hybrids are resistant to oncoviruses, have brown eggshell, produce 222-243 eggs per hen housed and 235-252 eggs per hen survived for 69 weeks of life. Synthetic lines ('polycrosses' of three to nine lines) were developed based on Poltava Clay chickens including two lines combining Poltava Clay and Rhode Island Red strains (Lukyanova and

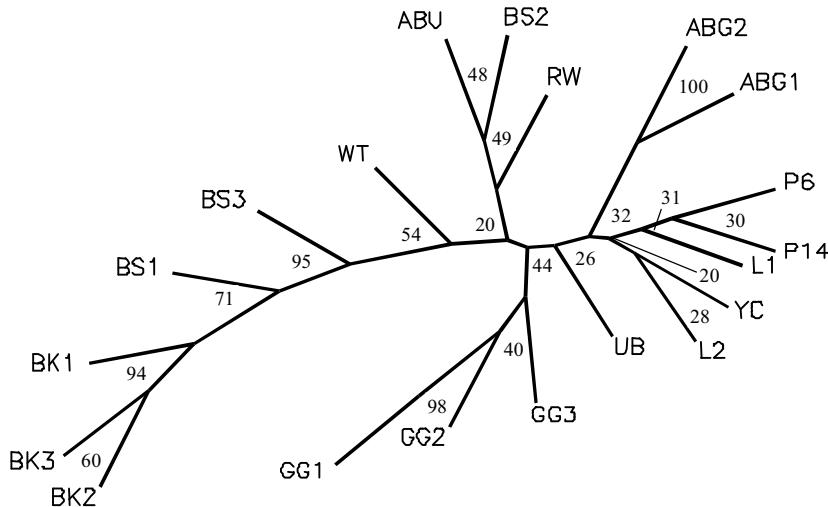


Figure 2. Dendrogram of phylogenetic relationships among 20 chicken populations, using Nei's (1972) standard genetic distance and the NJ method, based on 14 microsatellite loci. Consensus tree: numbers at the nodes are percentage bootstrap values from 1000 replications with resampled loci. Ukrainian populations: Ukrainian Bearded (UB), Poltava Clay (P6, P14), Yurlov Crower (YC), and Australorp Black (ABU). German populations: Red Jungle Fowl (*Gallus gallus*; GG1, GG2, GG3), Bergische Kräher (BK1, BK2, BK3), Bergische Schlotterkämme (BS1, BS2, BS3), Ramelsloher White (RW), Westfälische Totleger (WT), Australorp Black (ABG1, ABG2), and commercial layer lines (L1, L2) (from Romanov and Weigend, 2001).

Kovalenko, 1979; Romanov and Bondarenko, 1994; Ivanova and Kovalenko, 2003).

## Poltava Cuckoo

The period of development of the Cuckoo variety is presumed to be the 19th century. Original forms are unknown (Figure 3), although the relationship with Barred Plymouth Rocks is repudiated (Savelyev, 1953). In 1954, the Cuckoo population was 33.8 thousand birds. Currently, it is probably extinct (Mosyakina et al., 2005). The body constitution of the Cuckoo corresponds to that of egg type fowls (Figure 4 and 5). The comb is predominantly rose (gene  $R^*R$ ) or single ( $R^*N$ ), and earlobes are red. In plumage colour, they resemble the Barred Plymouth Rock (genes  $BARR^*BARR$ ,  $MC1R^*E$ ), but unlike the latter are characterised by interchanging light grey and dark grey bars. Cocks are lighter than hens (Penionzhkevich, 1962).

## Poltava Black

The variety is presumed to have been developed in the 19th century. Its ancestors are unknown. In the past, Black fowls were reared in Lubny District (Penionzhkevich, 1962). They numbered 42.9 thousand birds in 1954 (Solodky, 1956) and 8.5 thousand birds in 1964 (Iofe, 1968). At present, the variety is extinct (Mosyakina et al., 2005). Their body size is relatively small (Figure 6 and 7). The chickens have a rose ( $R^*R$ ) or single ( $R^*N$ ) comb, and a short, black beak. The self-black plumage colour ( $MC1R^*E$ ) is not glittering but dull in the females, and often glittering in the males (Len', 1959; Romanov and Bondarenko, 1994; Romanov et al., 1996; Ivanova and Kovalenko, 2003; Mosyakina et al., 2005). Legs are slate ( $ID^*N$ ).

In 2005, a plan to restore the Cuckoo and Black varieties was developed at the PRI because they had good potential for performance and were quite numerous and competitive.

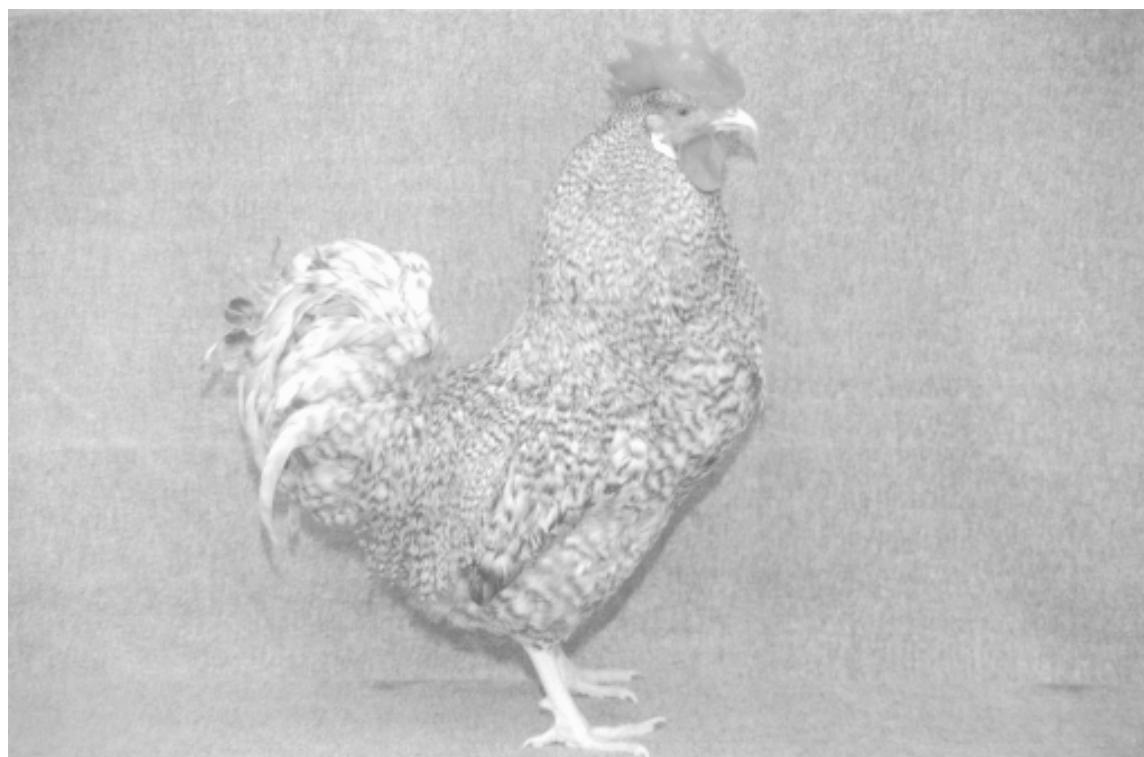


Figure 4. A cock of the restituted Poltava Cuckoo variety.

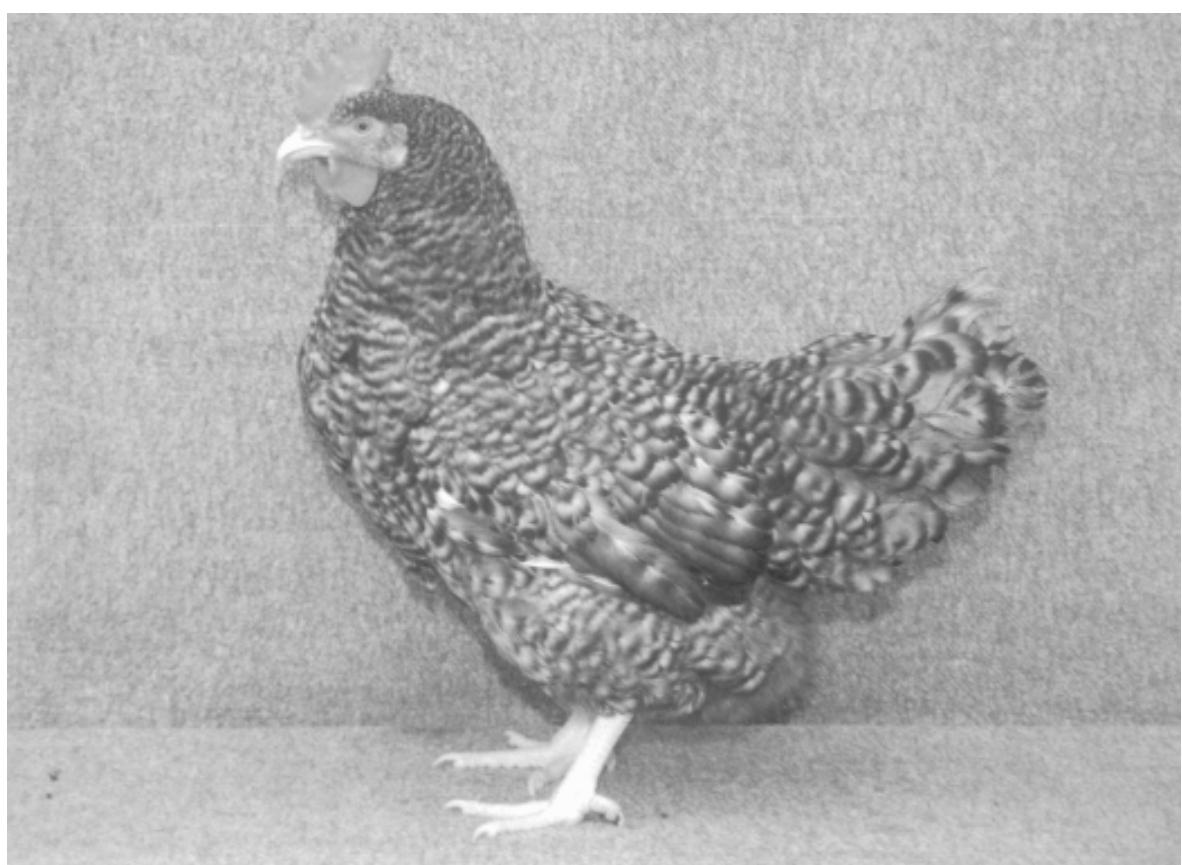
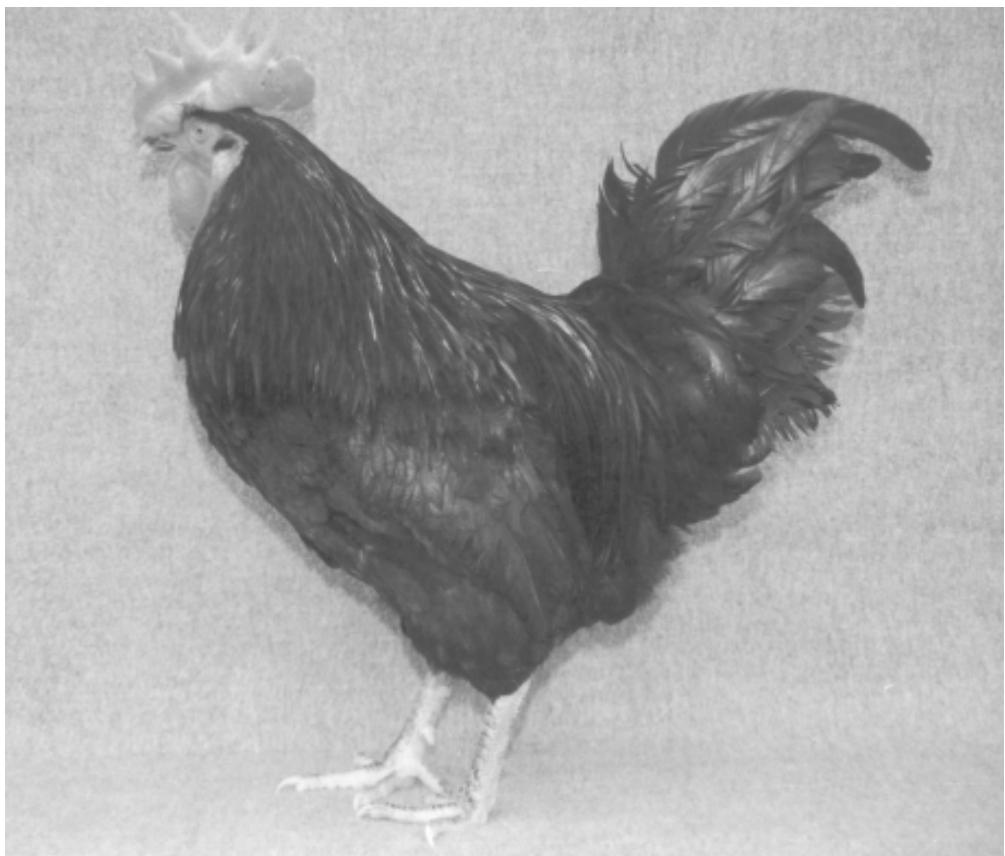


Figure 5. A hen of the restituted Poltava Cuckoo variety.



*Figure 6. A cock of the restituted Poltava Black variety.*



*Figure 7. A hen of the restituted Poltava Black variety.*

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## Pure line laying chickens at the Agassiz Research Centre

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### Summary

Six lines of laying chickens representing high-producing non-industrial lines chosen or produced with consideration for characters of production are being kept at the Agassiz Research Centre. The collection includes one Barred Plymouth Rock (Line 60), one Columbian Plymouth Rock, one Rhode Island Red (Line 50), and three White Leghorn lines (Blue, Black, and Burgundy). Before coming to the Agassiz Research Centre these pure lines were subjected to mild selection for egg production and their egg production approaches that of commercial hybrids. The lines are currently maintained as a genetic resource as live populations without selection and with populations large enough to minimize inbreeding. In addition, samples of DNA from these lines have been conserved for genetic studies, and samples of embryonic cells are being kept cryogenically to allow the possibility of reconstitution of the lines through the production of germline chimeras. Techniques of ovarian transplantation are being developed which will allow more efficient cryogenic conservation and recuperation of the genetic material into live populations.

### Résumé

Six lignées de poules pondeuses représentant des lignées de hautes production mais non industrielles choisies ou produites en considérant des caractères de production sont gardées au centre de recherches d'Agassiz. La collection inclut une lignée de Plymouth Rock Barrée (Lignée 60), une de Plymouth Rock Columbienne, une de Rouge de Rhode Island (Lignée 50), et trois lignées Leghorn Blanches (Bleu, Noir, Bourgogne). Dans le passé, ces lignées ont été soumises à la sélection pour les caractères de production et la production d'œufs des ces lignées pures s'approche à celle des lignées hybrides commerciales. Ces lignées sont actuellement maintenues comme ressources génétiques comme des populations vivantes sans sélection avec des populations suffisamment grandes pour minimiser

la consanguinité. En plus, des échantillons d'ADN des ces lignées sont gardés pour les études de génétique et des échantillons des cellules embryoniques sont gardés en congélation pour permettre la reconstitution de ces lignées par moyen des chimères des lignées de cellules germe. Des techniques de transplantation ovarienne sous développement vont permettre la conservation cryogénique plus efficace avec récupération du matériel génétique dans les populations vivantes.

**Keywords:** *Laying chicken, Middle level poultry, Genetic conservation, Cryogenic storage.*

### Industrialization of Chicken Breeding in Canada

In 1946, 263 breeders of laying chickens were entered in Canadian Record of Performance programs. At that time, there may have been another 40 breeders of chickens, as many as 20 breeders of turkeys and up to 18 breeders of waterfowl. By 1980, Crawford (1984a) was able to find only 13 middle-level poultry breeders in Canada, defined (Crawford, 1984b) as breeders of those traditional breeds that were usually kept for both meat and eggs. These breeders kept a total of 20 stocks, including 11 strains of chickens, one of turkeys, and eight of waterfowl. Most of these lines have since been lost.

At one time, poultry meat and eggs in Canada were produced from middle-level lines. However, in the 1950s and 1960s, some breeding companies began to dominate the market not only in Canada but around the world and produced stock that was specialized for production of either meat or eggs (Carter, 1964). Consolidation resulted in a progressively smaller number of companies, now

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known as primary breeders, which maintained breeding populations, practiced selection for commercial production, and sold hybrid individuals that would become the parents of commercial offspring.

Canada has been home to two of these primary poultry breeders. According to Crawford (1984b), Hybrid Turkeys Ltd. was a family-owned company in 1979, but was subsequently purchased by a corporation based in The Netherlands. The other major Canadian primary breeder was Shaver Poultry Breeding Farms Ltd., which sold both layer and broiler chickens but was a dominant force in the international layer market. Crawford (1984b) reported that Shaver Poultry Breeding Farms Ltd. kept a large reserve of genetic resources. In 1985, D. McQ. Shaver retired as Chairman and Chief Executive Officer of the company and Shaver Poultry Breeding Farms Ltd. is now owned by Hendrix Breeding Farms, one of only two major primary breeding companies of laying chickens in the world.

In his retirement, D. McQ. Shaver became involved in poultry breeding as a non-commercial hobby and acquired eight lines of laying chickens which he kept for a number of years. In 2003, six of the lines were transferred to the Agassiz Research Centre of Agriculture and Agri-Food Canada. A policy on the release of these lines to interested parties is currently under development. This report is a description of these six lines of laying chickens.

## Background of the Agassiz Lines

The six layer lines kept at the Agassiz Research Centre include one Barred Plymouth Rock (Line 60), one Columbian Plymouth Rock, a Rhode Island Red (Line 50), and three White Leghorn lines (Blue, Black, and Burgundy). General descriptions of these breeds are provided by the American Poultry Association (1983). Before coming to the Agassiz Research Centre, the lines were maintained by producing 425 females and 80 males in each generation. Production of the females was recorded and the best 200 were chosen on the basis of egg production, early egg size, and egg shell quality, with minor selection for egg colour. Males from the best 75 females were used for the next generation. This mating system should result in an effective population size of 218 and an increase in inbreeding of 0.229% per generation (following Falconer, 1989).

The Barred Plymouth Rock (Line 60) originated in the late 1950s from Harco stock, a well known line from Massachusetts. Before coming to the Agassiz Research Centre, it had been maintained by pedigree matings for more than 50 generations. The K gene has been maintained in Line 60 which would allow feather sexing if desired. This line could be crossed (as the mother line) with the Rhode Island Red (Line 50).

The Columbia Plymouth Rock Line was synthesized in the early 1960s from several stocks carrying the silver gene, S, (Light Sussex, White Leghorn) or others (Rhode Island Red) and the population was closed in about 1972. Mating females of this line (S-) with Rhode Island Red males (ss) allows the male and female offspring to be separated on the basis of colour. This line is considered to be a very rustic line.

The Rhode Island Red (Line 50) is considered to be from the long established Warren strain. The line is known to cross well with Barred Plymouth Rocks and Columbian Plymouth Rocks, which was confirmed by testing both in-house and at the University of Guelph. Before coming to the Agassiz Research Centre, Line 50 was reproduced for more than 50 generations by pedigree matings. It is known for its rusticity and the ability to perform on sub-optimum nutrition levels. The slow feathering K gene is maintained in the line to allow feather sexing if needed.

The Blue White Leghorn Line was synthesized in the late 1970s from commercial stocks that were known for high interior egg quality, to which the Cornell K Line (Cole and Hutt, 1973) was added to increase resistance to leukosis. The Blue Line has been used as the mother of a hybrid, with the Burgundy line as father, which is used as the mother of a cross to the Black line.

The Black White Leghorn Line was founded on Tancred and Hollywood lines in the late 1920s and has been maintained by pedigree matings from then until it came to the Agassiz Research Centre. This line is known as a male line and has been crossed to the Blue line either as a two-way cross or in a three-way cross including the Burgundy line.

The Burgundy White Leghorn Line was developed from three commercial lines. The fast-feathering gene, k, has been eliminated and the inclusion of slow feathering, K, allows this line to be crossed to a fast-feathering line to produce a feather-sexable cross. The Burgundy line has been used as the father of a mother line, with the hybrid being crossed to the Black line.

## Management and Data Collection

Eggs are incubated artificially, chicks are reared until 16 weeks of age in groups of 30, and pullets are subsequently caged in groups of three. Feed and clean water are provided to allow for *ad libitum* consumption. Day length is kept at nine hours until 18 weeks, when it is increased to 14 hours. A standard vaccination program for the area is used.

Production data were recorded in the first generation after the chicks arrived at the Agassiz Research Centre. Body weight was monitored during the rearing period and recorded for individual birds at housing (16 wk) and at 20, 40, and 60 weeks of age. Egg production was measured

for five days per week and extrapolated to seven days, and egg weights were recorded at 30, 40, 50, and 60 weeks. Data was recorded to 40 weeks of age for the Black and Blue lines and to 60 weeks of age for the other four lines.

## Production Results and Discussion

The general appearance of the hens is shown in figure 1. The three lines of White Leghorn have a very similar appearance and only one is shown to represent all three. The feather colour and pattern of each of the lines is as described by the American Poultry Association (1983). However, these lines

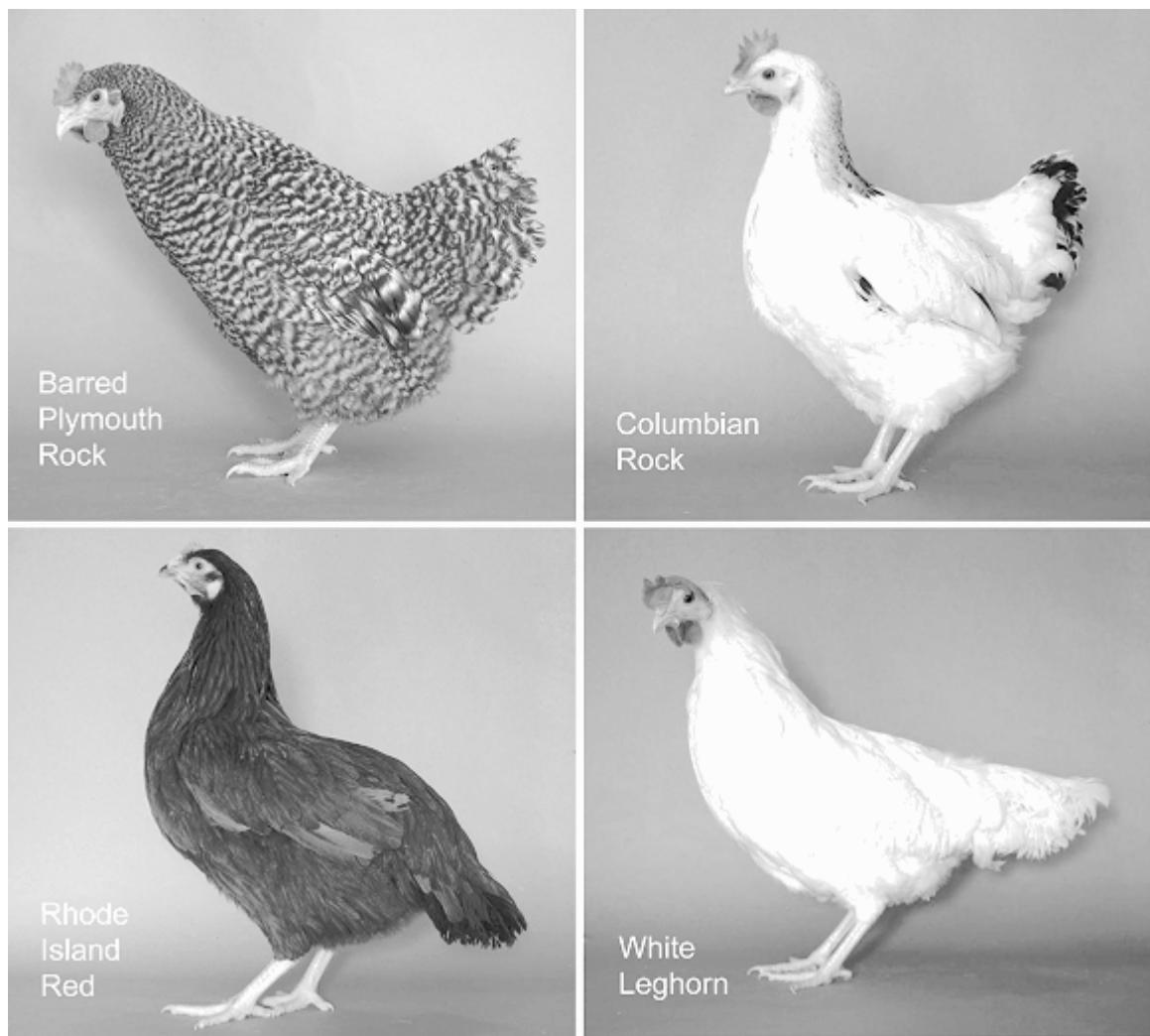


Figure 1. Barred Plymouth Rock (Line 60), Columbian Plymouth Rock, Rhode Island Red (Line 50), and White Leghorn (Black, Blue, Burgundy Lines) hens.

have not been selected for exhibitions and the colour and pattern demonstrate variation that the American Poultry Association (1983) would consider to be defects. These do not affect production characteristics.

The American Poultry Association (1983) provides standard body weights for cockerels and pullets, defined as male and female birds less than a year old. At 40 weeks of age, body weights of these six lines (Table 1) are all lower than the cockerel and pullet weights described by the American Poultry Association for these breeds, except that Black line males are very close to the American Poultry Association standard of 5 lbs (2 273 g). Lohman (2005a) expects their LSL-Lite hen to weigh 1 593 g at 40 weeks which is very close to the Black, Blue, and Burgundy lines. The Lohman Brown Classic Guide (Lohman, 2005b) shows a range of body weights from 1 848 to 2 042 g at 40 weeks, which encompasses body weights for females of the Barred Plymouth Rock, Columbian Plymouth Rock, and Rhode Island Red females. Synthesis and selection of these lines for production characteristics appears to have produced body weights nearer to commercial than fancier standards.

Management guides (Lohman 2005a, 2005b) also give expected egg production of hybrid commercial hens. Peak production of LSL-Lite hens is expected to be 94.2 hen-day-percent at 31 weeks with greater than 90 % hen-day production for 23 weeks, and that for Lohman Brown Classic hens should be 93.0 hen-day-percent at 28 weeks with greater than 90 % hen-day production for 14 weeks. Lohman expects their LSL-Lite hybrids to produce 126.6 eggs to 280 days of age (247.3 eggs to 420 days) and their Classic Brown hens to produce 128.0 eggs to 280 days of age (243.3 eggs to 420 days).

The egg production levels of the Agassiz pure lines are less than that expected for commercial hybrids (Table 2). Only the Rhode Island Red line reached the same peak production as expected for Lohman lines (93.0 hen-day-production), although peak production for the Barred Plymouth Rock, Black, and Burgundy lines approached that expected from Lohman hybrids. Hen housed egg production of Black line hens to 40 weeks of age was only 2 eggs lower than that expected of Lohman LSL-Lite hens and that of Blue line hens was only 4.5 eggs less. Fairful (1990) summarized research showing that heterosis for egg production traits is consistent and substantial, with a range of -3 to 40 % but commonly above 10%. The egg production of the Agassiz pure lines shown in

table 2 suggests that hybrids produced by these lines could be expected to equal or exceed that of common commercial hybrids.

The high egg production of these lines may have been obtained at the expense of egg weight (Table 3) because of the negative correlation between egg production and egg weight (Fairful and Gowe, 1990). Weight of eggs from a commercial white-egg line (Lohman, 2005a) can be expected to be 59.2 g at 31 weeks and 61.9 g at 41 weeks, which is clearly more than that seen for the Agassiz White Leghorn lines. Egg weight from the Agassiz Brown-egg lines was also lower than expected for commercial hybrids (Lohman 2005b). Although early egg weight was low for both white and brown-egg lines, it increased more rapidly than expected from commercial lines over the production cycle. Eggs in North America are marketed on the basis of grade which is largely based on egg size, and the most valuable egg size is 56 to 60 g. Egg size of the Agassiz pure lines fell within this range for most of the production cycle.

## Conservation Plans

At the Agassiz Research Centre, the six lines are kept as populations of at least 160 females (more if space allows) and 64 males per line which should result in an effective population size of 183 and an increase of inbreeding of 0.27 % per generation (following Falconer, 1989). Lines are reproduced yearly using artificial insemination. Semen from groups of eight males is mixed and used on 20 females. No selection is practiced except against obvious defects.

Samples of DNA were obtained from 15 males and 15 females of each line of the original populations that came to the Agassiz Research Centre. Following techniques from J. E. Fulton (Hy-Line International, personal communication), forty ml of packed RBCs were suspended in 3 µl of lysis buffer (10 mM Tris-HCl pH8.0, 400mM NaCl, 2mM disodium EDTA), to which 200 µl 10% SDS was subsequently added. The mixture was digested with 16 µl proteinase K (20 mg / ml) overnight at 37°C with shaking, and the protein was removed by adding 2 ml of 5M NaCl to each sample, after which the DNA was precipitated by ethanol. Samples are stored at -20°C.

Primordial germ cells, harvested from embryonic blood or the primitive gonad, can be cryopreserved and used to generate germline chimeras, allowing the preservation of both male and female germplasm (Petitte, 2006). Creation of germline

Table 1. Body weights (g  $\pm$  SD) of male and female chickens from six lines.

Line	No.	Males			Females					
		16 wk	20 wk	40 wk	60 wk	n (> 20 wk)	16 wk	20 wk	40 wk	60 wk
Barred Plymouth Rock	64	1 999 $\pm$ 174	2 349 $\pm$ 223	2 736 $\pm$ 253	3 139 $\pm$ 307	156 (135)	1 445 $\pm$ 123	1 783 $\pm$ 159	1 997 $\pm$ 201	2 109 $\pm$ 238
Columbian Plymouth Rock	64	1 848 $\pm$ 166	2 032 $\pm$ 209	2 377 $\pm$ 280	2 783 $\pm$ 343	156 (135)	1 334 $\pm$ 137	1 666 $\pm$ 178	1 878 $\pm$ 248	1 989 $\pm$ 289
Rhode Island Red	64	2 135 $\pm$ 178	2 360 $\pm$ 206	2 737 $\pm$ 246	3 185 $\pm$ 290	156 (134)	1 488 $\pm$ 114	1 817 $\pm$ 157	2 045 $\pm$ 238	2 164 $\pm$ 258
Blue	64	1 471 $\pm$ 102	1 712 $\pm$ 123	2 063 $\pm$ 183	-	150	1 119 $\pm$ 102	1 394 $\pm$ 122	1 516 $\pm$ 169	-
Black	64	1 551 $\pm$ 115	1 888 $\pm$ 151	2 311 $\pm$ 207	-	150	1 167 $\pm$ 99	1 497 $\pm$ 127	1 666 $\pm$ 165	-
Burgundy	64	1 625 $\pm$ 145	1 773 $\pm$ 148	2 062 $\pm$ 166	2 354 $\pm$ 195	156 (130)	1 157 $\pm$ 93	1 450 $\pm$ 123	1 630 $\pm$ 162	1 701 $\pm$ 207

Table 2. Egg production of six lines of laying hens.

Line	Hens housed <sup>1</sup>	Peak production		Weeks above 90% hen-day production	Hen housed egg production ( $\pm$ SD)		
		% hen day	Age (wk)		hen-day production	To 280 days of age	To 420 days of age
Barred Plymouth Rock	270	91.6	24	5	117.9 $\pm$ 8.1	223.2 $\pm$ 15.0	223.2 $\pm$ 15.0
Columbian Plymouth Rock	270	87.9	24	0	116.7 $\pm$ 10.6	215.5 $\pm$ 24.4	215.5 $\pm$ 24.4
Rhode Island Red	273	93.0	26	7	120.6 $\pm$ 10.6	228.8 $\pm$ 23.0	228.8 $\pm$ 23.0
Blue	312	90.0	25	2	122.1 $\pm$ 12.4	-	-
Black	312	92.6	25	7	124.6 $\pm$ 10.8	-	-
Burgundy	273	92.4	27	6	120.7 $\pm$ 10.6	228.8 $\pm$ 23.5	228.8 $\pm$ 23.5

<sup>1</sup>Housed in cages holding three hens each.

Table 3. Weight of eggs from six lines of laying hens.

Line	No.	Week 31	Week 41	Week 51	Week 61
Barred Plymouth Rock	83 to 139	55.2±3.4	58.7±4.0	60.3±4.0	61.1±4.4
Columbian Plymouth Rock	72 to 127	54.1±4.5	57.5±4.7	58.4±5.0	58.9±5.6
Rhode Island Red	86 to 131	56.6±4.0	60.0±4.3	61.9±5.2	62.6±5.1
Blue	123 to 124	52.3±3.5	56.1±3.7	-	-
Black	126 to 138	52.5±3.3	57.2±3.9	-	-
Burgundy	80 to 140	55.0±4.2	59.0±4.7	61.0±5.1	62.2±5.2

chimeras from cryopreserved gonadal primordial germ cells (Tajima *et al.*, 1998; Song *et al.* 2005) requires approximately 10 pairs of gonads to generate one germline chimera. Three hundred pairs of Stage 27 gonads from each of the six lines representing 90 individual birds per line were cryopreserved (Tajima *et al.*, 1998), which should allow recovery of 30 individual birds by production of germline chimeras if needed.

A surgical technique for orthotopic transplantation of ovarian tissue in newly hatched chickens has been developed (Song and Silversides, 2006) and used to produce donor-derived offspring from the host hens (Song and Silversides, 2007). This provides an alternative approach for cryopreserving avian female germplasm, and research is underway to evaluate the efficiency of using cryopreserved ovaries to give rise to donor-derived offspring. Once this has been demonstrated, ovaries from newly hatched chicks from each of six lines will be stored in liquid nitrogen.

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