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Reproductive Performance of the Ardennaise Chicken Breed under Traditional and Modern Breeding Management Systems

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Abstract: Enhancing the use of traditional chicken breeds is necessary to insure long-term conservation of global genetic diversity in poultry. A logical start in this process is to evaluate performance. The objective of this study was to estimate reproductive traits in the Ardennaise chicken breed under traditional and modern management systems. Reproductive performance indicated lighting programs [Natural (NAT) or Artificial (ART) day length] were highly significant for egg weight, hatchability ($p \leq 0.001$), early and mid-term embryonic mortality ($p \leq 0.01$). Feeding treatments [*ad libitum* (AL) or mild Feed-restriction (FR)] varied greatly with egg weight, hatchability, fertility ($p \leq 0.001$) and late embryonic mortality ($p \leq 0.05$). Most precocious age at first egg (23 weeks), longest duration of laying period (>27 weeks), utmost maximum production peak (56.67%), largest egg number (70.13 eggs/hen) and number of chicks hatched (24.10 chicks/hen) were performed under ART-AL. Heaviest egg weight (53.21g), highest fertility (70.20%), greatest hatchability (55.58%), highest liveability during rearing (95.74%) and lay (100%), lowest early (3.51%) and mid-term embryonic mortality (1.17%) were achieved under NAT-AL. To summarize, most of traits studied in the Ardennaise chicken were moderate when compared to those expected by broiler breeders.

Key words: Ardennaise chicken breed, reproduction, photoperiod, light patterns, feeding management

INTRODUCTION

Most of Belgian traditional poultry breeds are under critical or endangered status according to a recent survey (Larivière and Leroy, 2007). There is a need for a concrete rescue operation to stop the rapid erosion of remaining genetic resources (Larivière *et al.*, 2007). The identification of candidate breeds for priority conservation has led to the evaluation of genetic resources for potential contribution to production. As Belgium's most ancient chicken breed, described by La Perre de Roo in 1880 (Brandt and Willems, 1985), the Ardennaise has remained unselected for production traits. Today, a number of thirteen different varieties have been developed by fanciers. The Ardennaise breed has recently undergone an evaluation of its growing performance (Larivière *et al.*, 2009) but no data exist on reproductive efficiency under traditional or modern production systems. Reliable information on broiler breeders and related management practices, obtained from literature made available by breeding companies, can be used as a reference. However, intensive management methods such as artificial lighting programs or feed restriction, being beneficial to health and/or reproductive performance in broiler breeders, do not necessarily apply to traditional breeds and their local environment conditions. Favourable responses or adaptation of local breeds to modern techniques toward optimization of breeding output is questioned. The aim of the present study was to quantify improvement in reproductive performance of the Ardennaise chicken breed under different photoperiodic and feed management programs.

MATERIALS AND METHODS

Subjects, husbandry and feeding: Day-old chicks were obtained from an Ardennaise chicken breed nucleus flock (about 10 males and 100 females), unselected for production traits. As-hatched birds were vaccinated by injection against Marek's Disease and were fed a typical "Label" mash diet (lower energy and protein than commercial broiler diets, genetically modified organism-free and no coccidiostats) (Table 1) with continuous supply of water. Diets were mainly composed of soybean, wheat and corn.

Rearing and breeding management: Three hundred and ten and ninety-four Ardennaise chicks were hatched in Belgium (latitude 50° North) during winter 2004 and 2005, respectively. Chicks were dispatched and reared in six and four pens, respectively. Each pen measured 1.4 m x 1.5 m x 2 m (width x depth x height), with floor litter (wood-shavings), 10 nipple drinkers and one feeder (metal hopper). These two groups of chicks, from day-old to 50 weeks of age, were exposed to an artificial standard broiler breeder day length program (ART) (Aviagen, 2008) and a program simulating natural day-length (NAT), respectively (Table 2). Illumination under NAT or ART was provided by cool white fluorescent lamps of 64 Ra and 4300 K (model F36W/133, Havells Sylvania, Germany). Light intensity, measured at floor levels in all pens with a digital luxmeter (Mavolux-Digital, Gossen-Metrawatt GmbH, Germany), varied from 8.96-31.0 lux during rearing and from 35.10-45.33 lux during lay.

Table 1: Calculated composition proportions (%) of the diets fed to the Ardennaise chicken breeders

	Diets		
Ingredients	Starter	Grower	Layer
Wheat	27.0	21.5	9.3
Wheat and enzymes (Vitazym)	10.0	10.0	-
Soybean meal	31.9	27.1	26.1
Corn	25.0	35.0	45.0
Sugar-beet pulp	-	-	2.5
Lucerne leaf meal	-	-	3.0
Limestone	0.5	0.7	7.1
Oyster shell	-	-	0.4
Soybean oil	2.2	2.7	4.0
DL-Methionine	0.2	0.2	0.1
L-Lysine HCL	0.1	0.1	-
Dicalcium phosphate	1.9	1.6	1.4
Vitamin mix	0.01	0.1	-
Mineral mix	1.0	1.0	1.0
Essential oils (plant extracts)	0.1	0.0	-
Laboratory analysis			
Dry matter (g/kg)	25.9	25.3	38.0
Ash (g/kg)	56.1	53.6	122.5
Fat (g/kg)	43.1	49.6	63.8
CF (g/kg)	872.2	872.7	883.8
CP (g/kg)	220.0	200.0	170.0
ME (kcal/kg)	2937.3	3034.4	2800.0

Table 2: Day length (hours) of the artificial (ART) and the natural (NAT) (latitude 50° North) lighting programs for the Ardennaise chicken breeders from day-old to 50 weeks of age

	Day length (hours)	
Age	ART	NAT
1-3 days	23	23
4-6 days	12	12
1-4 weeks	8	8
5-8	8	10
9-12	8	12
13-16	8	14
17-18	8	15
19	10	15
20	12	15
21	13	16½
22	14	16½
23	14 ½	16½
24	15	16½
25	15 ½	16½
26	16	16½
27-28	16 ½	16½
29-32	16 ½	15
33-36	16 ½	13
37-40	16 ½	10
41-44	16 ½	8½
45-48	16 ½	7½
49-50	16 ½	8½

The starter diet was given *ad libitum* during the first 2 weeks and the grower diet was fed from 3-15 weeks of age. During the growing period from 3 weeks of age, birds under ART were fed *ad libitum* (AL) and those under NAT, divided in two groups, were allocated to one of the two feeding regimes: AL or feed restriction (FR). FR diet for both males and females (no sex-separate feeding) was based on feed allowance, as a % of live body weight, of a slow-growing breeder female (Sasso SA31) program (Table 3) (Sasso, 2003). Thus, to allocate correct amounts of food and to monitor growth rate during rearing, males and females of both diet treatments were weighed on a weekly basis from day-old to 21 days with a small digital scale (HR 2395 model, Phillips, The Netherlands) and with a larger hanging scale (235-6S model, Salter Brecknell, U.K.) at further ages up to 12 weeks of age. Food allocated from 13-15 weeks, however, was based on live body weight obtained at 12 weeks. Levels of feed restriction imposed to our slow-growing chicken breeders were fairly similar to those practiced in broiler breeders (2-14%) between 2 and 12 weeks of age (Aviagen, 2008).

Table 3: Food restriction program of as-hatched Ardennaise breeders (daily food allowance as a % of live body weight) based on a slow-growing breeder female program (Sasso SA31)

Age (weeks)	Food allowance/ live body weight (%)
0-2	*ad libitum*
3	14
4	14
5	11
6	11
7	10
8	10
9	9
10	8
11	5
12	5
13	5
14	5
15	5

At breeding stage, sixty hens were randomly taken from the ART group and forty from the NAT one. In the latter, twenty hens were in each of the feeding regimes (FR and AL). At 16 weeks, hens from ART-AL were divided in 6 groups of ten hens, those from NAT-AL and those from NAT-FR in 2 groups of 10 hens each. Each group was mated to one male during the entire study, transferred in a pen measuring 3.36 m x 3.71 m (12.47m^2), fed a layer diet (Table 1), restricted to 100 g of feed per day per bird, up to 50 weeks of age. Each pen was equipped with one feeder (metal hopper), a bell drinker and two nest boxes, raised at 30 cm height from the floor level. The nest box was a commercial chicken nest (Europa Nest, BRUJA GmbH, Hammelburg, Germany) with a floor space of 900 cm^2 (30 cm x 30 cm), carpeted with Astroturf©. Hatching eggs were collected twice a day and stored at 12-15°C, 70% RH, sharp point of egg downward, pre-heated for 12 h at 25°C prior to incubation. Laying performance was recorded per pen and included egg number, age at first egg, egg weight, duration of laying cycle (number of weeks between age at first and at last egg laid, without interruption), laying intensity in hen-housed % (number of total eggs produced divided by number of hens housed) (Sauveur, 1988) and maximum production peak. Mortality and food consumption, per pen, were also recorded from day-old. Up to 50 weeks of age, a total of 5084 eggs were collected. A number of 1230 eggs (45-50 weeks hen-age) were incubated in two settings. These eggs were identified according to the different breeding pens and treatments and those over 50 g were set at random within racks and trays, in a 1100 eggs capacity incubator (model ECO 3, Maino Enrico-Adriano S.N.C., Italy) for 18 days at 37.5°C (60-70% RH) with turning of once per hour at 90°. Eggs were then transferred in a hatcher (model 11, Maino Enrico-Adriano S.N.C., Italy) for 3 days at 36.5°C (60-70% RH) and were candled individually at 10 and 18 days of incubation, using a hand torch to identify clear eggs. Clear and un-hatched eggs (after 21 days) were removed, opened and visually inspected for evidence of development. Eggs were classified as infertile, hatched, early (before 10 days), mid-term (between 10 and 18 days) or late embryonic mortality (between 18 and 21 days). Reproductive performance were calculated and included fertility (number of chicks hatched + total dead embryos /number of eggs set) and hatchability (number of chicks hatched/number of eggs set). Liveability during rearing (number of day-old chicks entered-number of chicks dead at 15 weeks / number of day-old chicks entered) and during lay (number of breeders housed at 16 weeks -number of breeders dead until 50 weeks/number of breeders housed at 16 weeks), were calculated. Total feed consumed in kg per hen, to produce 100 eggs and 100 chicks at 50 weeks of age, were also calculated per pen.

Statistical analysis: An analysis of variance Proc GLM with SAS (SAS, 1989) was performed to compare in one hand the feeding treatments, i.e. NAT-AL vs NAT-FR and in the other hand the lighting treatments, i.e. NAT-AL vs ART-AL, for reproductive performance, individually measured on each egg.

RESULTS AND DISCUSSION

Parent stock of meat-type chickens under commercial conditions may be fed on quantitatively restricted rations during rearing in order to limit body weight at sexual maturity and thereby improve health and reproductive performance (Hocking *et al.*, 1989). The practice significantly reduces food costs and degree of food restriction varies from severe with broiler breeders to mild with growing pullets or broilers (for a review, see Larivière, 1998). In this experiment, controlled reduction of growth rate was achieved, as expected, in both sexes of the FR birds under NAT (Fig. 1). At 12 weeks of age, full fed birds were heavier (1117 g ± 189 g) than their restricted siblings (1054 g ± 188 g). Males weighed

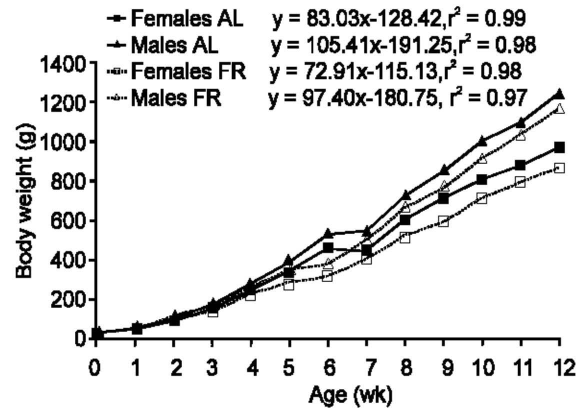

Fig. 1: Linear regression analysis of body weight on age in weeks of male and female Ardennaise chicken breeders fed *ad libitum* (AL) (n = 23 females; n = 25 males) or mild Feed Restriction (FR) (n = 20 females; n = 25 males), under natural lighting program, from day-old to 12 weeks

1249 g ± 162 g under AL and 1173 g ± 125 g under FR. Females weighed 974 g ± 82 g (AL) and 868 g ± 91 g (FR). Body weight of the FR birds was 94% and 89% of those attained in AL males and females, respectively. AL birds growth rate was depressed at 7 weeks because of a coccidiosis outbreak. Birds were treated as soon as the disease was diagnosed. Food usage averaged 4.16 kg per bird in the AL group and 3.43 kg per bird in the FR group. However, benefits of practicing feed restriction in the slow-growing Ardennaise in this experiment were not supported because reproductive performance was inferior.

Comparing NAT-AL and NAT-FR demonstrated that egg weight, fertility, hatchability ($p \leq 0.001$) and late embryonic mortality ($p \leq 0.05$) varied greatly between feed treatments, all values being highest under NAT-AL (Table 4). Results suggested that female Ardennaise breeders would not require feed restriction during rearing (2-15 weeks) to improve breeding performance. This agrees with higher productivity observed in slow-growing breeder genotypes fed *ad libitum* (Heck *et al.*, 2004). Similarly, another study has demonstrated that dwarf meat-type chicken require less severe FR than large genotypes (Proudfoot *et al.*, 1984).

Photoperiod is the most important factor synchronizing reproduction cycle in birds (Sauveur, 1988), influencing egg production and weight, age at first egg (Sharp, 1993; Morris, 2004) and liveability (Lewis *et al.*, 1992). In this study, egg weight, hatchability ($p \leq 0.001$), early and mid-term embryonic mortality ($p \leq 0.01$) were highly significantly higher with NAT-AL when compared to ART-AL (except early and mid-term embryonic mortality) (Table 4). Laying intensity curves (hen-housed %) performed by the Ardennaise under the three treatments (Fig. 2) were consistently inferior when compared to the

Table 4: Comparison of least squares means of reproductive performance (± SE) at 50 weeks of age in the Ardennaise chicken breeders under the different lighting [natural (NAT) or artificial (ART) day length] and feeding programs [*ad libitum* (AL) or fed-restricted (FR)] from 2-15 weeks of age

Traits	NAT-FR	F-test[1]	NAT-AL	F-test[2]	ART-AL
Number of eggs collected	508	-	408	-	4168
Egg weight (g)	50.12 ± 0.32	***	53.21 ± 0.41	***	50.74 ± 0.09
Number of eggs incubated	157	-	171	-	902
Fertility (%)	45.22 ± 0.04	***	70.18 ± 0.04	N.S.	64.41 ± 0.02
Hatchability (%)	36.94 ± 0.04	***	55.56 ± 0.04	***	34.37 ± 0.02
Early embryonic mortality (%)	3.82 ± 0.02	N.S.	3.51 ± 0.02	**	11.42 ± 0.01
Mid-term embryonic mortality (%)	1.27 ± 0.02	N.S.	1.17 ± 0.02	**	7.65 ± 0.01
Late embryonic mortality (%)	3.18 ± 0.18	*	9.94 ± 0.30	N.S.	10.98 ± 0.31

[1] Comparison between NAT-FR and NAT-AL. [2]Comparison between NAT-AL and ART-AL. N.S.: non significant; *p≤0.05; **p≤0.01; ***p ≤0.001.

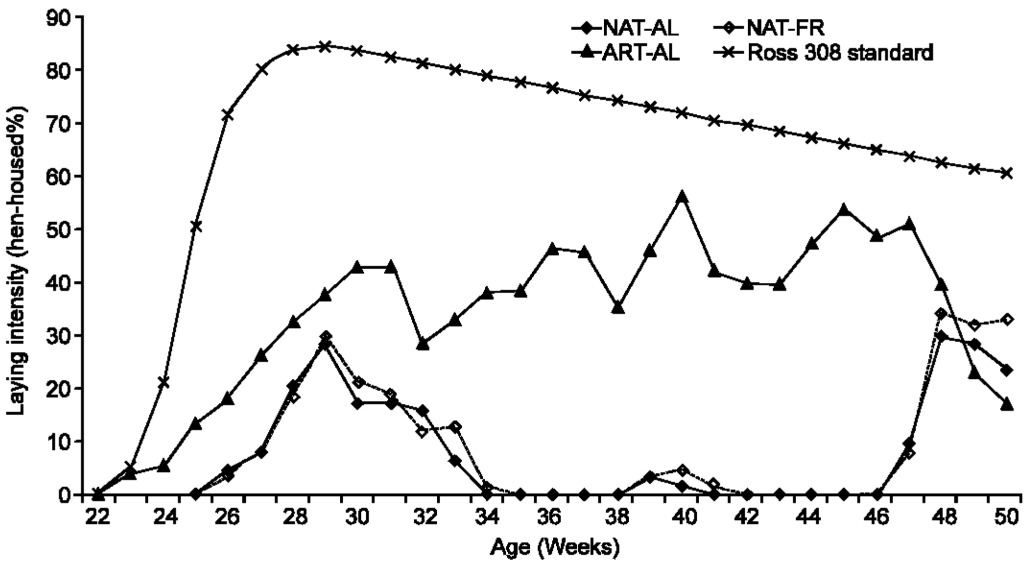

Fig. 2: Laying intensity (hen-housed %) of Ardennaise chicken hens managed under three different treatments of lighting programmes [natural (NAT) or artificial (ART) day length] and feeding regimes from 2-15 weeks of age [*ad libitum* (AL), fed-restricted (FR)], compared with the standard for broiler breeder female Ross 308 under artificial lighting and feed restriction

one expected from Ross 308 broiler Parent Stock Performance Objective Manual (Aviagen, 2008).

Differences in photosensitivity have been observed between commercial layers and broiler breeders (Eitan and Soller, 1994) and between dwarf and large meat-type chickens (Proudfoot *et al.*, 1984), indicating the involvement of genetic factors. However, reduction in rate of egg production has mainly been attributed to seasonal changes in day length, marked by a shortened photoperiod during the laying year (Morris *et al.*, 1964), like in the simulated natural day length program (Table 2). As seen on Fig. 2, natural patterns, which are more variable, have a reduced egg production. Drastic changes in performance are more to be expected under variable than constant light patterns (Lewis and Morris, 2005).

Overall means of liveability and reproductive efficiency index are presented in Table 5. These variables were calculated per pen and comparison between the different treatments was not analyzed statistically because individuals were not experimental units. Reproductive performance of the Ardennaise showed

most precocious age at first egg (23 weeks) and utmost laying intensity (34.55%) under ART-AL. This was also reflected in highest maximum production peak (56.67%) and longest laying cycle (>28 weeks) (Table 5). In addition, largest egg number (70.13 eggs/hen) and number of chicks hatched per hen (24.10 chicks/hen) resulted in better feed efficiency to produce 100 eggs (38.18kg/hen) or 100 chicks (111.10 kg/hen). NAT-AL performed heaviest egg weight (53.21g ± 0.41), greatest hatchability (55.56% ± 0.04), lowest early (3.51% ± 0.02) and mid-term embryonic mortality (1.17% ± 0.02) (Table 4) and highest liveability during rearing (95.74%) and lay (100.0%) (Table 5). NAT-FR and NAT-AL groups had

Table 5: Overall means of liveability and reproductive efficiency index per group of Ardennaise chicken breeders, under three different combined lighting [natural (NAT) or artificial (ART) day length] and feeding programs from 2-15 weeks of age [*ad libitum* (AL) or fed-restricted (FR)], at 50 weeks of age

Traits	NAT-FR	NAT-AL	ART-AL
Number of chicks entered	47	47	310
Liveability during rearing (%)	93.63	95.74	90.32
Number of hens entered	20	20	60
Liveability during lay (%)	100.0	100.0	95.0
Number of eggs collected	508	408	4168
Laying intensity (%)	8.5	7.4	34.55
Age at first egg (weeks)	26	26	23
Duration of laying cycle (weeks)	10	9	28
Egg number per hen	25.4	20.4	70.13
Number of chicks hatched per hen	9.4	11.4	24.10
Total feed consumed per hen (kg)	30.0	30.8	26.78
Total feed per hen per 100 eggs produced (kg)	118.2	150.8	38.18
Total feed per hen per 100 chicks produced (kg)	319.8	270.8	111.10

fairly similar laying intensity (7.44-8.46%) and liveability during rearing (93.63-95.74%) and same during lay (100%). Nevertheless, egg number per hen in NAT-FR (25.4 eggs) and NAT-AL (20.4 eggs) was low and feed efficiency to produce 100 eggs and 100 chicks was therefore impaired, raising consumption to 4 and 3 times the quantity eaten under ART-AL, respectively. In contrast with the Ardennaise raised under ART-AL, broiler breeder Ross 308 parent stock (Aviagen, 2008), a popular commercial strain, is expected to achieve twice as much laying intensity (66.4%), more than 1.7 times the egg number per hen (122.2 hatching eggs) and 4.4 times the number of chicks hatched per hen (106.8 chicks), at 50 weeks of age. Performance of a popular commercial broiler breeder is to reach an age at first egg at 23 weeks, with a maximum production peak 1.5 times higher in magnitude (89.6%) at 35-38 weeks, and an egg weight ranging from 50.4-67.2 g. Hatchability will be 1.36 times higher (87.4%) at 45 weeks hen-age. Total embryonic mortality can affect up to 8% of broiler embryos (Scott and Mackenzie, 1993). Overall liveability will be similar during rearing (95.0-96.0%) and lay (92.0%). Expected total feed to produce 100 eggs and 100 chicks per hen, from day-old till end of lay, will be 31.7 kg and 37.4 kg, respectively. The Ardennaise is far from this performance.

The Ardennaise had similar results to those of seven French traditional chicken breeds recently studied (Tixier-Boichard *et al*., 2006), reaching maximum production peak of 43-67% with an egg weight of 51.7-58.1 g. Being a presumed ancestor of the Ardennaise, the French Gauloise chicken breed with its golden strain presented a quite similar laying curve but its black strain showed lower egg production magnitude, under NAT (N'Dri, 2007). Under ART, the golden strain had a lower laying intensity and the black strain was less persistent during lay. Low fertility (8%) and high early embryonic mortality (33%) values have been reported in traditional chicken breeds (Hocking *et al*., 2007). This can be explained by poor management practices, mating behaviour or reproductive physiology in flocks often maintained in small groups.

Conclusion: Egg weight, fertility, hatchability and late embryonic mortality varied greatly between feed regimes and were all greater under *ad libitum* feeding during rearing. Magnitude of laying curve was highest and more persistent under artificial day-length program with *ad libitum* feeding, reflected in an egg number up to 3.5 times higher than with other treatments. Effect of light programs was highly significant with egg weight, hatchability, early and mid-term embryonic mortality with higher values for egg weight and hatchability under natural day length. Our study has demonstrated the improvement potential through modification of environmental conditions. However, a true comparison with commercial broiler breeders, under the same environmental conditions and our traditional breed would be required.

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