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PRODUCTION PERFORMANCES OF THE POULTRY-LAYING SECTOR IN ALGERIA: DATA ANALYSIS OF AN TABLE EGGS PRODUCTION COMPLEX

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Abstract

Subject description: In Algeria, the fluctuation of the quantities produced of eggs for consumption in time and space is one of the causes of the instability of prices on the market of this highly demanded commodity. One of the main causes of this fluctuation is the mastery of the technical management of farms.
Objectives: This study aims to evaluate the level of technical management of laying hens through the study of zootechnical performances over a period of 15 years in a specialised industrial rearing complex.
Methods: End-of-band results, weekly data sheets and rearing registries have been used to create the database containing the performance of more than 1.4 million layers.
Results: The results showed that the production duration varies from 42 to 64 weeks. Average mortality rate was very high (around 26%). Average feed consumption per hen was higher than 113 g/hen/day, average feed consumption per cycle was 63.41±0.81 Kg/hen/cycle and conversion index 2.57±0.23. Average egg broken rate was 0.85 ± 0.64%, eggs production per starting laying hen varied from one band to another, which strongly affected average egg laying rate that was 73.43 ± 3.99%, egg laying rate achieved at peak laying was 89.68 ± 6.01%.
Conclusion: The level of performance in this center is close to the standard performances of the strains and satisfactory compared to that obtained in some regions in Algeria.
Keywords: hens, breeding, table eggs, strains, performance, feed.

PERFORMANCES DE PRODUCTION DE LA FILIERE AVICOLE PONTE EN ALGERIE : ANALYSE DES DONNEES D'UN ATELIER DE PRODUCTION DES ŒUFS DE CONSOMMATION

Résumé

Description du sujet : En Algérie la fluctuation des quantités produites des œufs de consommation dans le temps et dans l'espace est l'une des causes de l'instabilité des prix sur le marché de cette denrée très demandée. L'une des principales causes de cette fluctuation est la maitrise de la gestion technique des élevages.
Objectifs : Cette étude a pour but d'évaluer le niveau de maîtrise de l'élevage des poules pondeuses à travers l'étude des performances zootechniques obtenues sur une période de 15 années au niveau d'un centre d'élevage industriel spécialisé.
Méthodes : Les bilans de fin de bande, les fiches hebdomadaires et les registres d'élevage ont été utilisés pour constituer la base de données contenant les performances d'un total de plus de 1,4 millions de poules.
Résultats : Les résultats ont montrés que La durée de production varie de 42 à 64 semaines. Le taux de mortalité moyen a été très élevé (près de 26%). La consommation moyenne d'aliment par sujet a été supérieur à 113 g/poule/jour, la consommation moyenne d'aliment par cycle est de 63,41 ± 0,81 Kg/poule/cycle et l'indice de conversion est de 2,57±0,23. Le taux de casse moyen est de 0,85 ± 0,64%, la production d'œufs par poule départ varie d'une bande à une autre, ce qui a fortement affecté le taux de ponte moyen qui est de 73,43 ± 3,99%, le taux de ponte au pic de ponte réalisé est de 89,68 ± 6,01%.
Conclusion : Le niveau des performances dans ce centre est proche des performances des souches et satisfaisant par rapport à celui obtenu dans quelques régions en Algérie.
Mots clés : poule pondeuse, élevage, œufs de consommation, souches, performances.

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INTRODUCTION

The refocusing of Algerian livestock farmers towards intensive poultry production has become a major concern of the state since the 1980, in order to increase the availability of animal protein induced by population growth, increasing urbanisation and massive salarisation [1]. National production of white meat increased considerably in 2017, reaching 5.3 million quintals, compared to 2.092 million quintals in 2009, an increase of 153%. Egg production for consumption has followed the same trend during the same period, increasing to 6.6 billion units produced in 2017, compared to 3.8 units in 2009. During the last ten years, poultry production has grown by 10.3% for white meat and 6.2% for table eggs [2]. However, intensification of the poultry sector is not without its problems. It is characterised by a significant fluctuation in the quantities of eggs produced in time and space. In terms of performance, it is still fragile and very sensitive to variations in both endogenous and exogenous actors, and price analysis shows that poultry markets are marked by relatively significant seasonal price variations [3].

Thus, the poor production performance recorded in poultry farms (mortality of more than 10%, low average daily gain, loss of eggs and wastage of feed) is related to the characteristics of poultry farms and farmers [4]. Technical, economic and socio-institutional factors are partly responsible for the poor performance of poultry farms and the instability of poultry product prices [5]. According to the objectives traced by the growth plan of the Ministry of Agriculture in 2018, the poultry sector should produce in the future 8.9 billion table eggs, and the export of 700 million table eggs. Even though these objectives are being achieved, professionals are complaining about the irregularity of imports and input prices, which is one problem among others that causes the instability of the prices of this product on the market. There are also other insufficiencies that need to be resolved, particularly those related to the training of producers and the development of a plan to prevent the main diseases affecting poultry flocks [2]. It is in this context that we propose to assess the management level of laying hen rearing through the study of zootechnical performance recorded over a period of 15 years at a specialised industrial rearing complex in the region Bouira (Algeria).

MATERIALS AND METHODS

1. Poultry buildings and livestock management

The criteria for choosing a factory farming complex are the size of the hen population, the up-to-date recording system, the quality of the buildings and the mechanisation of operations. This complex has four 2.8m high, prefabricated, dark-type buildings with a surface area of 1296m² (12mx108m). Each building consists of a breeding area and a sanitary room and is equipped with five 142 cm wide batteries and 85cm between batteries. Each battery is designed in three superposed floors and is equipped with an automatic system for feeding, watering and evacuation of droppings. Temperature is set at 21°C with limits of 18°C and 24°C where the alarm is activated. Ventilation is dynamic and one-sided. Each building has 140 emergency openings in case of heatwave or failure of the ventilation system.

The air cooling system is of the pad-cooling type. Lighting is provided by 40w lamps, at a rate of 150 per building (6 rows of 25 lamps). They are fixed at 2m from the ground. The space between the lamps is 4m in length and 1m in width. The light intensity applied is 20 lux throughout the production period and is controlled by a dimmer located at the sanitary room level. All ambient factors are controlled by means of a control panel located in the sanitary room. The strains used are Tetra-SL, ISA Brown and Hy-line. Only a single feed is distributed during the entire production period. It is based on maize, soybean cake, meal from milling and supplemented with limestone, bi-calcium phosphate and VMC. Each battery has an automatic trolley connected to the storage silo (with a capacity of 20 tons) by a pipe system. Distribution is done three times a day (at 8am, 10am and 2pm). Feed consumption is recorded by means of scales connected to the control box. Egg collection was automatic and became manual during the last two years.

2. Data collection and studied parameters

The study material consists of end-of-tape reports, weekly sheets and breeding records archived for 15 consecutive years (1997 to 2012), i.e. a total of 12 tapes. The collected data is entered and arranged in a table on Microsoft Office Excel®2013.

3. Parameters studied

The parameters studied are:
- Number of hens starting.
- Laying age (weeks): this is the age at which the hens start laying.
- Culling age (weeks).
- Laying duration (weeks): this is the age of the hens at culling minus the age at which they start laying.
- Mortality rate (%) = ((starting flock - remaining flock)/starting flock) x100.
- Consumption per cycle per hen (kg/hen) = amount of feed consumed per production cycle / the number of birds.
- Consumption per day per hen (g/hens per day) = total amount of feed consumed per day / number of hens
- Feed conversion index = quantity of feed consumed / (average egg weight x gross production). Average egg weight = 60g.
- Egg production per starting hen: this is the number of eggs layed per hen during the entire production period.
- Peak laying rate (%): is the maximum egg production obtained during the entire production cycle.
- Laying rate (%) = (the number of eggs layed per day / the number of hens present) x 100.
- Breakage rate (%) = (number of eggs broken / number of eggs laid) x 100.

4. Statistical analyses

The recorded and/or calculated data were subjected to an analysis of variance using software R 3.6.1 with the band and strain as variation factors.

RESULTS

1. Staffing levels

During the 15 years, the total number of laying hens raised was 1.43 million, with an average of 119104±6114 hens per flock (Table 1) and an average of 30077± 2129 per building (Table 2).

Table 1: Number of laying hens installed between 1997 and 2012

Bands n°	Strains	Years	Total number of hens per year
1	Tetra-SL	1997-1998	117000
2	Tetra-SL	1998-1999	118770
3	Tetra-SL	1999-2001	117557
4	Tetra-SL	2001-2002	114790
5	Tetra-SL	2002-2003	121781
6	ISA Brown	2003-2004	117407
7	Tetra-SL	2004-2006	117165
8	Tetra-SL	2006-2007	107855
9	ISA Brown	2007-2008	119891
10	Hy-Line	2008-2010	134341
11	Tetra-SL	2010-2011	122450
12	ISA Brown	2011-2012	120242
		Total	1429249
	Mean ± Standard deviation		119104±6114

2. Laying time

The laying duration is significantly longer in the 2nd band (Tetra-SL strain) and the 10 th band (Hy-Line strain), with 64 and 62 weeks respectively (p<0.001; Table 2). The significant variation in laying duration over the 15 years is closely related to the significant variation in the age of laying (Table 2) as well as the variation in the age of culling which is later in the 2nd and 10th band (Table 2), respectively 84 weeks of age (Tetra-SL strain) and 83 weeks (Hy-Line strain).

Table 2: Performance recorded during the 15 years

Parameters	**Band1**	**Band2**	**Band3**	**Band4**	**Band5**	**Band6**	**Band7**	**Band8**	**Band9**	**Band10**	**Band11**	**Band12**	**ESM**	***p***
Average number hens installed per building	29250 **ab**	29692.5 **ab**	29389.2 **ab**	28697.5 **ab**	30445.25 **b**	29351.7 **ab**	29291.2 **ab**	26963.7 **a**	29972.7 **b**	33585.2 **c**	30612 .5 **bc**	30060.5 **b**	263.3	<0.001
Laying age (weeks)	20.25 **a**	20.00 **a**	19.00 **a**	21.25 **ab**	21.25 **ab**	19.50 **a**	23.50 **bc**	23.75 **c**	20.75 **a**	21.50 **ab**	20.75 **a**	23.75 **c**	0.26	<0.001
Reform age (weeks)	78.25 **ce**	84.00 **e**	72.00 **bc**	63.00 **a**	67.25 **ab**	76.75 **cd**	78.50 **ce**	75.00 **c**	76.25 **c**	83.25 **de**	78.50 **ce**	74.75 **c**	0.91	<0.001
Laying time (weeks)	58 **eg**	64 **g**	53 **cde**	41.75 **a**	46 **ab**	57.25 **cdef**	55 **cde**	51.25 **bd**	55.50 **cdef**	62 **fg**	57.75 **dg**	51 **bc**	0.95	<0.001
Mortality rate (%)	14.65 **a**	16.29 **ab**	27.30 **ac**	48.52 **d**	28.53 **ac**	27.12 **ac**	30.87 **c**	14.35 **a**	20.67 **ac**	26.31 **ac**	29.43 **bc**	27.62 **ac**	1.49	<0.001
Feed consumption/ hen/day (g)	114.22 **bce**	114.35 **bce**	113.07 **bce**	112.74 **bcd**	110.89 **ac**	106.33 **a**	119.10 **e**	116.88 **ce**	108.56 **ab**	113.27 **bce**	112.41 **acd**	117.40 **de**	0 .60	<0.001
Feed consumption/ hen/cycle (kg)	6.87 **df**	7.62 **f**	6.49 **cde**	5.01 **a**	5.72 **abc**	6.4 **bde**	6.72 **df**	5.54 **ab**	6.18 **bd**	7.27 **ef**	6.68 **de**	5.54 **ab**	0.12	<0.001
Production / starting hen	286.00 **ce**	343.25 **f**	280.25 **bce**	235.75 **a**	229.00 **a**	309.25 **ef**	285.75 **ce**	244.0 **ab**	273.75 **bce**	254.50 **ac**	307.50 **def**	272.50 **bcd**	5	<0.001
Peak laying rate (%)	93.40 **b**	93.27 **b**	93.80 **b**	93.95 **b**	84.27 **ab**	93.76 **b**	89.87 **ab**	89.42 **ab**	78.86 **a**	89.55 **ab**	89.80 **ab**	86.15 **ab**	0.87	<0.001
laying rate (%)	69.71 **a**	74.82 **ac**	72.90 **ab**	80.71 **c**	69.72 **a**	76.11 **bc**	73.47 **ab**	74.12 **ab**	69.42 **a**	74.83 **ac**	76.32 **bc**	74.41 **ab**	0.55	<0.001
Breakage rate (%)	1.23 **d**	1.91 **e**	0.79 **c**	0.43 **a**	0.44 **a**	0.41 **a**	0.60 **b**	0.49 **ab**	0.43 **a**	0.61 **b**	0.43 **a**	0.53 **ab**	0.06	<0.001
Feed conversion ratio	2.69 **a**	2.54 **a**	2.53 **a**	2.40 **a**	2.74 **a**	2.46 **a**	2.69 **a**	2.63 **a**	2.66 **a**	2.38 **a**	2.50 **a**	2.58 **a**	0.03	0.433

Mean values in the same column with different letters are significantly different at $p<0.05$.

3. Mortality rate
The mortality rates (average 26%) are significantly different in the 12 bands ($p<0.001$; Table 2). Mortality rates of hens per week according to the strains exploited, Tétra-SL, ISA Brown and Hy-Line, are significantly similar ($p=0.369$; Table 3). The highest peak mortality was observed in the 4th Tetra-SL strain band with a rate of 48.52%, i.e. a loss of 24,752 birds in a single night.

Table 3: Evolution of performances according to strains

Parameters	Tetra-SL	ISA Brown	Hy-Line	SE	*p*
Starting number of hens	243068.51**c**	102809.65**b**	37455.79**a**	4358.89	<0.001
Number of deaths per week	1069.39**c**	437.10**b**	150.01**a**	51.24	<0.001
Mortality rate/week (%)	0.50**a**	0.44**a**	0.42**a**	0.02	0.369
Distributed feed (ton/week)	1.926**c**	0.764**b**	0.296**a**	0.03	<0.001
Feed consumption/hen/day(g)	115.61**b**	110.03**a**	112.99**ab**	0.69	<0.001
Laying rate (%)	70.73**a**	72.06**ab**	74.94**b**	0.63	0.032
Breakage rate (%)	1.24**b**	0.49**a**	0.62**a**	0.04	<0.001
Feed conversion ratio	2.68**b**	2.54**b**	2.36**a**	0.02	<0.001

Mean values in the same line with different letters are significantly different at $p<0.05$.

4. Daily feed consumption per hen
The quantities of feed consumed per hen per day are significantly different (Table 3) between the three strains (Tetra-SL, ISA Brown and Hy-Line). A decrease in feed consumption (Table 2) was recorded for hens of the ISA Brown strain at the 6th flock.

5. Feed consumption per production cycle
The global average consumption per cycle per hen was significantly different from one band to another (Table 2). The 2nd and 10th bands had a high feed consumption of 76.2 kg/hen (Tetra-SL strain) and 72.7 kg/hen (Hy-Line strain) respectively. The lowest significant overall average consumption per hen during its production cycle was recorded by the 4th flock (Tetra-SL strain), i.e. 50.1kg/hen over 41.75 weeks of production.

6. Feed conversion ratio
The average feed conversion ratio or consumption index (CI) calculated over the study period is 2.57±0.23, which is significantly similar across the 12 bands ($p=0.433$; Table 2). By strain, CI was significantly different in the three strains ($p=0.001$; Table 3). That recorded by the Hy-Line strain remains significantly better (2.36) with an eggs laying time of 62 weeks.

7. Production per "starting hen"
This production was significantly different from one band to another ($p<0.001$; Table 2). The best production was recorded by the Tetra-SL strain (band2 and band11) as well as the ISA Brown strain (band 6).

The production average recorded by the Hy-Line in band 10 was 254.50 eggs / hen starting) in a laying period of 62 weeks. It should be noted that the highest production was carried out by the 2nd band (Tétra-SL) ie 343 eggs / hen.

8. Laying rate
The laying rate fluctuated throughout the 15 years (even within the same strain) from one band to another ($p<0.001$; Table 2). The best rate was recorded by hens of the Tetra-SL strain in the 4th flock with a rate of 80.71%. By strain, the laying rate was significantly different in the three strains ($p<0.001$; Table 3). It was better for the Hy-Line strain with a rate of 74.94%.

9. Peak egg-laying rate
The maximum production level was reached by the Tetra-SL strain in the first four bands and the ISA Brown strain in the sixth band (Table 2) with an average of 93.63%. The Hy-Line strain recorded a peak of 83.25%.

10. Breakage rate
The breakage rate was significantly high in the 2nd band with the Tetra-SL strain (Table 2) at 1.91%.

DISCUSSION

Numbers put in place are much higher than the average size of farms in Algeria estimated at 4,705 laying hens per band. This density is linked to the small surface area of the livestock buildings (436m²±162), the under-utilisation of production capacity and the extensive nature of the production processes used (buildings with static ventilation) [4].

The minimum implemented was recorded in the 8th band (107855 hens) and the maximum in the 10th band (134341 hens). This variability can be explained by a high level of mortality of hens during their transport from the production units of the pullets started to the production unit of table eggs.

According to Cloutier and Lemelin [6], egg production begins around the 19th week of age (the laying age) and continues until the 70th week of age (the culling age), which corresponds to a 12-month laying cycle, i.e. 51 weeks. It is higher than the 59±4 weeks recorded by Mahmoudi et *al.* [4] in Algeria in the M'sila region in private farms. It is also much higher than the French average in 2006, which was 48 weeks according to Pascale and Anne [7]. More recently, ITAVI [8], on the performance of caged laying hens in France, reports production durations ranging from 56 to 59 weeks.

According to the breeding and management guidelines for the Tetra-SL and Hy-line strains, the production period can be between 18 and 90 weeks of age respectively, i.e. a laying period of 72 weeks, and between 18 and 100 weeks of age respectively, i.e. a laying period of 82 weeks.

Mortality rates are very high compared to the average (4.99%) recorded in eastern Algeria by Alloui et *al.* [9] and that (13.3%) reported for the M'sila region by Mahmoudi et *al.* [4]. They are also higher than the average of 7% recorded in Morocco [10] and the French average of 6.1% [7].

The mortality rates of hens per week according to the strains exploited, Tétra-SL, ISA Brown and Hy-Line, respectively 53 weeks (26.50%); 54 weeks (24%) and 62 weeks (26%) are also too high compared to the average recommended by the guides for the three strains, which are respectively 5% to 7% at a laying time of 72 weeks; 6% at a laying time of 72 weeks and 2.9% with the same laying time (62 weeks).

The highest peak mortality in the 4th Tetra-SL strain band due to the failure of the ventilation and cooling system, which led to an increase in temperature and hen mortality. According to the strain's rearing guides, the mortality rate must not exceed 5 to 7% in a production period of 18 to 90 weeks of age and a building temperature of 20°C. The harmful effects of heat in poultry farming are known and have been widely studied [11].

Badly insulated buildings, insufficient ventilation and sometimes failure of the cooling system lead to an increase in temperature above the recommended 20°C, which causes excessive stress to the birds that die from hyperthermia [12]. Prolonged exposure to very high temperatures (42°C) is lethal to hens [13].

The mortality rates recorded in the last three flocks can be explained by Marek's disease, which affected the flock. This disease poses severe threats to factory farming and the development of strategies to control it and is currently one of the greatest challenges according to Payne and Venugopan [14]. This secular disease, introduced into Algeria in the 1990s with the importation of chickens [15], is constantly reappearing in different types of farming [16]. According to GIPAC-USSEC [17], in poultry farms with increasingly efficient strains that are therefore more sensitive to farming stress, introduction of certain pathogens into the farm can lead to lower productivity and lower product quality, and even mortality. There is also an increase in mortality beyond 12 months of production, which can be explained by the overexploitation of hens. The mortality rate of the Hy-Line strain increases with age until it reaches its highest rate at 100 weeks of age, which is 8.4%. In the case of the ISA Brown strain, the mortality rate of 0.1% at 18 weeks of age reaches 6.8% at 100 weeks of age.

The quantities of feed consumed per hen per day for the three strains remain within the standards of 100-120g/hen/day recommended by Van Eekeren et *al.* [18].

The strain rearing guidelines recommend an average feed consumption of the Tetra-SL strain of 108-114g/d/hen and 107-113g/d/hen respectively with production durations of 62 weeks and 72 weeks. For the ISA Brown strain, the average is 111g/d/poultry at 82 weeks of age, while for the Hy-Line, the average is 105-112g/d/poultry with a production duration of 82 weeks.

The decrease in consumption that was recorded by the hens of the ISA Brown strain in the 6th band is related to the frequent interruption of feed supply, bad presentation and abrupt change in feed form during this rearing period. Feeding guides for laying hens recommend at least 75-80% of the feed should contain particles between 0.5 and 3.2mm in size, i.e. a maximum of 15% of particles smaller than 0.5mm and a maximum of 10% of particles larger than 3.2mm. Feed consumption is reduced by 4g/day when the feed is finely ground and leads to a reduction in the mass of egg produced [19].

Laying hens select their feed intake according to the relative size of the particles in relation to the beak. In the case of a mixture of whole wheat and a feed in the form of meal, animals preferentially ingest particles larger than 2 mm [20].

The main problem affecting egg production and egg weight of modern strains of laying hens is the reduction in feed intake often observed at the beginning of egg production [21]. Low feed intake results in hens not reaching standard weight at this age, which reduces egg size throughout the laying cycle [22, 23].

The high consumption recorded in the 2nd and 10th band is due to their production time which was significantly longer respectively 64 and 62 weeks of age.

The lowest overall average consumption per hen during its production cycle but remains higher than that recommended by Pineau and Morinière [24], according to which the average consumption of a hen over its laying year should not exceed 44kg of feed.

Globally, the difference in the level of feed consumption per hen per production cycle observed from one flock to another can be explained by the length of exploitation of hens in the production phase, which varies from one year to another, pathological problems and breakdowns in the feed chain. In fact, through the study of the technical data sheets, we have noted the irregularity of the feed supply but also its bad presentation. Feed consumption increases with heavier grain size [25].

It has been known for a long time [26] that hens, as is the case with other livestock, adjust their feed intake to meet their energy requirements and, therefore, an increase in the energy concentration of the feed should reduce feed consumption proportionally. An increase in energy content could improve nutrient utilization and egg size [27].

Bouvarel et *al.* [28] reviewed a series of experiments on laying hens over the last 20 years and reported that on average a 10% increase in the energy content of the feed resulted in a reduction in feed intake of only 5.5%.

The consumption index (CI) calculated during the study period is higher than that recorded by Alloui et *al*. [2] in eastern Algeria, i.e. 2.43 ± 0.02.

The best conversion index recorded by the Hy-Line strain remains higher than that recommended by the strain's rearing guide with a shorter (40 weeks) and longer (80 weeks) laying time (1.87 to 1.99 and 1.98 to 2.10 respectively). It is higher than the results reported by Magdelaine and Conter [29] for France (2.11) and Reunion Island (2.2). On the other hand, it is better than those reported by the same authors for the Ivory Coast (3.27) and Senegal (3.11). The variation in consumption indices per strain is closely linked to the significant difference in egg production and the quantity of feed consumed by the strains exploited.

The best production recorded by the most exploited strain during the 15 Tetra-SL years (band2 and band11) is in the standards recommended by the strain guide, ie a total number of eggs / hen from 325 to 330 for a longer laying period (72 weeks).

The average production recorded by the Hy-Line is lower than the standards recommended by the strain guide, which are 264.5 to 273.7 eggs/start hen with the same laying time. Egg production is highest in the heat neutral zone. It decreases significantly (by more than 20 points) when hens are exposed to constant high temperatures (30°C) if the feed is not modified [30].

The best production of recorded in the 2nd band (Tétra-SL) is higher than that recommended by the breeding guide for the strain, which is 330 eggs/hen. It is also higher than that reported by Mahmoudi et *al*. [4] for some private farms in the M'sila region, which is 280.9 eggs/hen. It is also higher than that recorded by Magdelaine and Conter [29] in France (294 eggs/hen), the Czech Republic (310 eggs/hen) and Poland (315 eggs/hen), as well as the average reported by Jacquet [31] in Belgium (323 eggs/hen).

The highest laying rate recorded by hens of the Tetra-SL strain in the 4th band is better than that recorded by Alloui et *al*. [9] in eastern Algeria, i.e. 77.75%. It is lower than the rate recommended by the breeding guide for the strain, i.e. 88.3% with the same production period (42 weeks of age). By strain, the best spawning rate recorded by the Hy-Line strain remains lower than the average recorded in France for the period 2014-2017 and which varies from 81.4% to 85.1% according to the [8].

The maximum level of production which has been achieved by the Tétra-SL strain and the ISA Brown strain is lower compared to the peak egg production recommended by the breeding guides for these two strains, which is 96%.

The spawning peak of the Hy-Line strain is much lower than the spawning peak recommended by the strain guide which is 95% to 96% and that recorded by Meluzzi et *al.* [32] with the same strain which is 97.1%. Egg production increases rapidly at about 20 weeks of age and peaks at about 28 to 30 weeks of age [33].

The highest breakage rate recorded in the 2nd band with the Tetra-SL strain is better compared to that recorded in France in 2014, 2015, 2016 and 2017 in cage breeding, which is respectively 5.4%, 5.4%, 3.9% and 7.1% [8]. This breakage is mainly due to the collection system and the transport of eggs from the poultry buildings to the cold room; as it could be explained by the bad quality of the eggshell [34]. The resistance to eggshell breakage is significantly influenced by the increasing level of calcium and a clear tendency for the shell to be more resistant with the largest calcium particle [35]. Sauveur and Picard [36] indicate that calcium requirements are of the order of 3.5 to 4% for egg formation during the laying period. In addition, an effect of genotype on egg shell quality is also reported by Škrbić et *al.* [37].

The rate of broken and cracked eggs is low at the beginning of production and then increases during the laying cycle, reaching values of around 12 or even around 20% in some farms at the end of a production year, depending on management, feeding and environmental conditions [38].

CONCLUSION

The poultry complex studied is characterised by production performances close to those of the strains in some bands but low in others. Zootechnical and sanitary constraints are responsible for the poor performance, in particular the irregularity of the feed supply and its bad presentation, as well as pathological problems.

To improve its productivity, the poultry complex must improve its breeding conditions by investing in the installation of new equipment (feeding chains, ventilation systems, etc.). The supply in quantity and quality of raw materials and the formulation of feeds that meet the needs and requirements of the strains used are essential.

It is also necessary to avoid transport stress, control and respect sanitary barriers and intensify prophylactic measures in order to reduce the mortality rate which is too high during the whole study period and to reduce its impact on production yield.

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