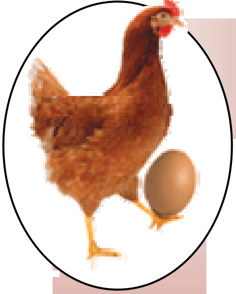

2008 RESEARCH REPORT

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"STUDY OF THE YIELD FEATURES, BEHAVIORAL AND ANATOMO-PHYSIOLOGICAL ADAPTABILITY OF SOME LAYING HYBRIDS WITHIN THE CONDITIONS OF DIFFERENT RAISING ALTERNATIVE SYSTEMS"

STAGE 2008
- single stage -

Project manager: *Prof.* USTUROI Marius Giorgi, PhD

Research team: *Prof.* Boişteanu Paul Corneliu, PhD
Prof. Pop Ioan Mircea, PhD
Lect. Doliş Marius Gheorghe, PhD
Assist. Radu-Rusu Răzvan Mihail, PhD

SYNTHESIS OF THE RESEARCH REPORT FOR THE 2008 STAGE (SINGLE)

1. RESEARCHES GOAL

In most countries, laying hens husbandry is organised on industrial farm platforms, of great capacities. Although more than 75% of laying hens flocks across the world are accommodated in batteries, the dynamics of public opinion related trends to induce renunciation from these superintensive husbandry systems *(Conrad, D., 2000).*

In July 1999, an European Union directive has been issued. It regulates the comfort contitions which should be provided to the laying hens; therefore the conventional cages will be kept in function till 2012. Then, they will be replaced with improved cages aor certain alternative systems will be used, in order to allow fowl to express the natural instincts *(Van Horne, P., 2001).*

Thus, certain alternative husbandry systems have been designed, although they are not enough founded on a technical-scientific solid basis *(Dun, P., 1992).* Lontime, researchs were dedicated to the development of some alternative systems, from which, most appropriate was considered the so-called "furnished cage", endorsed with nest, resting poles on single level, and "*dust bath*" (sand); moreover, more cage floor area was allocated to each bird, compared to the conventional cages (*Reuvekamp, B.F., 2000).*

In oru country, the husbandry of laying hens hybrids is almost exclusively fone in conventional cages. The replacement of this system through a straight movement is excluded because it will certainly lead to an extinction of a profitable economic field and will disbalance the protein balance of human consumers, through the exteinction of table eggs, which could be bought now at affordable prices.

The goal of our researches could be framed within the same conjuncture. We proposed to bring new improvements on the semi-intensive, intensive (at ground) and intensive (in cage batteries) rearing systems, used in our country to accommodate those hens producing table eggs.

2. THE BIOGICAL MATERIAL

The biological material we used was represented by the "Lohmann Brown" commercial laying hybrid, bought at 18 weeks old, from a farm that is specialised in pullets rearing. An acclimatisation period of 2 weekd after breeding was considered.

That hybrid has been created in Germany, from 4 pure bloodlines of the Rhode-Island breed (hybrid males = A roosters x B females and hybrid females= C roosters x D females). The "Lohmann Brown" hybrid is very precocious, reaching 40% laying intensity at 20 weeks old, while production peak is reached at 28 weeks old (93%). Throughout 60 weeks of usage, "Lohmann Brown" produces 337.5 eggs.

3. EXPERIMENTAL DESIGN

Basing on the analysis of data from specialty references, related to the efficacy of certain different alternative rearing systems, it was decided to test three technological versions, as following:

- accommodation and rearing in size-modified cages;
- accommodation and rearing in opened cages
- accommodation and rearing on permanent litter, at ground, in halls providing externat access.

3 (three) separate experiments were organised, which were differenciated through the applied husbandry system. In the first 2 experiments, a control group (Lc-1), was established. The superintensive system principles have been used for the birds within Lc-1

group. They have been accommodated in B.P.-3 cage batteries, at a brooding density level of a hen/500 cm^2, which meant 4 hens/cage of 2000 cm^2. In the experiment III, a <u>different control group</u> was used <u>(Lc-2)</u>, accommodated within the intensive husbandry system, exploitation at group, on permanent litter at a density of 6 hens/m^2

Experiment I: "Evaluation of the morpho-productive and behavioural response of the A genotype ("Lohmann Brown" hybrid) at the conditions provided by the husbandry system which included size modified cage batteries" *(tab. 1).*

Table 1

Experimental design for experiment I

Notice	Experimental group		
	Lc-1	Lexp-1	Lexp-2
Husbandry system	Superintensive	Superintensive	Superintensive
Brooding density	4 hens/cage of 2000 cm^2	5 hens/cage of 3000 cm^2	6 hens/cage of 6000 cm^2
Cage type	standard	modified	modified
Surface of cage floor/hen (cm^2)	500	600	1000
Innitial flock (cap.)	432	435	432
Cages amount	108	87	72
Cages size (cm)	L=40; w= 50	L=60; w= 50	L=120; w= 50
Cage surface (cm^2)	2000	3000	6000

In the <u>1st experimental group (Lexp-1)</u> the sizes of B.P.-3 battery cages were modified, to provide 600 cm^2 cage floor at brooding/hen. 5 hens were accommodated in a cage of 3000 cm^2. The individual space was enlarged more in the <u>2nd experimental group (Lexp-2)</u>, which meant 1000 cm^2/hen or 6 hens cage of 6000 cm^2.

Experiment II: "Evaluation of the morpho-productive and behavioural response of the A genotype ("Lohmann Brown" hybrid) at the conditions provided by the husbandry system which included opened cage batteries" *(tab. 2).*

Table 2

Experimental design for experiment II

Notice	Experimental group	
	Lc-1	Lexp-3
Husbandry system	Superintensive	Intensive
Brooding density	4 hens/cage of 2000 cm^2	4 hens/cage of 2000 cm^2
Cage type	standard	modified
Surface of cage floor/hen (cm^2)	500	500 cm^2 in resting+nesting cage and 500 cm^2 in feeding and watering cage
Innitial flock (cap.)	432	432
Cages amount	108	108
Cages size (cm)	L=40; l= 50	L=40; l= 50
Cage surface (cm^2)	2000	2000

The hens from the <u>3rd experiemental group (Lexp-3)</u> were accommodated in conventional B.P.-3 cages, whose front panels were removed, providing thus freedom of movement across the entire hall. Meantime, the cages from each battery lines were resetricted to certain limited features (feeding and watering on a side and laying+resting on the opposite side).

Experiment III: "Evaluation of the morpho-productive and behavioural response of the A genotype ("Lohmann Brown" hybrid) at the conditions provided by the husbandry system which included access to external paddocks *(tab. 3).*

Both hens groups were accommodated in a windowless shelter, divided in two identically sized compartments, which counted 252 m^2 each.

<u>The control group (Lc-2)</u> was accommodated in compartment I, endorsed for rearing at ground, on permanent litter. The floor was covered by a layer of minced hay, 15 cm thick,

the feeders and water devices being disposed intercalately; the nest were disposed across the walls on two levels.

Table 3

Experimental design for experiment III

Groups	Lc-2	Lexp-4
Husbandry system	Intensive	Semi-intensive
Rearing and exploiting technology	permanent litter	permanent litter, poles panels for sleeping and free acces to an external paddock
Surface of compartments	252 m^2	252 m^2
Brooding density	6.0 hens/m^2	7.5 hens/m^2
Innitial flocks	1512 hens	1890 hens
Feeding space	10 cm/hen	
Watering space	3 cm/hen	
Nests	1 nest/5 hens	

Hens from experimental group 4 (Lexp-4) were reared in compartment II, according to the semi-intenisve system, on permanent litter and having free acces to an external paddock. Wateres and feeder have been disposed both inside the compartment and otside, on the paddock surface (under a covered area).

4. APPLIED RESEARCH METHODS

Multiple traits have been investigated throughout the researches, assessed in accordance to certain recognised methods:

- body weight dynamics;
- eggs production dynamics;
- laying intenisty;
- feed consummption: whole intake (kg/group/period); average daily intake (g/hen/day); feed conversion (g feed/egg);
- fowl health status;
- eggs weight;
- morphologic anomalies (% eggs with malformed shell; % eggs without yolk; % eggs without shell; % eggs with double yolk; % eggs with broken shell);
- eggshell thickness;
- eggshell braking strength;
- eggs chemical composition*:* albumen (% dry matter, % proteins), yolk (% dry matter, % proteins; % lipids), shell (% minerals);
- microbial load on the shell

Quality traits have been assessed on the eggs produced during the main stages of laying curve (onset - 20th week; peak-28th week; plateau-37th week and ceasing-80th week).

Main experimental data have been statistically processed.

5. ACHIEVED RESULTS

5.1. Body weight dynamics in the studied fowl

Experiment I. Earlier investigations (20th week), weight bird was sensitive equal between groups (1577.82 ± 24.93 g LC-1, 1575.31 ± 30.61 g Lexp-1 and 1576.49 ± 35 63g to Lexp-2), first differences were found only in reaching the peak of laying, when birds weight was of 1901.69 ± 40.86 g LC-1, 1870.53 ± 38.07 g Lexp-1 and 1868.58 ± 45.01 g Lexp-2. At the end of the experiment differences between groups were stronger, mean weight of hens being studied reached 2125.13 ± 69.71 g in control group, 2087.83 ± 67.95 g in Lexp-1 and 2083.03 ± 66.99g in Lexp-2.

Experiment II. In the opened battery version, at the time of onset, weight of laying birds was uniform, being 1577.82 ± 24.93 g LC-1 and 1577.22 ± 35.96 g Lexp-3. The difference in intensity of lay birds made led to various efforts of the bodies, with repercussions on body weight. Thus, during laying peak, bird weight was 1901.69 ± 40.86 g in control (LC-1) and 1859.40 ± 45.37 g in Lexp-3. At the end of the experiment (80^{th} week), weight differences were more marked, being 2125.13 ± 69.71 g in controls (LC-1) and 2030.29 ± 69.64 g in Lexp-3. Character variability was average to high (V% = 11.17 to 24.82).

Experiment III. In the application of the intensive and semi-intensive systems, body weight of birds was within standard curve, but at its lower limit and very small differentiation between groups. Thus, at brooding moment, average weight of pullets was also sensitive equal, being 1603.04 ± 15.61 g in group LC-2 and 1602.87 ± 12.87 g in group Lexp-4. When birds were 80 weeks of age, body weight showed mean values of 1953.89 ± 47.22 g in group LC-2 and 1959.88 ± 44.84 g in group Lexp-4.

5.2. Feed consumption in the studied fowl

Experiment I. Birds raised in BP-3 batteries (with or without modification), the lowest feed consumption were recorded in the first stage of feeding (20-45 weeks), namely, the 106.32 ÷ 111.07 g / head / day, average daily intake and respectively 126.29 ÷ 134.38 g / egg-feed conversion. Between 46-65 weeks of age, consumption rate increased to levels of 111.99 ÷ 113.82 g / head / day, and that average daily intake to 146.48 ÷ 153.30 g / egg-feed conversion, equivalent position for the last stage of feeding (66-80 weeks), the average daily intake was the 119.74 ÷ 126.61 g / head / day and feed conversion index was 191 29 ÷ 211.59 g / egg. For the entire period we studied (20-80 weeks), the best feed consumption values were obtained in controls (LC-1), with an average daily intake of 112.63 grams / capita / day and a feed conversion index of 145.34 g / egg. Next position group ranged between Lexp-1 (115.10 g / head / day, average intake and 153.06 g / egg-feed conversion), and the last position Lexp-2 group (116.47 g / head / day-average intake and 155.35 g / egg-feed conversion).

Experiment II. Birds raised in opened batteries consumed more feed than those housed in standard cages, because they needed an additional energy to cover the costs of freedom of movement. Thus, birds in group Lexp-3 (accommodation in halls with opened batteries), had the following average daily intake: 115.18 g / head / day during weeks 20-45, 115.66 g / head / day during 46 -65 weeks, 135.60 g / head / day during weeks 66-80. On the whole period studied, observed group recorded an average consumption of 120.51 g / head / day. On feed conversion index, it was 141.65 g / egg in the first control period (20-45 weeks) of 158.38 g / egg in the second control period (46-65 weeks) and of 231.75 g / egg between 66-80 weeks, expressed as percentage difference from the control group (LC-1) was 12.16% in the first period of control by 8.12% in the second and of 21.15% in the last period. Overall, Lexp-3 group achieved a conversion index of 164.38 g / egg, with 19.04 g more than birds in the group have performed LC-1, kept in standard cages - BP-3 battery.

Experiment III.

The first phase of feeding lasted throughout 182 days and included the laying peak and the plateau of the curve lay. At this stage, the average daily consumption was 122.9 g / head / day in group LC-2 and 126.1 g / head / day in group Lexp-4, while feed conversion reached 169.7 g / egg at group LC-2 and 180.2 g / head / day in group Lexp-4. Between 46-65 weeks, average daily intake had increased slightly from the previous stage (129.8 g / head / day in group LC-2 and 133.2 g / head / day in group Lexp-4), while low intensity lay resulted in increased feed conversion (194.9 g / egg in group LC-2, and 207.3 g / egg-Lexp in group 3). End of laying period (weeks 66-80) was characterized by a reduction in average daily feed intake over the previous stage (124.1 g per capita in group LC-2 and 127.3 g / head in group-4 Lexp) and increased levels of feed conversion of 226.1 g / egg in sample LC-2, respectively, of 240.8 g / egg in group Lexp-4, reducing the effect of laying. For the entire period studied (19-80 weeks) better indicators were achieved by the birds in group LC-2 (average intake = 125.95 g / head / day, feed conversion = 188.29 g / egg), and more less convenient in group Lexp-4 (average intake = 129.96 g / head / day, feed conversion = 200.38 g / egg).

5.3. Casualties level in the studied fowl

Experiment I. In the variants of accommodation in BP-3 battery cages, at the end of 20th week of life of birds actually casualties were 0.23% in LC-1 and Lexp-2 and 0,46% to Lexp-1; there were caused by the stress of transport and accommodation, but also by the struggle for social hierarchy. Further, there was a significant reduction of casualties or no mortality. During the total period (20-80 weeks), the proportion of actual casualties differed between groups, depending on the technological solution adopted. Thus, the lowest mortality (8.22%) was found in Lexp-2, when birds have the advantage of freedom of movement (1000 cm^2 cage / bird). Next positions were taken by Lexp-1 (600 cm^2 cage / bird) with 9.57% mortality in controls and LC-1 (500 cm^2 of classical cage / bird) with 11.66%.

Experiment II. If birds housed in open battery (group Lexp-3), casualties at end of first week of experiments (the 20th) were 0.46% versus 0.23% as recorded in the control group (LC-2). For the whole period (20-80 weeks), the proportion of actual exits in group Lexp-3 was only 7.46% ie 36.02% lower than that recorded in controls LC-1, birds reared in unchanged battery cages BP-3.

Experiment III. Even if the birds have enjoyed the convenience provided by the permanent litter (LC-2), but especially the influence of external environment (Lexp-4), the proportion of actual casualties was quite high. In the flocks we studied, the rate of actual exits presented values higher than normal proportion, caused mainly by husbandry technology applied in each group. So, for example, the group of birds constantly exploited on litter (Lc-2) recorded at the end of experiment an 11.08% mortality caused largely by the action of negative factors (pollutants, excess humidity, heat etc.). The specific microclimate in closed halls (blind) became more polluted, in addition to litter increasingly degradation by the end of growth. At the group of whose birds had access to the paddock (Lexp-4), health was much better, evidenced by a much smaller proportion of the actual casualties, of 7.36% only.

5.4. Eggs yield and laying intensity

Experiment I. When testing batteries with modified dimensional cage, it was found that the classical version of brooding in LC-1 control group has allowed the highest production of eggs of 325.05 pieces / bird. This group was followed by group Lexp-1 with an average production of 319.09 eggs per bird and by group Lexp -2 with only 316.32 eggs / bird. Laying peak was reached in the 28th week, being 91.56% in group LC-1, from 89.97% in group Lexp-1 and 89.88% in group Lexp-2. After reaching the peak of laying, the laying intensity started to decrease, so that during experience end (80th week), it was 56.38% in control (LC-1), 54.25% in group-Lexp1 and 53.53% in group Lexp-2.

Experiment II. Birds in group Lexp-3 (raised in opened batteries) made a production of 311.34 eggs eggs / poultry only, lower by 1.57%, compared to group Lexp-2 (6 head / cage 6000cm^2), with 2.43% of those in group Lexp-1 (5 head / cage 3000cm^2) and 4.22% higher than in conventional batteries BP-3 (group LC-1). In this case, the maximum intensity was achieved during the 28th week of bird life, but was only 88.35%, with 3.51% lower than the control group LC-1 (birds reared in conventional batteries). Decrease the intensity of laying was somewhat obvious, so that at the end of the investigations (80-week life of birds), its level was only 52.13%.

Experiment III. Numeric egg production was 283.48 egg / bird in group LC-2 and only 273.40 egg / bird in group Lexp-4, less with 12.79% and with 15.89% than the hens of group LC-1 (reared in superintensive system in unchanged BP-3 batteries. Birds in the two groups have all made the top lay in the 28th week of life, but the intensity of laying was only 78.11% of those in group LC-2 and 75.33% for those in group Lexp-4. Percentage intensity difference lay between birds reared intensively (group LC-2) and semi-intensively (group Lexp-4), compared to the performance of hens kept in superiintensive system (LC-1 group) was 14.69% and respectively 17.73%. In this experience, lay end was characterized by a very low intensity of laying, only 49.56% of those in group LC-2 respectively, constituting 47.79% of the lot Lexp-4.

5.5. Proportion of the eggs with morphologic anomalies

Experiment I. During the start of laying, the most common abnormality was the broken shell eggs (0.60 ÷ 0.85%), followed by shell less eggs (0.20 ÷ 0.22%), those with malformed shell (0.16 ÷ 0.17%), eggs with two yolks (0.06 ÷ 0.08%) and eggs without yolk (0.03 ÷ 0.04%). More morphologically abnormal eggs were produced during laying ceasing (2.44% in LC-1, 2.35% in Lexp-1 and 2.27% in the Lexp-2). During this period many eggs were found with broken skell (1.18 ÷ 1.34%), malformed shell (0.63 ÷ 0.65%) and withouth shell eggs (0.27 ÷ 0.28 %).

Experiment II. During laying onset, more eggs were found with broken shell (0.78% in LC-1 and 0.99% at Lexp-3), and also shell less eggs (0.20% in LC-1 and 0.15 % in Lexp-3); during the whole period, abnormal eggs were found in a proportion of 1.27% in group LC-1 and of 1.41% in group Lexp-3. At the end of laying, there were found most eggs with deviations from normal morphology, a rate of 2.44% in group LC-1 and 2.68% in group Lexp-3. During this period, there prevailed the eggs with broken shells (1.34 ÷ 1.59%), followed by those with malformed shell (0.62 ÷ 0.63%) and shell less eggs, with a proportion of 0.28%.

Experiment III. Control performed at the beginning of laying revealed higher share for two types of anomalies, ie, broken shelled eggs (0.55 to 0.65%) and eggs without shell (0.19 to 0.21%). In a much smaller proportion have been highlighted the eggs with two yolks (from 0.04 to 0.06%), those without yolk (0.02 to 0.03%) and malformed shell (0.15-0.29%). At the end of laying (week 80th) it was found the highest proportion of eggs morphologically abnormal, with a total of 2.33% in group LC-2 and 1.97% in Lexp-4 group. The most numerous were the broken shell eggs (1.27 to 0.82%).

5.6. Eggs weight

Experiment I. Weighing lay eggs collected early (20th week) showed certain balance between groups (46.83 to 47.01 g), confirmed by the lack of statistical differences between them, while the character presented a mid variability (V% = 14.78 to 16.92). In those weeks with the highest intensity of laying (28th one), the greatest weight of eggs (60.17 ± 1.07 g) was in group LC-1 and lowest (59.96 ± 0.93 g) in Lexp-2. In the birds aged 37 weeks (laying curve plateau), egg weight varied between limits ranging from 62.99 ± 0.94 g in group LC-1 and 63.04 ± 0.99 g in group Lexp-1. Towards the end of production, average egg weight increased, reaching during the 80th week levels of 68.11 ± 1.56 g in control LC-1, 68.37 ± 1.63 g in group Lexp -1 and 68.24 ± 1.61 g in group Lexp-2, there was some heterogeneity of the studied trait, the coefficient of variation being 12.51 to 13.08%.

Experiment II. In those birds raised in batteries (conventional cages and opened cages), weight of eggs was close between the two groups, as confirmed by no statistically significant differences between them. Thus, at lay onset, average egg weight was 46.98 ± 1.30 g in group LC-1 and 46.78 ± 1.28 g in group Lexp-3. In the next stage character values increased to levels of 60.17 ± 1.07 g-group LC-1 and 60.12 ± 1.00 g-group Lexp-3 during laying peak, respectively until 62.99 ± 0.94 g-group LC-1 and 63.03 ± 0.87 g-group Lexp-3, during lay plateau curve. However, the highest levels of eggs weight were recorded in control group, last week (the 80th), when the trait reached 68.51 ± 1.56 g in birds from group 1 and 68.50 LC ± 1.76 g in those from group Lexp-3.

Experiment III. The fact that egg weight is a strong genetically determined trait, therefore less influenced by technological factors, has been confirmed by its dynamics, noted in eggs obtained from chickens reared in intensive and semi-intensive systems. Our investigations showed that when laying just started, egg weight was greater than 0.07 to 0.11 g of eggs from hens kept in conventional battery cages. During the next stages of control, there were lower weights determined, due, perhaps additional energy consumption required greater freedom of movement so for example, weight of eggs collected at the end of laying was 67.82 ± 1.273 g in LC-2 and 67.61 ± 1.542 g in Lexp-4 group.

5.7. Egshell thickness

Experiment I. Birds with the best intensity of lay (LC-1 control group) showed the most reduced thickness of the mineral shell, at the beginning of laying (.440 ± 0.015 mm) and at the peak of laying (0.400 ± 0.013 mm), during its plateau (0.388 ± 0.014 mm) and especially at the end of laying (0.354 ± 0.012 mm). At the opposite end, stood the eggs from birds with the lowest intensity of lay (group Lexp-2), in which the reduced rate of egg formation has allowed the development of a sufficient quantity of minerals to form crust. In that group, evolution of mineral shell thickness was as follows: 0.443 ± 0.014 mm at the beginning of laying, 0.404 ± 0.014 mm in peak lay, 0.391 ± 0.012 mm in plateau and 0.358 ± 0.012 mm at the end of laying.

Experiment II. Hens reared in opened cages (group Lexp-3) have received much more motion than those of conventional battery (group LC-1), where a lower egg production. Instead, the obtained eggs were characterized by a thicker mineral shell appearance found in each of the four determinations we carried out. Thus, in the group outlined above, minerals shell thickness was 0.448 ± 0.013 mm in the start of laying, 0.410 ± 0.012 mm at the top of the laying, 0.402 ± 0.013 mm in the plateau lay and 0.012 ± 0.369 mm at the end of laying. Shell thickness of eggs collected from hens in group Lexp-3 was 0.008 to 0.015 mm greater than that of eggs obtained from hens in the reference group (LC-1).

Experiment III. Assessment of egg shell thickness in group Lexp-4, on phases of the laying curve, showed us that at lay onset, it was higher, 0.452 ± 0.008 mm, then decreased to 0.405 ± 0.008 mm during lay peak, to 0.347 ± 0.007 mm during plateau and to 0.341 ± 0.009 mm during lay ceasing. In LC-2 group, it was a better lay-intensity, but shell thickness was lower, at the beginning of laying (0.434 ± 0.011 mm) and in other phases of laying (0.380 ± 0.010 mm peak lay, 0.329 ± 0.009 mm plateau and 0.322 ± 0.011 mm at the end of lay).

5.8. Egshell breaking strength

Experiment I. From our investigations, it resulted that at the beginning of laying (20th week) highest levels for mineral shell breaking strength occurred, with some differences between groups, given by the different intensity of laying. Thus, in group Lexp-2, where eggs had the highest recorded mineral shell thickness, it was found the best breaking strength (0.343 ± 0.009 kg f/cm^2), compared to only 0.340 ± 0.008 kg f/cm^2 as established for the eggs laid in LC-1 group (thin shell). Intermediate values for mineral shell resistance were shown in group Lexp-1, 0.342 ± 0.010 kg f/cm^2. At the end of laying (80th week), shell breaking strength decreased even more, ranging between 0.325 ± 0.008 kg f/cm^2 in LC-1 and 0.327 ± 0.009 kg f/cm^2 in Lexp-2 group.

Experiment II. The data we obtained indicated that the highest resistance of mineral shell was found in eggs from birds kept in opened battery cages (group Lexp-3) at each control stage. The highest parameter values were found at the beginning of laying (0.348 ± 0.00 kg f/cm^2), after which it began to fall to a level of 0.337 ± 0.008 kg f/cm^2 at the end of laying. In the control group (LC-1), the cracking resistance of the shell varied as follows: 0.340 ±

0.008 kg f/cm^3-lay onset, 0.330 ± 0.007 kg f/cm^2 lay on lay peak, 0.329 ± 0.008 kg f/cm^2 lay during the plateau curve and 0.325 ± 0.008 kg f/cm^2 at the end of laying.

Experiment III. Very low differences in shell strength occurred between the eggs laid by birds reared on litter and those having access to the outer paddock. Thus, the eggs collected from hens in the control group LC-2, resistance to pressure of shell eggs ranged from 0.340 ± 0.009 kg f/cm^2 - lay onset and 0.328 ± 0.008 kg f/cm^2 – lay ending, while in the eggs from group Lexp-4, the same quality parameter ranged from 0.341 ± 0.008 kg f/cm^2 – onset till 0.330 ± 0.007 kg f/cm^2 – ending.

5.9. Yolk chemical composition

Experiment I. The data we obtained showed that, at lay onset (20th week), the amount of egg *yolk dry matter* was somewhat low, ranging between 8.62 ± 0.235 g (Lc-1 group) and 8.64 ± 0.243 g (group Lexp-1), but slightly increased in the peak of laying (28th week), when ranged from 8.95 g (groups Lexp-1 and LC-1) till 8,96 ± 0.220 g (group Lexp-2). Next, yolk dry matter has not undergone significant changes, so that at the end of laying (80th week), it was 9.56 ± 0.272 g in control LC-1, 9.57 ± 0.279 g in Lexp-1 and 9.58 ± 0.303 g in Lexp-2. Regarding the *protein content* of egg yolk, it was 2.65 to 2.90 g in control LC-1, 2.68 to 2.93 g in group Lexp-1 and 2.67 to2.90 g in group Lexp-2. The yolk *lipid content* was close between the three groups of experience. So for example, in the beginning of laying (20th week), amount of fat in the yolk was 5.97 ± 0.092 g LC-1, 5.96 ± 0.080 g in Lexp-1 and 5.95 ± 0.062 g in Lexp-2. In the next stage, the yolk lipids were close between groups, but have quantitatively increased, so that the control by the end of laying (80th week) revealed values of 6.66 ± 0.111 g in group LC-1, 6.64 ± 0.090 g in group Lexp-1 and 0.101 ± 6.65 g in group Lexp-2.

Experiment II. At the beginning of laying, *dry matter content* of the yolk was in a smaller amount (8.62 ÷ 8.65 g), but increased slightly in the next control period (8.95 to 8.99 g peak lay and lay plateau from 9.14 to 9.18 g), reaching at the end of laying the levels of 9.56 ÷ 9.61 g. Neither for *yolk protein content* were determined statistical differences between the two groups. Quantitatively, egg yolk proteins in LC-group varied between 2.65 ± 0.035 g-laying onset and 2.90 ± 0.050 g-laying ceasing, while in group Lexp-3, variation ranged from 2.66 ± 0.044 g-laying began and 2.92 ± 0.039 g-lay ending. *Lipid content* at the beginning of laying was 5.97 ± 0.092 g in group LC-1 and 5.99 ± 0.076 g in Lexp-3. In the next stage of control, limits of variation were significantly higher than in the previous phase, being of 6.18 to 6.20 g during peak and 6.30 to 6.32 g in laying plateau. At the end of laying, resulting values were somewhat higher (6.66 ± 0.111 g in group LC-1 and 6.69 ± 0.085 g in Lexp-3).

Experiment III. In the birds kept in intensive and semiintensive systems, the *dry matter* content of yolk did not differ from that of eggs obtained from birds superintensively raised in BP-3 battery; also they were not differences between the two groups and even less statistically significant differences. So for example, eggs from the control group LC-2 (permanent litter growth), the amount of yolk dry matter ranged between 9.31 ± 0.238 g-laying began and 9.85 ± 0.273 g-lay end, while in group Lexp-4 (permanent litter growth and access to outdoor paddock), the same component of egg yolk ranged from 9.38 ± 0.252 g-laying began and 9.94 ± 0.290 g-lay ending. *Protein content* of eggs yolks collected from the control group LC-2 ranged from 2.98 ± 0.027 g-laying onset till 3.13 ± 0.047 g-lay ending; at those obtained from Lexp-4 hens, the limits of variation ranged from 3.01 ± 0.024 g-laying beginning to 3.18 ± 0.042 g-lay ending. *Lipids content* at the beginning of laying was 6.33 ± 0.085 g in control group LC-2 and 6.37 ± 0.086 g in Lexp-4 group. In the next stage of scrutiny, this component quantitatively increased, but no marked differences occurred between groups. Thus, the in peak laying period, lipids were determined in an amount of 6.44 ÷ 6.46 g and during plateau in the amount of 6.58 ÷ 6.62

g. during the control run at the end of laying, the values determined were somewhat higher, being 6.72 ± 0.099 g in control eggs (LC-2 group) and 6.76 ± 0.100 g in the Lexp-4 group.

5.10. Albumen chemical composition

Experiment I. The *dry matter content of albumen* decreased in parallel with increasing egg weight. Thus, if the beginning of laying (20th week), quantity of albumen dry matter was 4.30 ± 0.133 g in control LC-1, 4.29 ± 0.149 g in group-1 Lexp and 4.31 ± 0.100 g in group Lexp-2; at the end of laying (80th week), this chemical constituient reached levels of 3.95 ± 0.115 g in LC-1, 3, 96 ± 0.124 g in the Lexp-1 and 3.97 ± 0.115 g in Lexp-2. The *protein content* of the white - following further tests carried out on eggs collected at the beginning of laying (20th week) the levels were of 3.42 ± 0.054 g in LC-1 group, of 0.44 ± 0.033 g in Lexp-1 group and of 3.43 ± 0.043 g in Lexp-3. In the next stage, it has increased, but not significantly, reaching finally lay to levels ranging from 3.49 ± 0.045 g (group LC-1) and 3.52 ± 0.053 g (group Lexp-2).

Experiment II. *Dry matter* content was higher in albument at the beginning of laying (4.30 ÷ 4.32 g), but decreased in parallel with age of birds, reaching finally lay to only 3.95 ± 0.115 g in LC-1 group and 3.99 ± 0.103 g in Lexp-3 group. *The protein content* was kept relatively uniform throughout the period and no statistically significant differences were found between groups. So for example, in the control group LC-1, protein level was: 3.42 ± 0.054 g at the beginning of laying, 3.45 ± 0.058 g in peak, 3.46 ± 0.050 g in plateau and 3.49 ± 0.045 at the end of laying, while in the experimental group Lexp-3, the measured values were: 3.43 ± 0.048 g at the beginning of laying, 3.47 ± 0.050 g at laying peak, of 3.48 ± 0.058 g in plateau and 3.51 ± 0.056 at the end of laying.

Experiment III. *Dry matter* content of the albumen in the eggs collected from birds kept in intensive and semi-intensive systems was higher at the beginning of laying (4.29 ÷ 4.30 g), but declined to the end production, at the birds reaching the end of lay at 4.07 to 4.09 g. Statistically, no differences were found between the two groups. The protein content was kept relatively uniform throughout the considered period, giving values of 3.44 ÷ 0.46 g - eggs collected at the beginning of laying, of 3.46 ÷ 3.49 g at the peak of lay, of 3.49 ÷ 3.51 g at the eggs obtained during the plateau and of 3.51 ÷ 3.54 g at the end of laying.

5.11. Shell chemical composition

Experiment I. On laying onset (20th week), amount of *minerals in shell eggs* analyzed was of 5.25 ± 0.174 g in control LC-1, of 5.27 ± 0.170 g in group Lexp-1, and of 5.28 ± 0.147 g in Lexp-2. In the next phases of the curve lay eggs increased in volume and hence, increased mineral shell surface, so, the control performed at the end of laying were recorded the highest amounts of minerals in shell egg, with limits between 6 53 ± 0.145 g (group LC-1) and 6.55 ± 0.195 g (group Lexp-2).

Experiment II. During laying onset (20th week) the quantity of *minerals in shell eggs* studied was 5.25 ± 0.174 g in group LC-1 and 5.30 ± 0.175 g in group Lexp-3. The peak of laying brought minerals shell values of 6.26 ± 0.185 g in group LC-1 and 6.32 ± 0.199 g in group Lexp-3; during the plateau they were of 6.38 ± 0.180 g in LC-1group and 6.45 ± 0.191 g in group Lexp-3. At the end of laying, there were found the highest amounts of mineral substances (6.53 ± 0.145 g in LC-1 and 6.64 ± 0.192 g in Lexp-3).

Experiment III. In the control group LC-2, the quantity of *minerals in shell* ranged between 5.45 ± 0.143 g (beginning of lay) and 8.11 ± 0.215 g (end of lay). In Lexp-4 group, with rearing in open paddock hall, the shell mineral content ranged from 5.67 ± 0.162 g-laying onset till 8.44 ± 0.283 g-laying end.

5.12. Shell microbial load

Experiment I. On the surface of the shell from the eggs harvested at laying onset there were found 112.78 ± 3.908 germs/cm^2 in LC-1, 110.49 ± 3.674 germs/cm^2 in Lexp-1 and

106.31 ± 3.420 germs/cm^2 in Lexp-2. Statistically significant differences were detected between groups Lexp-2 and Lc-1, Lexp-1 groups. In the peak of laying, the amount of germs found on each cm^2 of shell varied from 120.14 ± 3.374 (Lexp-2) to 125.96 ± 3.723 (LC-1). Significant statistical differences were also found between Lexp-2 and other groups, same situation occurring for the next period (plateau lay). The highest values for microbial load were determined at the end of laying (80th week) as follows: 152.61 ± 4.960 germs/cm^2 shell in group LC-1, 150.11 ± 5.320 germs/cm^2 in Lexp-1 and only 146.61 ± 4.984 germs/cm^2 in Lexp-2. Between group Lexp-2 and LC-1, Lexp-1 group statistically significant differences ocurred.

Experiment II. If on the eggs collected from hens kept in conventional battery cages (group LC-1), the number of germs on the shell eggs ranged from 112.78 ± 3.908 germs/cm^2 (beginning of lay) to 152.61 ± 4.960 germs/cm^2 (end of lay), in the experimental group Lexp-3 eggs, the microbial crust was much higher, ranging from 148.62 ± 6.100 germs/cm^2 (beginning of lay) till 258.94 ± 13.999 germs/cm^2 (end of lay). This development has generated very significant differences between groups.

Experiment III. Highest microbial load has been shown on those eggs from birds raised in the hall provided with permanent litter and access to the paddock (group Lexp-4) and especially by the end of productive cycle (179.39 ± 6.485 germs/cm^2 at the beginning of laying and 312.37 ± 11.321 germs/cm^2 in lay ending). In the group accommodated on permanent litter (LC-2), degree of contamination of shell eggs was lower, with limits between 172.24 ± 5.437 germs/cm^2 (beginning of lay) and 295.37 ± 10.705 germs/cm^2 (lay end). If statistically significant differences were found between the two groups in the beginning and peak of laying, the following control steps (plateau and finally lay) brought significantly distinct type differences between groups.

6. PARTIAL CONCLUSIONS

Din investigațiile efectuate au rezultat o serie de concluzii şi anume:
The investigations have resulted in a number of conclusions, namely:

Conclusions from Experiment I. *Body weight* of birds was within the standard curve of the "Lohmann Brown hybrid, but with some differences between groups, determined by the possibilities of movement they have benefited. *Eggs production* ranged between 316.32 eggs per bird (group Lexp-2) and 325.05 eggs per bird (group LC-1) and influenced *food consumption*; the best feed conversion rate (145.34 g / egg) was determined in birds from group LC-1 and the poorest one (155.35 g / egg) in group-2 Lexp. Instead, in the group with the largest area of the bird cage (Lexp-2), *the mortality rate* was only 8.22%, compared to 9.57- 11.66% in other groups. *Eggs weight* showed an ascending line from beginning to the end of lay, without being detected significant differences between groups. *Shell thickness* was negatively correlated with laying intensity; it was higher (0.358 ÷ 0.443 mm) in group with the lowest production of eggs (Lexp-2). Moreover, this group was recorded the best *resistance to egg shells cracking* (0.327 ÷ 0.343 kg f/cm^2). *Chemical constituents of yolk* showed no differences between groups and were not significantly changed from one control stage to another. Regarding the *chemical composition of the white*, it should be noted that no significant differences were found between groups, even if eggs collected from Lexp-2 were somehow at more dry matter and higher protein content. The *quantity of mineral salts in shell* did not differ significantly between groups. In Lexp-2, it was detected a *shell microbial load* lower with 4.25 to 6.47 germs/cm^2, compared to the other two groups.

Conclusions from Experiment II. *Weight of birds* was within the standard curve of the hybrid we used, while was somewhat lower in group Lexp-3 (with free access to the hall floor). *Eggs production* was lower, only 311.34 eggs per bird, while the *consumption of food* from that group was higher by 19.04 g / egg than the reference group (LC 1). Instead, the group with free access to the hall floor (Lexp-3) presented lower *mortality*, by 4.20%, compared to the control group LC-1, whose birds were reared in conventional batteries BP-3. *Eggs weight* increased from 46.98 to 46.78 g as was in initially lay at 68.51 to 68.50 g at the end of laying. *Mineral shell thickness* was greater in group Lexp-3 (0.369 ÷ 0.448 mm), as well as *the egg shell breaking strength* (0.337 ÷ 0.348 kg f/cm^2). *Chemical constituents of yolk* showed increasing values from one stage to another control, but no significant differences between the two groups. A similar situation occurred for *the chemical composition of the albumen*. *The quantity of mineral salts in shell* although not varied significantly between groups, was of 0.05 to 0.11 g higher in eggs collected from birds with free access in the hall (group Lexp-3). Lexp-3 birds have spent some time on the bed of the batteries, whose *degree of contamination* has increased over time, in addition, many chickens are laying directly on bedding, hence the secondary and higher germ load with 24.11 to 41.06% compared with LC-1.

Conclusions from Experiment III. *Weight of the birds*, although it was higher compared to early experiences of classical caged hens (LC-1) at the end of operation was 165.25 to 171.24 g in it. Amount of *produced eggs* was at 283.48 eggs per bird in group reared on peranent litter (Lc-2) and only 273.40 eggs per bird in group with access to outdoor paddock (Lexp-4). *Food consumption* was significantly lower than that achieved by birds in previous experiences, being 188.29 g / egg birds in the control group LC-2 and 200.38 g / egg in Lexp-4 group. In contrast, *the mortality rate* for birds in the group established access to the paddock (Lexp-4) was less than 0.14 to 4.30%, compared with the situation at all other groups of experience. *Eggs weight* ranged from 47.05 to 47.09 g, as was the beginning of laying and 67.61 to 67.82 at the end of laying. *Mineral shell thickness* was 0.008 to 0.025 mm greater in eggs obtained from birds in group Lexp-4, but without differences with statistical significance. Naturally, *shell breaking strength* was improved in the eggs laid by birds housed in the hall with access to the paddock (group Lexp-4), of 0.341 ÷ 0.330 kgf/cm^2, compared to 0.340 to 0.328 kgf/cm^2 in the control group LC-2. The *chemical composition of the yolk* did not show significant differences between the two groups, only *protein and fat* were somewhat higher in eggs obtained from the group with access to the paddock (Lexp-4). A similar situation was found in the *chemical composition of the white*, except that the eggs in group Lexp-4 had a higher *protein content*. The amount of *minerals in eggshells* in the birds with access to the paddock (group Lexp-4) was 3.88 to 3.91%, higher than that of eggs from group LC-2, hence the significant differences between the two groups. *Germ load of the shell* it was 3.98 to 5.44% higher in the birds raised in the hall with access to the paddock (group Lexp-4), than those accommodated in the hall with permanent litter (group Lc -2) due to degradation of litter over time. Between the two groups were found significant differences in the first two controls, respectively, distinct significant at last two.

Based on the above data, we recommend that, at least for the next period, to maintain superintensive system of rearing laying hens in Romania, in BP-3 batteries but with modified dimensional cage, to allow accommodation of a number of five chickens/3000 cm^2 cage (600 cm^2 cage/bird), which ensures close technical results to these specified by the hybrid potential.