Performance and behaviour of chickens with different growing rate reared according to the organic system

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ABSTRACT

The performance and the behaviour of three different chicken strains, reared according to the EEC-Regulation 1804/1999 on organic system, were compared. The strains had very slow (Robusta maculata), slow (Kabir) and fast (Ross) growing rates, respectively. The trial was carried out on 200 chickens (male and female) per strain. Rearing lasted 81 days as required by the EEC Regulation. At slaughter age, 20 birds per group were killed. Robusta maculata and Kabir chickens showed more intense walking activity and better foraging aptitude; their antioxidant capacity was also superior. Ross chickens had a good growth rate and feed conversion index, reaching an excellent body weight, but the mortality and the culling rate were high indicating that fast-growing strains do not adapt well to organic production. Robusta maculata showed the worst productive performance although the mortality was low and Kabir birds gave intermediate results. The carcass traits were the best in Ross and the poorest in Robusta maculata. Male chickens were heavier and leaner than females.

Key words: Chickens, Performance, Behaviour, Organic system

RIASSUNTO

PRESTAZIONI PRODUTTIVE E COMPORTAMENTO DI POLLI A DIVERSO RITMO DI CRESCITA ALLEVATI CON IL SISTEMA BIOLOGICO

Sono state valutate le prestazioni produttive e il comportamento di polli appartenenti a genotipi a lento (Robusta maculata) medio (Kabir) e rapido accrescimento (Ross) allevati con il sistema biologico. A tale scopo sono stati utilizzati 200 soggetti (maschi e femmine) per tipo genetico per un periodo di 81 giorni, macellando poi 20 soggetti per ceppo. I polli di Robusta maculata e Kabir hanno mostrato un’attività motoria più intensa ed una migliore attitudine al pascolamento; hanno inoltre presentato una capacità antiossidante superiore. I polli Ross hanno fornito un migliore indice di conversione alimentare e più elevati tassi di accrescimento, raggiungendo buoni pesi finali, ma elevati livelli di mortalità, tanto da ritenersi poco adatti per questo tipo di allevamento. La Robusta maculata ha mostrato le peggiori prestazioni produttive anche se la mortalità è stata molto bassa; il Kabir ha evidenziato risultati intermedi. Le caratteristiche della carcassa hanno evidenziato un andamento analogo. I maschi erano più pesanti e magri delle femmine.

Parole chiave: Pollo, Prestazioni produttive, Comportamento, Allevamento biologico.
Introduction

In Europe an increasing number of consumers are willing to pay higher prices for the guarantee of organically grown animal products (Bennet, 1996). The organic livestock system promises such guarantees due to the guidelines of EEC-Regulation 1804/1999 which provides specifications for housing conditions, nutrition, breeding and animal care, disease prevention and veterinary treatment.

In relation to the choice of breed the regulation states that “account must be taken of the capacity of animals to adapt to local conditions, their vitality, and their resistance to disease”. In addition, specific health problems associated with some breeds or strains used in intensive systems should be avoided and slow-growing animals are recommended for the potential better adaptation to the outdoor environment and to a long rearing period (at least 81 d).

Despite these specifications, the reality of strains that are suitable for organic or free-range conditions is very different. Most birds originate from commercial suppliers, who furnish chickens that have been selected for high growth rate and good feed conversion under intensive conditions (Reiter and Bessei, 1996). Obtaining slow-growing strains is difficult and expensive and, therefore, many breeders use strains that have been selected for rapid growth rate and low feed conversion and which are extensively used in intensive production. In the organic system these genotypes can show muscular-skeletal problems induced by increased motor activity.

However, there are some slow-growing strains that have been selected for this type of rearing (Katz, 1995; Saveur, 1997) as well as some pure breeds, more suitable for extensive conditions. By using the latter ones, their extinction could be avoided.

Few scientific studies exist on the adaptation of different strains to the organic production system. Grashorn (1999) investigated the performance and meat quality of several strains reared under intensive, semi-intensive and extensive systems and found a progressive reduction of performance in birds reared extensively. Farmer et al. (1997), in comparing Ross with ISA chickens reared under extensive system, found a faster body weight gain and a more efficient feed conversion ratio in Ross chickens that also showed lower motion activity and higher mortality.

So, the choice of a genotype requires attaining a balance between rusticity and productive performance, but it also depends on the final destination of the birds (integrated production, free market, restoration, etc).

The objective of this work was to compare behaviour, growing performance and carcass traits of three different chicken strains with different growth rates reared under organic system (EEC-Regulation 1804/1999).

Material and methods

Animals, housing and feeding

Six hundred 1-day-old chicks of both sexes from a very slow-growing (Robusta maculata), slow-growing (Kabir) and fast-growing (Ross 208) genotypes were reared separately (2 replications per sex and genotype) under a brooder lamp for the first 3 weeks of life on the experimental farm of the Animal Production Department (University of Perugia). The environmental temperature ranged from 20 °C to 25 °C and the relative humidity from 65 to 75%. Incandescent lamps (30 lux) placed at bird level were used for illumination. Chicks were vaccinated against Mareks and Newcastle disease and coccidiosis (Paracox®-8).

After 21 days of age the birds of each strain were put in 4 covered shelters (2 replications per sex) (0.10 m²/bird) with straw litter and access to a grass paddock (4 m²/bird); feeders and drinkers were available both outdoors and indoors.

The trial was carried out from April to June 2002.

Chickens were fed ad libitum the same starter (1-21 d) and finisher (22 d to slaughter) diets, containing more than 80% certified organic ingredients, bought from a national agency. Characteristics of the diets are presented in Table 1.

Individual body weights were recorded weekly, as well as the collective feed intake of each subgroup. The average feed consumption of the group was used to calculate the individual feed:gain
PERFORMANCE AND BEHAVIOUR OF ORGANIC CHICKENS

The number of culled and dead birds was recorded and animals were sent to the Istituto Zooprofilattico Sperimentale Umbria e Marche for diagnosis.

At 81 days, a sample of 20 birds per strain (10 males and 10 females), each weighing between ±10% of the population mean, were slaughtered in the Department processing plant, 12 hours after feed withdrawal. Chickens were not transported and were electrically stunned (110 V; 350 Hz) before killing.

Grass samples were taken from 1 m² of paddock by cutting it at 3 cm above the ground for chemical analysis.

Table 1. Formulation (%), chemical composition (% d.m.) and energetic value (MJ kg⁻¹) of the diets.

| Ingredients          | Starter | Finisher | Grass |
|----------------------|---------|----------|-------|
| Maize                | 52.0    | 46.0     |       |
| Full fat soybean     | 30.5    | 12.5     |       |
| Wheat                | -       | 20.0     |       |
| Soybean meal*        | 9.0     | 14.0     |       |
| Alfalfa meal         | 2.8     | 2.8      |       |
| Gluten feed          | 3.0     | 2.0      |       |
| Vitamin-mineral premix**(1) | 1.0 | 1.0     |       |
| Dicalcium phosphate  | 1.0     | 1.0      |       |
| Sodium bicarbonate   | 0.5     | 0.5      |       |
| NaCl                 | 0.2     | 0.2      |       |
| Dry matter           | 90.89   | 90.80    | 25.30 |
| Crude protein        | 22.30   | 18.05    | 13.28 |
| Ether extract        | 7.95    | 4.98     | 5.88  |
| Crude fibre          | 4.67    | 4.01     | 23.25 |
| Ash                  | 5.76    | 5.59     | 7.86  |
| NDF - Neutral Detergent Fibre | 10.74 | 10.11   | 43.28 |
| ADF - Acid Detergent Fibre | 5.58 | 5.06    | 31.23 |
| Cellulose            | 4.22    | 3.56     | 26.41 |
| ADL - Acid Detergent Lignin | 1.03 | 1.11    | 4.82  |
| Hemicellulose        | 5.16    | 5.05     | 12.06 |
| Metabolisable Energy*| 12.54   | 12.98    | 5.78  |

Carotenoids mg (kg d.m.)⁻¹ | 18.31   | 102.10   |
α-tocopherol mg (kg d.m.)⁻¹ | 35.52   | 175.25   |

**(1) From conventional crops.
**(2) Amounts per kg: Vit. A 11.000 IU; Vit. D; 2.000 IU; Vit. B; 2.5 mg; Vit. B; 4 mg; Vit. B; 1.25 mg; Vit. B; 0.01 mg; α-tocopheryl acetate 30 mg; Biotin 0.06 mg; Vit. K 2.5 mg; Niacin 15 mg; Folic acid 0.30 mg; Pantothenic acid 10 mg; Choline chloride 600 mg; Mn 60 mg; Fe 50 mg; Zn 15 mg; I 0.5 mg; Co 0.5 mg.

* estimated by Carre and Rozo (1990).

Blood sample collection, analytical determinations and carcass dissection

Immediately before slaughter, blood samples were collected in heparinized vacutainers and centrifuged at 1,500 x g for 10 min at + 4 °C, to measure the in vivo antioxidant capacity by the Oxyadsorbent test produced by Diancron ® s.r.l. (Italy) (Cesarone et al., 1999).

After killing, carcasses were plucked, eviscerated (non-edible viscera: intestines, proventriculus, gall bladder, spleen, oesophagus and full crop) and
stored for 24 hours at +4 °C. Head, neck, legs, edible viscera (heart, liver, gizzard), and fat (perivisceral, perineal and abdominal) were removed in order to obtain the ready-to-cook carcass (ASPA, 1996).

The content of the crop without the grit was weighed and analysed to compare the feeding behaviour of the strains.

Chemical analyses of diet, grass and crop contents and carotenoids of the diet and grass were done according to the AOAC methods (1995); the metabolisable energy was estimated with the equation of Carre and Rozo (1990).

Alpha-tocopherol in the diet, grass and crop contents was extracted with diethylic-petrol ether (2:1) on 5 g of samples saponified with ethanol and KOH (50%). The homogenate was centrifuged (1,630 x g, 10 min) and the supernatant was transferred to a large test tube and dried to 0.5 ml under N2 at 30-40 °C. The pellet was re-extracted two more times with 20 vol of acetone and centrifuged. All supernatant fractions were combined and reduced to less than 1 ml under N2 at 30-40 °C. The pellet was then injected into the HPLC (Zaspel and Csallany, 1983).

Breast conformation was measured as follows: the maximal breast width and length were measured with a callipers, whereas the thickness was evaluated by inserting a metal needle in the fourth anterior of the sternum. Successively, the breast muscles and the thigh and drumstick (bone and meat) were excised to calculate the breast meat yield, the thigh and drumstick weight and the meat/bone ratio.

Statistical analyses
Data were analysed with a linear model (SAS/STAT, 1990 - procedure GLM) and the significance of differences was evaluated by t-test. The effect of strain only was included in the analysis of the behavioural observations and crop contents, whereas for the productive performance and carcass data, the sex effect and interaction were also included in the model.

Differences in culling and mortality rates were evaluated by X2 (Procedure FREQ).

Results and discussion
The chemical composition of the diet and of the grass samples are reported in Table 1. The grass had a high amount of carotenoids (102.10 mg kg d.m.-1) and a-tocopherol (175.25 mg kg d.m.-1). The a-tocopherol content is in agreement with the results of Lopez-Bote et al. (1998a) and is relatively higher than the recommendation for broiler diets (NRC, 1994).

Robusta maculata and Kabir chickens showed more active behaviour (Table 2), with more walking, less lying and more interest in the observer (P<0.05), and they spent more time outdoors than...
indoors (P<0.05). These genotypes showed a quicker reaction (P<0.05) in the tonic immobility test confirming the statement of Bryan-Jones (1996), who found that selecting for increased productivity did not result in the elimination of fear and stress behaviour.

In comparing the behaviour of a slow-growing with a fast-growing type, both reared under extensive conditions, Lewis et al. (1997) observed that the slow-growing strain was more active. As indicated by Schütz and Jensen (2001), selection for high production rates results in modified behaviour. Behaviour involving high energetic costs is less recurrent in selected strains, allowing them to save energy that can be reallocated to production traits.

Weeks et al. (1994) compared the behaviour of Ross broilers reared under free-range or kept inside and showed that free-range birds made little use of pasture and tended to stay indoors and/or near the house, rather than forage in the pasture. The authors attributed this behaviour mainly to leg weakness, which prevented the birds from pasturing and behaving naturally.

The differences in foraging behaviour agree with the statement of Appleby et al. (1992), who reported that free-range conditions allow poultry, mainly from slow growing strains, to express not

### Table 3. Comparison between chemical composition of the crop contents in the three strains and in vivo antioxidant capacity at 81d.

| Strain            | Kabir | Ross | Robusta maculata | SEM |
|-------------------|-------|------|------------------|-----|
| Crude protein     | %     | 10.4a| 12.4b            | 10.0a| 2.4 |
| Ether extract     |       | 3.0  | 3.5              | 2.9  | 1.1 |
| NDF               |       | 10.0 | 9.8              | 10.2 | 1.8 |
| ADF               |       | 6.2  | 5.7              | 6.3  | 0.9 |
| Estimated Metabolisable Energy | MJ kg⁻¹ | 7.6ab | 8.7b | 6.7a | 2.3 |
| Carotenoids       | mg kg⁻¹| 20.2b | 19.1a | 21.2b | 1.6 |
| a-tocopherol      |       | 38.0b| 36.2a            | 38.5b| 2.6 |
| Antioxidant capacity | µmol HClO ml⁻¹ | 700B | 522A | 715B | 58 |

N=20 per strain. Means within rows bearing different superscript (A..B; a..b) differ significantly at P<0.01 and P<0.05.

### Table 4. Performance of broilers at 81d.

| Strain            | Kabir | Ross | Robusta maculata | P | SEM |
|-------------------|-------|------|------------------|---|-----|
| Sex               |       |      |                  |   |     |
| Live weight (LW)  | g     | 2,150| 2,372            | 2,942| 3,590| 1,540| 1,670| ** | ** | 121 |
| Feed intake(1)    | g/d   | 88.6 | 101.5            | 112.6| 139.1| 66.5 | 73.9 | ** | ** | 11.8 |
| Daily gain        | "     | 26.2 | 28.9             | 35.8 | 43.8 | 18.7 | 20.2 | ** | ** | 5.8 |
| Feed to gain ratio(1) |       | 3.3  | 3.3              | 3.1  | 3.0  | 3.4  | 3.5  | n.s.| *  | 0.2 |
| Culled birds      | %     | 0 0  | 3.0              | 5.0  | 0 0  | **  | *   | 3.2(2) |
| Mortality         | %     | 4.0  | 5.0              | 9.0  | 10.0| 4.0  | 4.0  | n.s.| ** | 5.8(2) |

N=100 for each strain/sex. (1) 12 replications ** = P<0.01; * = P<0.05.

(2) X² value
Figure 1. Trend of body weight and daily weight gain in the three strains (female).

Solid line = body weight; dotted line = weight gain.
K = Kabir; R = Ross; RM = Robusta maculata.

Figure 2. Trend of body weight and daily weight gain in the three strains (male).

Solid line = body weight; dotted line = weight gain.
K = Kabir; R = Ross; RM = Robusta maculata.
only species-specific behaviour, but also their innate ability to provide for their own nutritional requirements.

Although it is difficult to estimate chick ingestion, because the more fibrous particles tend to move more slowly toward the proventriculus and gizzard, the comparative analysis of the crop contents showed a different feeding behaviour among strains (Table 3). In particular the crop contents of Robusta maculata and Kabir chickens had less protein and energy and higher amounts of α-tocopherol and carotenoids, indicating higher grass ingestion.

The higher antioxidant capacity (P<0.01) of the two slow-growing genotypes, resulted from the higher antioxidant intake (α-tocopherol, carotenoids, etc.), the greater locomotory activity and the slower rate of maturing. It is known that late maturity delays the transformation from oxidative to glycolytic muscle metabolism, and that locomotory activity increases the number of mitochondria in α-W fibres and hence turns them into α-R fibres in all animal species, (Ouhayoun and Dalle Zotte, 1993). Greater oxidative processes increase free-radical production and the animal develops a more efficient mechanism for controlling them (Alessio, 2000).

Throughout the experiment, the body weights of the three genotypes were markedly different in the two sexes (Figures 1 and 2), and these differences increased with age. All strains showed a reduction in daily weight gain at 4 weeks that coincided with being moved to the outdoor paddock.

As expected, the growth rate of the Ross strain was much higher than that of Kabir and especially of the Robusta maculata until 9-10 weeks of age. Thereafter, the daily gains of the Ross genotype dropped and the three genotypes had a similar growth rate.

At 81 days of age, the Ross broilers of both sexes reached their highest body weights (Table 4) with a satisfactory feed/gain ratio, and high culling and mortality rates, confirming previous findings (Castellini et al., 2002a). Mortality was mainly due to ascites (50 % of total: data not shown) and to sudden death syndrome (10%).

All culled birds had leg problems, which prevented normal movement. Arthritis with acute inflammation in several joints was diagnosed.

Table 5. Carcass traits of broilers at 81 d.

| Strain          | Kabir  | Ross  | Robusta maculata | P     | SEM |
|-----------------|--------|-------|------------------|-------|-----|
|                 | F  | M  | F  | M  | F  | M  |     |     |
| LW/adult LW     |   |    |    |    |    |    |     |     |
| %               |  48.8| 47.4| 64.1| 66.4| 41.6| 39.7|      |      |
| Ready-to-cook-carcass | 1,392| 1,541| 2,062| 2,513| 981| 1,068| ** | **  |
| g               |     |    | 2,062| 2,513| 981| 1,068|      |      |
| Ready-to-cook-carcass | 64.7| 64.8| 70.1| 70.0| 63.9| 64.0| n.s.| 6.4  |
| %              |     |     |     |     |     |     |      |      |
| Empty gastrointestinal tract | 5.9| 5.9| 5.6| 5.5| 6.8| 6.7| n.s. | 1.1  |
| "              |     |     |     |     |     |     |      |      |
| Gastrointestinal content | 5.1| 5.1| 4.7| 4.7| 5.6| 5.6| n.s. | 1.0  |
| "              |     |     |     |     |     |     |      |      |
| Abdominal fat   | 1.1| 1.0| 1.6| 1.1| 0.3| 0.2| *   | 0.5  |
| "              |     |     |     |     |     |     |      |      |
| Breast meat yield | 20.2| 20.8| 25.0| 25.6| 11.8| 12.0| n.s. | 5.0  |
| % carcass       |     |     |     |     |     |     |      |      |
| Breast width    | 11.0| 11.0| 13.9| 14.5| 5.9| 6.0| n.s. | 4.3  |
| cm             |     |     |     |     |     |     |      |      |
| Breast layer thickness | 2.2| 2.2| 2.4| 2.5| 1.7| 1.8| n.s. | 1.2  |
| "              |     |     |     |     |     |     |      |      |
| Breast bone length | 15.8| 15.9| 14.0| 15.8| 8.9| 9.3| n.s. | 4.7  |
| % carcass       | 17.1| 17.1| 20.2| 21.0| 17.6| 18.3| n.s. |      |
| Thigh          |     |     |     |     |     |     |      |      |
| Drumstick      | 16.0| 16.1| 15.1| 15.3| 16.5| 16.7| n.s. | 2.5  |
| Meat to bone ratio | 3.2| 3.3| 3.4| 3.4| 2.9| 2.9| n.s. | 0.6  |

N = 10 for each strain/sex.  
** = P<0.01;  * = P<0.05.
whereas no specific infectious diseases were observed throughout the trial. The reasons for such a high culling rate were probably due to the excessive weight of the birds as already postulated by Jones and Hocking (1999). Weeks et al (1994) showed that about 80% of the Ross birds had gait abnormality at the 7th week of age. With age and increasing live weight, the leg joints of these animals are excessively stressed and lameness, ascites and other related problems increase (Network For Animal Health And Welfare In Organic Agriculture, 2002).

Beside leg weakness, some authors (Qureshi et al., 1998; Rauw et al., 1998; Yunis et al., 2000; Thiele, 2001) have reported that selection for rapid growth reduces the immune-competence and increases the susceptibility to environmental stresses.

The body weight of Robusta maculata broilers was less than 2 kg, which is the minimum marketable weight for organic products (Saveur, 1997), and they had a higher (P<0.01) feed/gain ratio than the Ross. Kabir chick performance was in between that of the other two strains.

According to the objectives reported in the Ross manual (Ross Breeders, 1999), the performance of the free-range reared birds is generally about 25% lower than it would be under intensive conditions. It is evident that fast-growing birds do not perform well under poor environmental conditions, whereas intensive rearing provides them with what is needed to cover all of their physiological needs (Reiter and Bessei, 1996). Besides the poorer environment and the intake of grass it should be pointed out that the dietary requirements of the fast-growing strains from 8 to 12 weeks are unknown and it is possible that they are inadequate to support normal growth and survival at that age.

The carcass traits reported in Table 5 show that the characteristics of the carcass (weight, breast, abdominal fat and meat:bone ratio) were significantly lower (P<0.01) in Robusta maculata broilers than in the Ross broilers. Kabir chickens had intermediate values. The ready-to-cook carcass yield was significantly higher in Ross chickens (P<0.05) presumably due to the lower percentage of digestive tract which in turn was due to the reduced grass ingestion.

Male chickens were heavier and leaner than females.

The proportion of drumstick was greater in both Robusta maculata and Kabir chickens when compared to the Ross (P<0.05).

Conclusions

Modern meat-type poultry have been intensively selected for growth rate and feed conversion. As such these strains grow very rapidly and behave very differently with respect to the less intensely selected strains. Such birds may not adapt well to organic growing conditions, as they exhibit leg problems and increased mortality.

Slow-growing genotypes have greater locomotory activity and pasture aptitude and a higher resistance to the poorer conditions of the organic system than the faster-growing hybrids.

The final recommendations of the Network for Animal Health and Welfare in Organic Agriculture (2002) suggest that in order to reduce the likelihood of welfare problems the use of commercial breeds should be avoided, unless they have been tested and shown to work under organic conditions.

On the contrary chickens with a slower growing rate and, therefore a history of less growth rate selection, express more “natural” behavioural patterns, and should probably be used for extensive production systems. However, strains with excessively low growth rates, like the Robusta maculata, require a very long rearing time (until 120 d - Castellini et al., 2002b), resulting in very high production costs. It is clear that such strains would require a special market niche even with an organic label (DOP, tourism etc).

The position of pure breeds as an organic product could be strengthened if future research would show their ability to perform with lower quality feed, and to produce meat with well-differentiated qualitative characteristics. Since the meat obtained from the organic system has a lower oxidative stability (Castellini et al., 2002), a higher intake of antioxidants improves the shelf-life of the products (Lopez-Bote et al., 1988).

The Kabir strain appears to be a genotype that shows suitable adaptation to the organic system.
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