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Do Broilers Prefer to Eat from a Certain Type of Feeder?

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ABSTRACT

This study compared three types of feeders for broilers: Fênix, Tube and Automatic feeders. Bird's feeding behavior and preference were considered in this the evaluation. Preference was assessed by examining birds' behavioral activities, such as eating, standing and lying around the equipments, and meal duration as function of the environmental variables. Data on the behavioral activities and meal size were collected in a broiler commercial farm using a portable video camera, and the direct footages were analyzed. The time spent in each activity, feeding bout duration and time spent near the trough were statistically analyzed using the test of means and medians. Pearson's correlation test was used to evaluate the relationship between ambient environmental data and the time of feeding. A prospective scenario was established and data were pair wised compared to it. There were interactions between environmental characteristics and feeding and lying down activities during the experiment. Eating behavior was more frequent in the area around the Tube feeder. The duration of feeding time was higher when the birds used the Tube feeder (214 ± 28s), followed by the use of the Fênix feeder (123 ± 17s) and the Automatic feeder (77 ± 29s). Birds preferred eating from the Tube feeder probably due to the absence of the partition grid above the feeder plate.

INTRODUCTION

Recent progress in the broiler industry relies in the development of genetics, nutrition, health, and management (Murakami *et al*., 1995). Several studies and proposals have been made to optimize management, including ideal flock density and rearing environment (Lucchese Filho, 1997; Simon, 1997; Goldflus *et al*., 1997; Lana *et al*., 2001; Mortari *et al*., 2002; Pereira *et al*., 2007).

The feeding behavior of broilers has been studied in relation to feed type (Harlander-Matauschek & Häuler, 2009), feed restriction (Savory & Kostal, 2006), different diet types (Siegel *et al*., 1997; Emmans & Kyriazikis, 2001; Bouvarel *et al*., 2008), and the nature of bouts (Nielsen *et al*., 1995; Yo *et al*., 1997; Picard *et al*., 2002). Also the feeding event criteria and its interpretation with respect to feeding bout intervals have been discussed by authors that tried to estimate specific levels of hunger and animal welfare (Slater, 1974; Berdoy, 1993; Nielsen, 1999; Keeling, 2002). However, there is a lack of information on how those variables interact, particularly under specific rearing environmental conditions.

Bigelow & Houpt (1988) advocate that the feeding behavior needed to be better understood and assessed in order to compare results from different research studies. A feeding bout is an estimation of the period of time during which a meal occurs. It can be grouped in several bouts and standardized allowing comparison between different experiments

(Berdoy, 1993). Several techniques have been used to register bird's behavior during feeding, such as direct and videotaped observations as well as beak movement recording (Sowell *et al*., 1998; Bley & Bessei, 2008). Although the observation of feeding behavior is relatively simple, the precise determination of meal size and modeling its frequency and interval is a rather difficult task. Howie *et al*. (2009) discussed the statistical distribution of feeding events and developed a new methodology to estimate feeding bouts when it is not possible to monitor or to identify the proper intervals between visits to the trough (Yeatles *et al*., 2001).

The Fênix feeder (Inova, 2008) is a manual feeder for broiler developed by Neves & Trevisan (2007) and it is still in testing and simulation phase, one being the present study. This equipment presents various innovations in relation to manual feeders commercialized nowadays, especially in terms of handling and ergonomics, allowing its throughout the growth phase, avoiding the use of a specific feeder for the chicks in the initial phase. This feeder has a partition grid above the plate for the growing and final phase, but it can be removed for use in the first days of rearing, allowing easy access to the ration for the chicks. The objective of the present study was to identify the preference of broilers to eat from a certain type of feeder by comparing three types of feeders: conventional Tube (T) and Automatic (A) feeders and a newly developed product called Fênix (F). The interaction of feeding with behavioral activities associated with specific rearing environmental conditions was observed, and meal length and frequency were determined.

MATERIALS AND METHODS

The experiment was carried out in an integrated broiler farm located at latitude 22° 26' S and longitude 47° 32'W. Local altitude is 635m and the climate is characterized by having dry winter and hot and wet summer. The trial was conducted during July, 2009. The studied broiler house was open-sided with East-West solar orientation, and it was 100m long, 8.5m wide and 2.8m high. It housed 14,000 Ross® broilers at a stocking density of 16 birds m-2. Manual chick feeders were used during the starter phase and Tube feeders combined with one line of automatic feeders placed in the center of the house was used during the grower and finisher phases. Water was supplied in bell-type drinkers. The house used circulation fans and low-pressure foggers to control heat stress. Polypropylene curtains on the side walls controlled excessive natural ventilation, sunlight incidence, and the entrance of rain. The concrete floor was covered by Pinus wood-shavings litter.

Feeder characteristics

Three types of feeders were used in this study: Fênix manual feeder (F), which was recently developed and still not commercially available; conventional Tube manual feeders (T) of a local brand and used during the grower-finisher phase; and automatic feeders (A), also of a local brand and used during the grower-finisher phase. Both Fênix and Automatic feeders had a grid partition attached to the trough. The Fênix feeder was setup before of the arrival of the batch. Their dimensions are shown in Table 1.

Experimental procedure

Video images were recorded using two simultaneous cameras in a pair-wise comparison between the feeders. The following comparisons were made: Fênix (F1) *versus* Tube (T1) feeders, and Fênix (F2) *versus* Automatic (A2) feeders. Both F1 and F2 are the same Fênix feeder, but in distinct comparisons (different times). Recording were made for about 55min twice daily, one in the morning (9h00min - 12h00min) and the other in the afternoon (13h00min - 16h00min). However, only 45min were used for analysis as the first 10 min were not used to account for human interference on bird behavior during video camera setup. In general, 24 video footages were done in pairs, with a total of 48 footages. The cameras were attached to a metal holder to allow recording birds' activities around the feeders from the top, and the feeders were placed in the center of the recorded area (1.0m by 1.5m), below the video camera. Images were

Table 1 - Dimensions of the tested feeders and partition grid characteristics.

Feeder	External dimensions (m)		Partition grid (m)		
	Height	Diameter	Length*	Width**	Quantity
Fênix	0.70	0.36	0.085	0.035	9
Tube	0.60	0.42	NA	NA	NA
Automatic	0.25	0.33	0.060	0.140	14

*Refers to the horizontal distance of the partition grid. **Refers to the vertical distance of the partition grid. NA = Does not apply.

Table 2 - Total number (a) and percentage (b) of birds performing each behavioral activity according pair-wise comparison of Fênix (F1) *versus* Tube (T1) and Fênix (F2)*versus* Automatic (A2).

	Behavioral activities						
Data type	Feeder type	Eating	p-Value	Standing up	p-Value	Lying down	p-Value
a	F1	6.77 ± 0.34	0.000*	1.42 ± 020	0.05*	6.95 ± 0.74	0.005*
	T1	8.94 ± 0.38		1.29 ± 0.23		4.61 ± 0.36	
	F2	5.77 ± 0.24	0.000*	1.26 ± 0.13	0.001*	7.15 ± 0.68	0.000*
	A2	3.75 ± 0.29		0.70 ± 0.10		1.68 ± 0.17	
b	F1	49.7 ± 2.4	0.002*	11.4 ± 1.7	NS	38.0 ± 2.4	0.004*
	T1	60.0 ± 2.2		10.6 ± 2.0		29.4 ± 1.6	
	F2	46.0 ± 2.0	0.004*	10.8 ± 1.1	0.001*	43.2 ± 2.6	0.002*
	A2	56.8 ± 3.1		12.4 ±1.6		30.8 ± 3.1	

Student t-test. Data expressed as mean ± standard error. *p-Value < 0.05; NS = not significant.

digitalized using the VOB extension (DVD/video). The actual area used for analysis was a circle of 0.9m diameter surrounding the feeder, which was virtually marked in the video images.

Environmental data (temperature, relative humidity and light intensity) were recorded using a Hobo® data logger placed 0.30m above the floor between the pair feeders analyzed. The data logger was set to record data every 30s, allowing simultaneous recording of video image and environmental variables. Both internal and external air speed were recorded twice daily simultaneously to video recording using a HTA 4200® apparatus, been one in the morning e other in the afternoon. Birds were submitted to standard farm management during the trial.

The following behaviors were analyzed based on video image data as follows: (1) three types of behavioral activities in the determined area around the feeders - eating, standing and lying down; (2) birds were randomly selected and followed to determine meal time. In order to analyze behavioral activities, the three previously described behaviors happening during 10s were quantified every 5min of video recording, in a total of nine events per video recording (45min each). The activity of feeding was characterized as the bird placing its beak inside the feeder. The bird was standing up when it was exploring the area around the feeder, either slowly walking or standing still. Birds were considered to be lying down when resting on the floor. Meal time started to be counted when the bird placed its beak inside the feeder (start of the bout) and stopped when it moved away from the feeder (end of the bout). If it stopped eating for less than 20s and returns to eating, the same bout was considered.

The pullet manual feeders and the Fênix feeder (without grid partition) were used during the first days of rearing. Later, pullet feeders were replaced by Tube feeders, and the partition grid was connected to the Fênix feeder plate. The Automatic feeders were turned on in the third week. From that moment on, birds had access to all feeders, prior to the beginning of the test. The trial was conducted during the steepest segment of the genetic strain growth curve, which corresponded to the interval of approximately 17 to 24 days of age (Goliomytis *et al*., 2003).

Data analyses

Tests of means and medians were used to statistically analyze the data and significance was considered when $\alpha \geq 95\%$. Data were processed using the software MINITAB® 15.1 (Minitab, 2005).

Behavioral activities were analyzed by pair-wise comparison between Fênix and Tube feeders and between Fênix and Automatic feeders. Descriptive analysis (mean and standard error) was used. In specific cases, the percentage of birds as function of the total number of birds present in the studied perimeter was used for analysis. Student's t-test was applied for comparative analysis, and Pearson's correlation was used when interactions among period of the day, age and environmental variables were determined. Two environmental temperature limits were considered in the interactions: L1 = $17 \leq T$ (°C) ≤ 22; L2 = $2 < T$ (°C) ≤ 26) defined according to the data recorded during the experiment.

Meal time (MT) was also analyzed using pair-wise comparison between as Fênix (F1) *versus* Tube (T1) feeders and Fênix (F2) *versus* Automatic (A2). It was also analyzed for each individual feeder (F, T, and A), using data median for descriptive analysis. Mann-Whitney test was used to compare treatments. The possible interactions between environmental data, age, and period of the day with the behavioral response of the birds was analyzed within the following temperature limits: L1 = $17 \leq T$ (°C) ≤ 22; L2 = $2 < T$ (°C) ≤ 26, defined according to the variation of collected data and as function of the time lag [1 = 0 < MT (s) < 100; 2 = 100 < MT (s) < 200; 3 = 201 < MT (s) < 300; 4 = MT (s) < 300].

RESULTS AND DISCUSSION

Results are organized into two sections: behavioral activity analysis and the time the birds spent eating at the feeder.

Behavioral activities

The Student t-test results of the pair-wise comparison relative to behavioral activities are shown in Table 2. The same test was applied for the percentage of the birds performing each observed activity (Table 3). There were significant differences ($P < 0.05$) among the behaviors of eating, standing up, and lying down in the area around the feeders. The number of birds eating around the Tube feeders (T1) was higher as compared to the other feeders, whereas the lowest number was recorded around the Automatic (A2) feeders. Standing up was not significantly different among feeders according to the pair-wise comparison, while the lying-down behavior was higher at the Fênix feeder in both trials (F1 and F2) as compared to the other two feeders.

When analyzing the period of the day (morning and afternoon), eating near the Tube feeder (T1) tended to be higher during the afternoon. At the same feeder, a high incidence of the birds standing up in the morning was observed (Table 3). A clear trend of a higher number of birds lying down around the Fênix feeder (F1) was recorded in the afternoon.

There were significant differences among the tested feeders as to the standing activity, despite the observed low frequencies of this behavior. However, it is not clear if these differences can be associated to the type of studied feeders; rather, it is suggested in literature that this may be related to locomotion disorders (Sherwin, 1995; Koene, 1998; Sherwin, 1999; Fiscus Le Van *et al*. 2000; Martrenchar *et al*., 2000; Pettit-Riley and Esteves, 2001). Leg weakness may prevent the expression of natural behavior of chickens to explore the environment and look for food.

The difference in the way animals feed themselves is highly influenced by the design (size, geometry, angle and spacing) and allocation of the equipments (Hyun *et al*., 1998; Hyun & Ellis, 2002; Wolter *et al*., 2009). The social hierarchy in large groups also tends to establish an order of access to feeding, as shown by Pagel & Dawkins (1997). Nevertheless, in the third and forth weeks of growth, birds are still young and probably do not show much aggression when disputing feed.

The interactions among activity frequencies at the Fênix feeder (F1) and the Tube feeder (T1), as well as feeding and lying down percentages with environmental variables are shown in Table 4a. The same analysis for Fênix feeder (F2) and Automatic feeder (A2) is presented in Table 4b. Person's correlation was calculated in order to evaluate the relationship between environmental variables and behavioral activity percentages, differentiating feeder type and broiler age (third and fourth week). In this specific case (Table 5), Pearson's correlation results show the influence of environmental variables (temperature, light intensity, and relative humidity) on behavioral activities. The obtained results suggest that environmental variables influence broiler activity as a function of age (Table 4a,b). Different interactions between environmental data with eating and lying-down activities when birds were three or four weeks old were found. The most significant interactions obtained were between relative humidity and eating at the Fênix feeder (F1) and Tube feeder (T1) during the third week of rearing (RH= 69.4 ± 19.6 %), and between environmental temperature and eating and lying-down at Automatic feeder (A2) during the fourth week of rearing (T= 23.7 ± 1.5°C).

The minimum influence of thermal environment and the adoption of specific diets in rapid growth broilers are reported as the best ways to improve field performance (Jaenisch, 1998; Vieira *et al*., 2004; Kidd *et al*., 2005). Cahaner *et al*. (1995) suggest that fast-

Table 3 - Total number of birds exerting each behavioral activity as determined by pair-wise comparison of Fênix (F1) *versus* Tube (T1) and Fênix (F2) *versus* Automatic (A2) feeders as a function of periods of the day (morning and afternoon).

	Behavioral activity						
Feeder type	Period	Eating	p-Value	Standing up	p-Value	Lying down	p-Value
F1	morning	6.17 ± 0.56	NS	1.65 ± 0.32	NS	5.11 ± 0.66	0.013*
	afternoon	7.37 ± 0.40		1.19 ± 0.23		8.80 ± 1.3	
T1	morning	8.11 ± 0.64	0.032*	1.93 ± 0.42	0.005*	5.04 ± 0.55	NS
	afternoon	9.76 ± 0.61		0.65 ± 0.11		4.19 ± 0.46	
F2	morning	5.43 ± 0.32	NS	1.30 ± 0.18	NS	7.54 ± 1.2	NS
	afternoon	6.11 ± 0.36		1.22 ± 0.18		6.76 ± 0.58	
A2	morning	3.39 ± 0.40	NS	0.83 ± 0.13	NS	1.63 ± 0.22	NS
	afternoon	4.11 ± 0.41		0.57 ± 0.15		1.72 ± 0.25	

Student t-test. Data expressed as mean value ± standard error. *p-value < 0.05; NS = not significant.

Table 4 - Quantity (a) and percentage (b) of eating and lying down activities according to pair-wise comparison of Fênix *versus* Tube feeders and Fênix *versus* Automatic feeders as a function of rearing age and environmental variables.

			Feeder type				Environmental variables				
			Fênix		Tube						
Week	Day	Data	Eating	Lying down	Eating	Lying down	T (°C)	L (lx)	RH (%)	Iav (m s-1)	Eav (m s-1)
3rd	17	a	4.61 ± 0.82	13.44 ± 3.08	6.89 ± 1.60	1.33 ± 0.32	22.4 ± 1.3	725 ± 181	58.8 ± 5.3	0.31	1.90
		b	21.28 ± 3.45	49.47 ± 6.32	46.38 ± 9.77	11.72 ± 3.22					
	18	a	5.78 ± 0.77	0.78 ± 0.26	7.89 ± 0.84	4.67 ± 1.15	18.1 ± 0.2	61 ± 3	78.4 ± 1.8	0.00	1.93
		b	68.06 ± 6.41	8.04 ± 2.49	62.26 ± 4.88	32.21 ± 4.14					
	20	a	8.56 ± 0.82	4.33 ± 0.57	10.61 ± 0.76	6.89 ± 1.13	23.4 ± 0.9	84 ± 16	72.6 ± 0.9	0.35	1.28
		b	65.01 ± 3.62	32.39 ± 3.39	59.84 ± 3.53	35.98 ± 3.31					
	21	a	8.17 ± 0.85	3.39 ± 0.54	9.22 ± 0.75	4.61 ± 0.70	24.4 ± 0.5	503 ± 66	67.9 ± 2.5	0.19	1.22
		b	64.31 ± 4.09	27.65 ± 3.92	64.81 ± 3.79	30.75 ± 3.67					
4th	23	a	5.72 ± 0.82	5.89 ± 0.71	8.28 ± 0.60	4.61 ± 0.70	25.8 ± 0.2	460 ± 55	64.2 ± 0.9	0.25	0.63
		b	43.34 ± 4.62	48.36 ± 5.56	62.26 ± 4.22	33.17 ± 4.12					
	24	a	7.78 ± 0.63	13.89 ± 1.11	10.72 ± 0.39	5.56 ± 0.52	23.8 ± 0.6	524 ± 84	66.0 ± 2.2	0.65	0.84
		b	36.46 ± 3.24	61.80 ± 3.34	64.44 ± 2.13	32.71 ± 2.46					
			Fênix		Automatic						
3 rd	17	a	6.72 ± 0.66	1.83 ± 0.31	2.78 ± 0.51	1.5 ± 0.46	22.7 ± 0.4	321 ± 58	55.9 ± 1.3	0.31	1.90
		b	61.68 ± 2.71	16.21 ± 2.55	48.54 ± 7.74	31.03 ± 7.99					
	18	a	6.06 ± 0.50	2.89 ± 0.82	2.78 ± 0.36	0.17 ± 0.09	17.7 ± 0.2	36 ± 4	80.5 ± 0.7	0.00	1.93
		b	57.67 ± 4.63	23.87 ± 5.49	77.12 ± 5.67	5.28 ± 3.14					
	20	a	4.61 ± 0.47	17.17 ± 2.14	2.11 ± 0.56	2.61 ± 0.49	22.9 ± 0.8	38 ± 4	74.7 ± 0.5	0.35	1.28
		b	25.49 ± 4.22	73.63 ± 4.40	33.73 ± 6.88	54.51 ± 7.78					
	21	a	6.61 ± 0.65	5.67 ± 0.57	6.17 ± 0.47	2.00 ± 0.35	25.0 ± 0.2	354 ± 45	66.0 ± 0.8	0.19	1.22
		b	49.81 ± 3.99	43.32 ± 3.89	72.59 ± 3.90	21.68 ± 3.66					
4 th	23	a	4.94 ± 0.49	5.28 ± 0.79	6.72 ± 0.64	1.33 ± 0.20	24.4 ± 0.2	399 ± 36	70.9 ± 1.9	0.25	0.63
		b	46.12 ± 4.46	43.94 ± 5.41	76.47 ± 4.04	17.69 ± 3.56					
	24	a	5.67 ± 0.64	10.06 ± 1.27	1.94 ± 0.68	2.44 ± 0.44	22.7 ± 0.4	321 ± 58	55.9 ± 1.3	0.65	0.84
		b	35.05 ± 3.61	58.39 ± 4.71	32.25 ± 7.94	54.60 ± 8.89					

T = temperature; L = luminosity; RH = humidity; Iav = internal air velocity; Eav = external air velocity.

Table 5 - Interaction between the percentage of eating and lying down behavioral activities in the pair-wise comparison of Fênix (F1) *versus* Tube (T1) feeders and Fênix (F2) *versus* Automatic (A2) feeders as a function of rearing age and environmental variable.

			Pearson's correlation									
Week	Type	Activity	T (°C)	P-value	L (lx)	p-value	RH (%)	p-value	Iav (m s-1)	p-value	Eav (m s-1)	p-value
3rd	F1	eating	-0.2	NS	-0.4	0.001*	0.6**	0.000*	-0.4	0.003*	-0.2	NS
		lying down	0.3	0.017*	0.1	NS	-0.3	0.005*	0.4	0.000*	0.2	NS
	T1	eating	-0.3	0.004*	-0.5	0.000*	0.5**	0.000*	-0.3	0.037*	0.5	0.000*
		lying down	0.1	NS	-0.1	NS	0.3	0.010*	-0.2	NS	-0.4	0.000*
	F2	comendo										
		eating	-0.2	NS	0.2	0.037*	-0.3	0.015*	-0.3	0.004*	0.2	NS
		lying down	0.3	0.016*	-0.3	0.017*	0.3	0.009*	0.3	0.012*	-0.2	0.041*
	A2	eating	-0.2	NS	0.2	NS	0.1	NS	-0.4	0.001*	-0.1	NS
		lying down	0.3	0.008*	-0.1	NS	-0.1	NS	0.4	0.001*	-0.0	NS
4th	F1	eating	0.1	NS	0.2	NS	0.2	NS	-0.1	NS	0.1	NS
		lying down	-0.2	NS	0.1	NS	-0.1	NS	0.2	NS	-0.1	NS
	T1	eating	-0.2	NS	0.2	NS	0.3	NS	0.1	NS	0.1	NS
		lying down	0.1	NS	-0.1	NS	-0.3	NS	-0.1	NS	-0.0	NS
	F2	eating	0.3	NS	-0.1	NS	-0.1	NS	-0.3	NS	-0.2	NS
		lying down	-0.3	NS	0.2	NS	0.1	NS	0.4	0.024*	0.2	NS
	A2	eating	0.8**	0.000*	0.0	NS	-0.2	NS	-0.1	NS	-0.5**	0.001*
		lying down	-0.8**	0.000*	-0.1	NS	0.3	NS	0.0	NS	0.6**	0.000*

T = temperature; L = luminosity; RH= relative humidity; Iav = internal air velocity; Eav = external air velocity. *p-value < 0.05; **Significant interaction; NS = not significant.

growing broiler genetic strains are more sensitive to environmental temperature changes and extremes, especially under tropical rearing conditions, as determined by Macari & Furlan (2001). Therefore, under this specific scenario, environmental temperature could have been a limiting factor of the activity of eating recorded in the present study.

Table 6 presents the differences in eating and lying-down behavioral activities between environmental temperature limits of L1 = 17 ≤ T (°C) ≤ 22 and L2 = 22 < T (°C) ≤ 26. The Student t-test revealed that eating activity at the Tube feeder (T1) was higher at low environmental temperatures (L1), and that the opposite occurred at the Automatic feeder (A2), where the activity of eating was higher when environmental temperatures were higher than normal (L2). As to the Fênix feeder (F2), the results suggest that the activity of lying down was more frequent when temperatures were low (L1).

These results as different from those found by Rutz (1994), who observed that birds tended to reduce both feed intake and locomotor activity as environmental temperature increased, as also found by Curto *et al*. (2007), in a study with broiler breeders. In the present study, the recorded environmental temperatures were never above above 30 °C, which may indicate that ambient temperature did not limit feed intake, especially considering that young birds are more tolerant to high ambient temperatures and did not present heat stress signs (Lasiewski *et al*., 1966; Baião, 1995). In the present study, it was observed that when environmental temperatures were low, eating activity increased at the Tube feeder (T1) and decreased in Automatic feeder (A2), while the laying down activity increase in low temperatures in the Fênix feeder (F2). When temperature was low, the frequency of birds lying down and huddling in the surroundings of the feeders increased, as shown by Curtis (1983).

Analysis of meal length

Considering feeding bout times of the three group of broilers as 1 = 0 < TM (s) < 100, 2 = 100 < TM (s) < 200, 3 = 201 < TM (s) < 300, 4 = TM (s) < 300, and removing avoiding the outliers, median feeding time bout was 124.5 ± 28.7 s (median ± standard error), which is within time 1. Table 7 shows feeding bout duration according to birds' age and feeder type (F, T, and A). Considering time 1 as optimal feeding bout duration, feeder A provided the best meal time, followed by the Fênix feeder (F) and the Tube feeder (T). Although feeding bout duration at the automatic feeder was higher than time 1 [0 ≤ TM (s) ≤ 100], which is considered as optimal, nearly 50% of the feeding bouts occurred in less than 30s, which suggest that these bouts were excessively short to be considered an appropriate meal. Both at the Fênix and the Tube feeders, the percentages of feeding bouts occurring within that time range (time 1) were approximately 35 and 20%, respectively. Feeding bout duration at the Fênix feeder was significant closer to the time median (p-value <0.05) as compared to the other feeders. In general, the shortest median time of a feeding bout was spent at the Automatic feeder (77 ± 29s), followed by the Fênix feeder (123 ± 17s), and the Tube feeder (214 ± 28s). As broilers are not submitted to feed restriction at this age, the length of the meal may vary, according to Nielsen (1999) and Keeling (2002).

Table 7 - Total number (a) and percentage (b) of birds per feeding bout duration range according to feeder type (Fênix, Tube and Automatic feeders) and rearing age.

Week	Feeder	Data type	Time range 1	2	3	4
3rd	Fênix	a	11*	9	6	6
		b	34.4*	28.1	18.7	18.7
	Tube	a	7	4	8	13*
		b	21.9	12.5	25.0	40.6*
	Automatic	a	20*	6	3	3
		b	62.5*	18.7	9.4	9.4
4th	Fênix	a	6	7*	2	1
		b	37.5	43.7*	12.5	6.2
	Tube	a	6*	5	2	3
		b	37.5*	31.35	12.5	18.75
	Automatic	a	9*	2	2	3
		b	56.3*	12.5	12.5	18.7
Total	Fênix	a	17*	16	8	7
		b	35.4*	33.3	16.7	14.6
	Tube	a	13	9	10	16*
		b	27.1	18.7	20.8	33.3*
	Automatic	a	29*	8	5	6
		b	60.4*	16.7	10.4	12.5

Time range = 1 = 0 < t (s) < 100; 2 = 100 < t (s) < 200; 3 = 201 < t (s) < 300; 4 = t (s) < 300. Total = 3rd and 4th weeks. *Larger frequency of use by the broilers.

The Mann-Whitney test revealed that feeding bout durations at the Fênix (F) feeder were significantly different between the morning and the afternoon (Table 8). The analysis of the interactions between feeding bout duration at the feeders and environmental variables was carried out pair-wise (F1 *versus* T1, and F2 *versus* A2). The results of the Pearson's correlation

Table 6 - Frequency of eating and lying down behavioral activities according to the pair-wise comparison of Fênix (F1) *versus* Tube (T1) feeders and Fênix (F2) *versus* Automatic (A2) feeders as a function of different environmental temperature ranges (L1 and L2).

	Behavioral activity					
	Eating			Lying down		
Feeder type	L1	L2	p-value	L1	L2	p-value
F1	7.24 ± 0.53	6.43 ± 0.45	NS	8.20 ± 1.60	6.03 ± 0.58	NS
T1	10.49 ± 0.54	7.83 ± 0.50	0.000*	4.80 ± 0.73	4.48 ± 0.33	NS
F2	5.81 ± 0.42	5.75 ± 0.29	NS	9.70 ± 1.70	5.82 ± 0.50	0.031*
A2	1.97 ± 0.30	4.68 ± 0.36	0.000*	1.78 ± 0.32	1.62 ± 0.19	NS

L1 = 17° ≤ T (°C) ≤ 22; L2 = 22° < T (°C) ≤ 26. Data are expressed as mean ± standard error. *p-value < 0.05; NS = not significant.

test applied to the mentioned interactions are shown in Table 9, indicating that light intensity influences meal duration when birds were four weeks of age. The most significant interactions were obtained with light intensity (432 ± 32 lx) at the Fênix (F1) and the Tube (T1) feeders and with air velocity (0.45 ± 0.1 m s^{-1}) just at the Fênix (F1) feeder at the 4th week of rearing.

Table 8 - Median meal time of birds eating at the Fênix, Tube or Automatic feeders according to period (morning or afternoon).

Feeder type	Time of meal (s) morning	afternoon	p-Value
Fênix	173 ± 23	95 ± 25	0,0409*
Tube	201 ± 37	231 ± 42	NS
Automatic	57 ± 45	89 ± 38	NS

Mann-Whitney test. Data expressed as median ± standard error. *p-value < 0.05; NS = not significant.

Light intensity may vary from 5 to 100,000lx inside broiler houses (Prescott & Wathes, 1999; Théry, 2001). The recommended value established by FAWC (1992) is around 20lx. Kristensen *et al*. (2007) suggested that broilers are not influenced by light intensity, and that their behavioral activities are rather related to other factors, such as health, motivation, and age. Davis *et al*. (1999) found that young broilers (2 weeks old) prefer low light intensity. Similar findings were obtained by Vanderberg & Widowski (2000) and Prayitno *et al*. (1997). In the present study, birds were exposed to a wide range of light intensities, as natural sunlight was the only source of light, which varied from 36 to 725lx during the experiment. This probably contributed to the wide variation in behavioral activities found in the results.

CONCLUSIONS

Birds preferred to eat from the Tube feeder. Eating behavioral activity was more frequent in the Tube feeder, followed by the Fênix feeder, and the Automatic feeder. This activity was more frequent during the morning and at low ambient temperatures, with the exception of the birds surrounding the Automatic feeder, which ate more frequently when environmental temperatures were high.

Eating bout and meal duration was in general higher at the Tube feeder than at the other two feeders, which may be related to the fact that this feeder does not have the partition grid, allowing the bird full access to the feed.

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Table 9 - Interaction of of meal time in the pair-wise comparison of Fênix (F1) *versus* Tube (T1) feeders and Fênix (F2) *versus* Automatic (A2) feeders according to age and environmental variables.

Week	Feeder type	Pearson's correlation T (°C)	p-value	L (lx)	p-value	UR (%)	p-value	Iav (m s^{-1})	p-value	Eav (m s^{-1})	p-value
3rd	F1	0.2	NS	-0.1	NS	-0.0	NS	0.145	0.428	-0.169	NS
	T1	-0.1	NS	-0.3	NS	0.3	NS	-0.201	0.269	-0.082	NS
	F2	0.0	NS	-0.2	NS	0.2	NS	0.151	0.411	0.020*	NS
	A2	0.0	NS	-0.0	NS	0.1	NS	-0.361	0.042*	-0.125	NS
4th	F1	-0.4	NS	-0.5**	0.047*	0.4	NS	-0.253	0.344	0.586**	0.017*
	T1	-0.2	NS	0.6**	0.024*	-0.2	NS	0.699**	0.003*	-0.299	NS
	F2	0.1	NS	-0.3	NS	0.1	NS	-0.429	0.097	-0.123	NS
	A2	0.3	NS	0.2	NS	-0.2	NS	0.082	0.764	-0.208	NS
Total	F1	-0.0	NS	-0.1	NS	0.1	NS	-0.057	0.702	0.035	NS
	T1	-0.2	NS	-0.2	NS	0.3	NS	-0.039	0.791	0.084	NS
	F2	-0.1	NS	-0.3	0.030*	0.2	NS	-0.118	0.424	0.133	NS
	A2	-0.1	NS	0.1	NS	0.1	NS	-0.096	0.516	-0.170	NS

T = temperature; L = luminosity; RH= relative humidity; Iav = internal air velocity; Eav = external air velocity. *p-value < 0.05; **Significant interaction > 0.5; NS = not significant.

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