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Communication

[*Comunicação*]

Physical characteristics of the eggs of red-legged partridge (*Alectoris rufa*) reared in captivity

[*Características físicas dos ovos da perdiz vermelha* (Alectoris rufa) *criada em cativeiro*]

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The red-legged partridge (*Alectoris rufa*) is a game bird raised in captivity in countries like England, Spain, France, Italy and Portugal, to produce fertile eggs for incubation and chicks to provide birds for hunting and restocking purposes (Mourão *et al*., 2010). Due to the red-legged partridge reproductive cycle characteristics, egg production is markedly seasonal, especially when fowls are raised under natural photoperiod (González-Redondo, 2006). The physical characteristics of the egg such as weight, shape, volume and surface are important for the poultry industry and in biological studies, as they can be used in research on population and ecological morphology and to predict chick weight, egg hatchability, shell quality characteristics, and egg contents parameters (Narushin and Romanov, 2002; Altuntas and Sekeroglu, 2010). The physical characteristics of eggs depend on various factors, namely the genotype, the diet, the light regime, the body weight and the age of the female at laying (French and Tullet, 1991; Etches, 1996). The effects of female age on egg characteristics in different avian species are well known (French and Tullet, 1991; Etches, 1996), however the available information concerning the red-legged partridge reared in captivity is scarce (Mourão *et al*., 2010).

The objective of the present study was to evaluate the effects of female age (1, 2 and 3-year-old) and month of laying (March, April and May) on the physical characteristics of the red-legged partridge eggs reared in captivity. A total of 2878 eggs obtained from a red-legged partridge local farm in Évora (South of Portugal, 38°35'N, 07°52'W, 300m) were used in this study. Females of three classes of age (1, 2 and 3-year-old) were housed in couples (1 male and 1 female) in flat-deck cages under a natural photoperiod. All animals were fed with a commercial concentrate for breeding game birds (21.5% crude protein). Feed and water were available *ad libitum*. Eggs were collected manually, three to four times a day, to reduce the risk of damage, identified with the number of cage, time of collection and the laying date. After identification, the eggs were transported to the selection and cleaning room, and subsequently the following determinations were performed: egg weight (W, g), determined with an electronic balance; and maximum egg length (L, mm) and breadth (B, mm), measured with digital callipers. Egg shape index (ES) = B/L (Romanoff and Romanoff, 1949), volume (V, cm^3), $V_1 = 0.51LB^2$ (Hoyt, 1979) and $V_2 = 0.913W$ (Etches, 1996), and surface area (S, cm^2), $S_1 = 4.835W^{0.662}$ (Paganelli *et al*., 1974), $S_2 = 4.951V_1^{0.666}$ (Etches, 1996) and $S_3 = 4.951V_2^{0.666}$ (Etches, 1996) were calculated from the previously measured egg parameters. Normal distribution and homocedasticity data were assessed by the Kolmogorov-Smirnov test and Levene's test, respectively. Except for

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maximum breadth (B), all the other variables were normally distributed and had homogeneous variance. B was subjected to logarithmic transformation. The results were subjected to a multi-factorial analysis of variance (GLM). When significant, the means differences in the factors of variation (P<0.05) were compared using the Tukey-Kramer test. All tests were performed with SPSS 13.0 statistical package.

The effect of female breeder age at laying, month of laying and the interaction of both on egg weight, maximum length, maximum breadth and egg shape index are presented in Table 1. The average egg weight (n = 2878) observed in this study was 18.1±1.3g. This is in accordance with *Alectoris rufa* egg weights reported by other authors (Mourão *et al*., 2010). There was a significant effect (P<0.01) of breeder age and also month of laying on egg weight. One-year-old breeders layed significantly lighter eggs (17.5±1.3g) then 2 and 3-year old breeders (18.1±1.3g and 18.0±1.4g respectively). Moreover, significantly lighter eggs were obtained, on average, in the beginning of the laying period (March, 17.4±1.4g), than later in time (April and May, 18.1±1.4g and 18.2±1.3g respectively). Indeed, the lowest (P<0.01) average egg weight was obtained in the first month of laying (March) for the 1-year-old females (Table 1). Other authors also reported an increase in egg weight with increasing female age and as the laying season progresses, with lighter eggs in the beginning of the laying period and heavier eggs in subsequent weeks in several poultry species (French and Tullet, 1991; Etches, 1996). However, Cabezas-Díaz *et al*. (2005) and Mourão *et al*. (2010) reported that older-red legged partridges produced lighter eggs.

Table 1. Red-legged partridge (*Alectoris rufa*) egg weight, dimensions and shape index, according to female age (A) and month (M) of laying (mean ± standard deviation)

	Female Age									Probability of effects		
	1			2			3			Age	Month	AxM
	March	April	May	March	April	May	March	April	May			
W	16.8 ± 1.2a	17.7 ± 1.3b	18.0 ± 1.3ce	17.9 ± 1.4bc	18.3 ± 1.3d	18.3 ± 1.2cd	17.6 ± 1.5be	18.3 ± 1.4cd	18.3 ± 1.4cd	<0.01	<0.01	<0.01
B	28.4 ± 0.8a	28.9 ± 0.8b	29.2 ± 0.8c	29.2 ± 0.9bcd	29.4 ± 0.8cd	29.4 ± 0.7cd	29.0 ± 0.9bc	29.4 ± 0.8cd	29.4 ± 0.8d	<0.01	<0.01	<0.01
L	38.3 ± 1.3ab	38.4 ± 1.3ab	38.4 ± 1.3ab	38.8 ± 1.3a	38.6 ± 1.4a	38.5 ± 1.4ab	38.7 ± 1.6ab	38.4 ± 1.5ab	38.3 ± 1.4b	<0.01	>0.05	>0.05
ES	0.74 ± 0.3a	0.75 ± 0.03a	0.76 ± 0.03bde	0.75 ± 0.03ae	0.76 ± 0.03bde	0.76 ± 0.03bd	0.75 ± 0.03ad	0.77 ± 0.03bc	0.77 ± 0.03c	<0.01	<0.01	>0.05
N	47	342	458	99	504	695	49	304	380			

W (g) = weight of eggs; B (mm) = maximum breadth of eggs; L (mm) = maximum length of eggs; ES (B/L) = egg shape index; N = number of eggs. Mean values within the same row followed by distinct letters are significantly different (P<0.05; Tukey-Kramer method).

Egg length varied on average from 38.3±1.4 to 38.8±1.3mm and was only affected (P<0.01) by age. Two year old partridges layed longer eggs (38.7±1.4mm) when compared to 1 and 3-year-old partridges (38.4±1.3 and 38.5±1.5mm, respectively). Egg breadth was significantly lower on eggs from 1-year-old (28.9±0.8mm) than from 2 and 3-years-old (29.3±0.8 and 29.3±0.8mm respectively) females. Moreover, eggs layed in March (beginning of the laying period) had a significantly (P<0.01) lower maximum breadth (28.9±0.9mm) than those layed later on (April, 29.2±0.8mm and May, 29.3±0.7mm). Indeed, when comparing individual means (Table 1), the lowest (P<0.01) B and L were observed for eggs layed by 1-year-old females, during the beginning of the laying season (March). This is in accordance with *Alectoris rufa* egg dimensions reported by other authors (Mourão *et al*., 2010). Average egg shape index (ES = 0.76±0.03) was also similar to those reported by other authors for red-legged partridge (*Alectoris rufa*; Mourão *et al*., 2010), Chukar partridge (*Alectoris chukar*; Karabağ *et al*., 2010) and Rock partridge (*Alectoris graeca*); (Tilki and Saatci, 2004). ES increased (P<0.01),

resulting in eggs less elongated as the female age progressed (Table 1). Irrespectively of partridges age, ES also increased with the laying season. These changes on ES, both with partridges age and month of laying, may be attributed to an increased (P<0.01) maximum breadth of the eggs with a simultaneous stagnation on the maximum length.

Eggs volume and surface area according to female age and month of laying are presented in Table 2. Egg volumes estimated either way (V_1 or V_2) were significantly (P<0.01) lower for eggs from 1-year-old partridges (16.33±1.21 or 15.97±1.18cm^3) than 2 and 3-year-old breeders (16.96±1.22 or 16.56±1.16 and 16.85±1.30 or 16.47±1.29cm^3, respectively). Moreover, eggs layed in the beginning of the laying season (March) were lower in volume than those layed later on. The effects of the main factors, age of female and month of than laying, on egg volume (V_1 and V_2) are similar to those observed on egg maximum breadth (B) and weight (W), which was expected since those parameters are used in the estimation of V_1 and V_2, respectively. When comparing individual means, V_1 and V_2 significantly increased with the laying season for the 1-year-old females, however for 2 and 3-year-old females only V_2 was significantly lower in the beginning of the laying season (March), indicating that the equation proposed by Etches (1996) may allow a better discrimination of egg volumes (Table 2). No other published data for partridge egg volume were found in the literature.

Table 2. Red-legged partridge (*Alectoris rufa*) egg volume and surface area according to female age (A) and month (M) of laying (mean ± standard deviation)

	Female Age									Probability of effects		
	1			2			3			Age	Month	AxM
	March	April	May	March	April	May	March	April	May			
V_1	15.77 ± 1.21a	16.44 ± 1.19b	16.78 ± 1.17cd	16.87 ± 1.29ce	17.04 ± 1.23e	16.97 ± 1.19ce	16.67 ± 1.33bde	16.92 ± 1.33ce	16.95 ± 1.27ce	<0.01	<0.01	<0.01
V_2	15.33 ± 1.13a	16.11 ± 1.17b	16.45 ± 1.14cd	16.30 ± 1.24bc	16.73 ± 1.18e	16.66 ± 1.13ce	16.09 ± 1.38bd	16.66 ± 1.31ce	16.67 ± 1.24ce	<0.01	<0.01	<0.01
S_1	31.28 ± 1.52a	32.32 ± 1.55b	32.77 ± 1.50de	32.57 ± 1.64bd	33.13 ± 1.56c	33.05 ± 1.49cd	32.28 ± 1.85be	33.04 ± 1.73cd	33.05 ± 1.64cd	<0.01	<0.01	<0.01
S_2	31.05 ± 1.58a	31.93 ± 1.54b	32.37 ± 1.51c	32.49 ± 1.66cd	32.71 ± 1.58d	32.62 ± 1.53cd	32.23 ± 1.71bcd	32.54 ± 1.70cd	32.59 ± 1.64cd	<0.01	<0.01	<0.01
S_3	30.48 ± 1.49a	31.51 ± 1.52b	31.95 ± 1.48ce	31.75 ± 1.61bc	32.30 ± 1.53d	32.22 ± 1.46cd	31.47 ± 1.81be	32.21 ± 1.69cd	32.22 ± 1.61cd	<0.01	<0.01	<0.01
N	47	342	458	99	504	695	49	304	380			

W (g) = weight of eggs; B (mm) = maximum breadth of eggs; L (mm) = maximum length of eggs; V (cm^3) = volume (V_1 = 0,51LB^2; V_2 = 0,913W); S (cm^2) = surface area (S_1 = 4,835W^{0,662}; S_2 = 4,951$V_1^{0,666}$; S_3 = 4,951$V_2^{0,666}$); N = number of eggs. Mean values within the same row, followed by distinct letters are significantly different (P<0.05; Tukey-Kramer method).

Egg surface area was estimated using three different equations, S_1 using a correlation with egg weight (Paganelli *et al.*, 1974), and S_2 and S_3 using a correlation with egg volume, V_1 (Etches, 1996) or V_2 (Etches, 1996), respectively. The effects of female age and month of laying on egg surface area were significant (P<0.01), irrespectively of the equation used. Younger partridges layed eggs with a lower (P<0.01) surface area (S_1 = 32.12±1.57cm^2; S_2 = 31.79±1.56cm^2; S_3 = 31.31±1.54cm^2) than those layed by 2 and 3-year-old breeders (S_1 = 32.91±1.53 and 32.79±1.70cm^2; S_2 = 32.60±1.56 and 32.45±1.67cm^2; S_3 = 32.09±1.50 and 31.97±1.67cm^2, respectively). As it was observed for other parameters, the effect of month is more noticeable in the beginning of laying season, and significantly increased as the laying season

progressed, however this was not always the case for 2 and 3-year-old partridges (Table 2). As well as for egg volume, no other published data for partridge egg surface area were found in the literature.

The physical characteristics of eggs from *Alectoris rufa* are considerably influenced by the age of the female. The important role of red-legged partridges as game birds and the problems associated with fertility and hatchability, which may be due to bird age or egg physical characteristics, underscore the necessity for more detailed research in this area

Keywords: Red-legged partridge, *Alectoris rufa*, egg characteristics

RESUMO

O objetivo do presente estudo foi avaliar os efeitos da idade das fêmeas (um, dois e três anos) e do mês de postura (março, abril e maio) sobre as características físicas dos ovos da perdiz vermelha (Alectoris rufa) criada em cativeiro. O peso (W), o comprimento máximo (L) e a largura máxima (B) de 2878 ovos foram determinados diretamente, enquanto o índice de forma (B/L), o volume (V) e a superfície (S) foram calculados com base nos parâmetros determinados diretamente. A análise mostrou diferenças significativas (P<0,01) no peso dos ovos entre as diferentes idades e entre meses de postura, com menor peso nas fêmeas mais jovens. Observaram-se diferenças significativas (P<0,01) no comprimento do ovo entre as classes de idade, mas não entre os meses de postura (P>0,05). Observaram-se diferenças significativas (P<0,01) na largura máxima e no índice de forma do ovo entre as diferentes classes de idades, com valores mais elevados nas fêmeas mais velhas e no período de postura mais tardio. O volume dos ovos estimados por meio de $V_1 = 0{,}51LB^2$ *e* $V_2=0{,}913W$ *foi afetado significativamente (P<0,01) pela idade e pelo mês de postura, bem como as áreas,* $S_1=4.835W^{0{,}662}$, $S_2=4{,}951V_1^{0{,}666}$ *e* $S_3=4{,}951V_2^{0{,}666}$*, as quais apresentaram os mesmos efeitos.*

Palavras-chave: perdiz vermelha, Alectoris rufa, *características dos ovos*

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