Reproductive and behavioral aspects of partridges (*Rhynchotus rufescens*) using different mating strategies

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Abstract: Breeding wild species in captivity very often fail, due to the lack of knowledge of breeding and handling techniques. The goal of this research was to evaluate the reproductive performance of partridges submitted to five different male:female ratios. An experiment was carried out on 72 birds in a random design using 4 replications. Partridges were raised and mated in places (2.0x2.0x1.0 m), using the proportions of one (1:1), two (2:1), three (3:1) and four (4:1) females per male and also one male mated to three females individually (3R:1), in a rotational system. Reproductive records from the breeding season from September 2004 to March 2005 were used. The studied traits were: laying rate, fertility and damaged egg rate. Nonparametric analyses of these traits were carried out. None of them were affected by mating sex ratio ($P<0.05$). One replication of the treatments 1:1, 2:1 and 4:1 were video-tape recorded for three days, 12 hours/day, giving 36 hours/treatment. The video tapes were sampled according to the scan method to fit an ethogram and to perform time budget analysis for the different behavior categories. They were also watched for one hour per day (from 10:00 to 10:30 AM and from 03:00 to 03:30 PM) to the study of dominance and agonistic behavior. The results showed the birds spent most of their time walking or resting. Female dominance could be related to displacing behavior ($r=1.00$) and male resting behavior was related to less eggs damaged ($r=0.90$). The knowledge on features of dominant and subordinate animals was largely improved and this information seems to be very useful to be applied in the selection of sires and dams.

Keywords: agonistic behaviour; dominant birds; laying birds; Red-Wing tinamous; Tinamous; wild birds

Introduction

The ample geographic dispersion, the alimentary habit omnivorous and the taste of the meat become the domestication of the South American partridge (*Rhynchotus rufescens*) attractive for economic purposes. Researches carried out using this bird in similar environment used to raise broilers have shown good performance to growth rate (Queiroz et al., 2004), excellent carcass and breast yields (Moro et al., 2006) and perfect adaptation to feed ration pounded and pelletized (Hoshiba et al., 2003). However, the reproductive performance of this species in captivity is still a problem to be solved. According to Sick (1997), in natural conditions, the females lay around 25 eggs during the reproductive season and the male is responsible for hatching them. Bump & Bump (1969) studying eggs collected in nature, reported 6 no fertilized eggs among 114, and hatchability equal to 88%, emphasizing that even in nature reproductive problems occurs. Similar results to these have not been verified for partridges raised in captivity. Carnio et al. (1999) reported percentages of fertility, hatchability and birth equal to 49.26%, 52.13% and 25.7%, respectively. Cravino (s.d.) found percentage of infertility ranging from 30 to 65%, and emphasized the necessity of studies to determine the causes of the reduced reproductive success of this bird in captivity. Bruneli et al. (2005), in a study carried out using a production system similar to that used for broilers, mentioned percentages equal to

71,0%, 54.0% and of 38,0% for fertility, hatchability and birth, respectively. Although the last results show a better efficiency, they are far from those necessary to make the domestication of partridges an economic activity.

The aims of this research were to evaluate the reproductive performance of partridges using different proportion of females to one male and to study behavioral aspects of males and females in these experimental conditions.

Material and methods

The experiment was carried out during the reproductive season from September 2004 to March 2005. The birds were kept in a commercial avian barn, inside boxes measuring 2.0x1.0x2.1 m, in the Wild Animal Sector, of Animal Science Department, at School of Agricultural and Veterinary Sciences, of São Paulo State University (FCAV-UNESP / Jaboticabal, Brazil). All animals were fed on a daily basis, with an egg production pelletized ration, based on corn and soybean. Feed and water supply were *ad libitum*.

Five different proportion of females per male were studied. The seventy two birds were lodged randomly in 24 boxes (2 months before the reproductive season), compounding the following treatments, with 4 replications each: T1: Rotational system => one female per male per week, 3 females per male; T2: Couple => 1 male:1 female; T3: Trio => 1 male: 2 females; T4: Quartet => 1 male:3 females and T5: Quintet => 1 male:4 females. Each replication of T1 used two boxes, one for lodging the females while waiting their turn to mate and the other for lodging the mating couple. The male was kept with one female per week.

The egg collection was done four times per day, registering the origin and the laying order of the eggs in each box and treatment. The broken or pecked eggs were quantified and discarded immediately after the collection.

The reproductive traits number of laid eggs per female, rate of fertility and percentage of broken and discharged eggs were analyzed by the Kruskal-Wallis Test (P=0.05).

One replication of the treatments T2, T3 and T5 were video-tape recorded for three consecutive days, 12 hours/day, giving 36 hours/treatment. The birds were observed during the day because they show only day activity. They received white ink marks on different places of body in order to allow the identification of individuals by distance. The sex determination was done by cloaca reversion. It was also used information on T2 and T5 replications from a trial carried out in the reproductive season 2003-2004. The experimental procedure used in this trial was the same described previously.

The video tapes were sampled according to the scan method (Lehner, 1992) to fit an ethogram (Table 1) and to perform time budget analysis for the different behavior categories. They were also watched for one hour per day (from 10:00 to 10:30 AM and from 03:00 to 03:30 PM) to the study of dominance and agonistic behavior. The threatening, attacking and avoiding behaviors were evaluated to all animals placed in the same box. The results found in each replication were transferred to a socialmetric matrix to be computed in a joint analysis. The final matrix was gotten by adding the values on the matrices of aggression and threatening and deducting those from the matrix of avoidance behavior. The Speraman´s correlations between the behavioral activities and behavioral activities and reproductive performance of partridges were estimated.

Table 1. Some categories of the ethogram of observed group of *Rhynchotus rufescens*.

Category	Description
Aggression Initiator (AG)	The bird pecks another one when it reaches near or when the other bird gets near.
Aggression Receiver (AP)	The bird which receives the pecks of others birds.
To threaten (AM)	The bird points or hurls its head in direction to the other, or it pursues the other.
To avoid (EV)	The bird, motionless or in displacement, as the approaching of another bird, changes the direction of its movement, avoiding the other.

To stand (PA)	The bird stands immobile in erect position at least for 5 seconds.
To stand sitting (SPA)	The bird stands in sitting position at least for 5 seconds.
To sit in activity (SAT)	The bird, in sitting position, scratches the ground or the bed lid with the beak or arranges the feathers with the beak.

Results and discussion

1. Reproductive Performance

Table 2 shows the average number of laid eggs per female, the rate of fertility and the percentage of broken and discharged eggs per treatment. Apparently, the means among treatments seem to be different but the Kruskal-Wallis tests were not significant (P>0.05). The high values of errors means for the traits indicated a huge variation among replications of the same treatment.

Table 2. Means and errors means of the number of laid eggs per female, rate of fertility and percentage of broken and discharged eggs per treatment of partridges (*Rhynchotus rufescens*) raised in captivity (Kruskal-Wallis).

	Couple	Trio	Quartet	Quintet	Rotational	P value
Number of laid eggs/female	20.25±6.18	12.62±6.18	15.75±6.18	16.06±6.18	17.91±6.18	0.9868
Fertility (%)	45.69±14.72	76.23±14.72	61.58±14.72	39.76±14.72	62.35±14.72	0.3350
Broken and discharged eggs (%)	6.45± 12.85	35.92±12.85	32.62±12.85	24.62±12.85	32.34±12.85	0.2483

The percentage of total broken eggs, rate of fertility and the number of laid eggs per female of each observed treatment replication used in the behavioral study are shown in table 3.

Table 3. Number of laid eggs per female, percentage of fertility and total percentage of broken and discharged eggs of the replication of treatments used to the behavioral study of partridges (*Rhynchotus rufescens*).

	Couple 1	Couple 2	Trio	Quintet 1	Quintet 2
Number of eggs	8.00	30.00	3.24	3.90	16.00
Fertility (%)	37.99	92.30	57.78	27.98	42.55
Broken eggs (%)	26.90	13.33	40.47	37.42	26.56

2. Frequency of behaviors.

The frequencies of the behaviors listed on table 1 were analyzed individually per animal. The displacement behavior showed the high frequencies among all behaviors for the majority of the studied animals. The exception was the female of the couple 2 that presented higher frequency for the behavior stand sitting (SPA) and sitting in activity (SAT).

Sorting the treatments in decreasing order, according to the displacement behavior, we can find Quintet 2, Couple 1, Trio, Couple 2 and Quintet 1, showing the average frequency of bout values of 40.o, 39.0, 25.0, 24.5, and 21.2, respectively. In analogous way, we can classify the birds according to the categories Stand sitting plus Sitting in activity, in ascending order of frequency of occurrence as: Quintet 1, Couple 2, Trio, Couple 1 and Quintet 2. Considering the birds according to sex, including females and males of all treatments, it could be verified that the males exhibited more activity than the females, except for the Trio, where occurred an inversion of these values.

Couple 1	F	M
F	0	12
M	9	0

Couple 2	F	M
F	0	-13
M	4	0

Trio	F 1	F 2	M
F 1	0	-5	2
F 2	5	0	2
M	2	1	0

Quintet 1	F 1	F 2	F 3	F 4	M
F 1	0	1	0	0	1
F 2	1	0	2	2	0
F 3	1	0	0	0	0
F 4	3	0	0	0	0
M	-2	0	0	0	0

Quintet 2	F 1	F 2	F 3	F 4	M
F 1	0	7	0	1	8
F 2	-3	0	0	1	-1
F 3	1	0	0	0	-3
F 4	0	4	1	0	1
M	0	4	1	0	0

Figure 1.Final agonistic behavior matrices between animals in the replication of the recorded treatments. The column values represent the animal who performs the action and the line the animal who receives the action. M= male; F= female.

3. Agonistic Behavior

Figure 1 shows the matrices got computing the agonistic interactions between animals of each replication treatment. They were built by the sum of acts of aggression and threat minus the avoidance behavior. Information on Figure 1 allows to understand the social interaction existing in each treatment recorded and also to outline a hierarchical arrangement of each group.

Aggression is a ritualized way of communication aiming to set a hierarchy in a small group (Loiselet, 2002). Although the couple 1 male received a greater number of aggressive acts from female (12), it also showed aggressive behavior and threatened the female (Figure 1). Couple 2 presented a different pattern; the male seemed to dominate the female in most of the time. The trio behavior could be placed in an intermediate position among those showed by couples 1 and 2: female 2 dominated both male and female 1 and the last ones disputed the dominant position between them. For quintet 2, Figure 1 shows the female 1 dominance over all other birds, followed by females 4, 3 and 2. The male could be set in the same hierarchical level of female 3. The hierarchical positions of animals belonging to Quintet 1 were not clear. The female 1 seemed to have more interaction with the male and females 2 and 4 dominated female 3. Setting a possible hierarchical classification in this group, female 2 would be the dominant among all, as it attacked all of them and was threatened only once by female 1. Female 1 would be the most weak. It could be set in this position because all females attacked it, including females 3 and 4 who did not show any domination signal. Despite of this, female 1 was the only who interacted with the male.

This hierarchical classification attempt in addition to the displacement analyses pointed out that dominant females showed more activity, catching up the values exhibited by males and even though surpassing them as showed by the Trio male. Sorting the agonistic interacting treatment means in decreasing order we have quintet 2, couple 1, couple 2, trio and quintet 1, showing the values, 36, 21, 17, 17, 13, respectively. A perfect correlation between agonistic encounters and displacement means was found, meaning that as the agonistic encounters arise, also increase the displacement frequencies.

It could be seen males exhibited more pronounced dominant signs mainly for males from couple 2 and quintet 2 (Figure 1). In these treatments coincidently, the number of laid eggs per female were higher, 30 and 16, and also the rate of fertility, 92.3% and 42.55%, respectively (Table 3). Cromberg et al. (2003) observed the behavior of two trios (1 male:2 females) of Red-Wing Tinamous in captivity. During the experiment, one of the females of the second trio wounded its foot showing difficulty for locomotion. Then this wounded female could be dominated by the male and it could breed with the sound female, which also presented a greater number of laid eggs.

4. Correlations between behavioral and reproductive traits

Table 4 presents the scores assigned for behavioral and reproductive traits of experimental partridges. The values for the behavioral traits Displacement and Standing sitting plus Sitting in activity were assigned as the females average for the recorded treatments with more than one female and the bout percentages of these behaviors for females and males of the couples. Broken eggs represent the percentage of eggs discharged per replication. The number of laid eggs per female per replication recorded shows the number of eggs laid per female only in the replications of treatments recorded and observed in the behavioral study and the total number of laid eggs is the total number of eggs laid by all females in each treatment, including the replications not recorded and observed. Female dominance assigns the highest values of agonistic behavior directed to the male and male dominance means the same for male.

Table 4. Values assigned to behavioral and reproductive traits of South American partridges (*Rhynchotus rufescens*) raised in captivity.

	Couple 1	Couple 2	Trio	Quintet 1	Quintet 2
Area per animal in each replication (m^2)	1.0	1.0	0.6	0.4	0.4
Male Displacement	39.0	35.0	21.0	33.0	51.0
Female Displacement	39.0	14.0	27.0	18.2	37.2
Male Stsit+Sitact	11.0	10.0	19.0	14.0	5.0
Female Stsit+Sitact	17.0	37.0	18.0	29.0	8.0
Broken eggs per replication (%)	26.9	13.3	40.4	37.4	26.5
Number of laid eggs per female per replication recorded	8.0	30.0	3.2	3.9	16.0
Total number of laid eggs per experimental treatment	20.2	20.0	12.6	16.0	16.0
Female dominance	12.0	-13.0	2.0	1.0	8.0
Male dominance	9.0	4.0	2.0	0.0	4.0

Stsit+Sitact = Standing sitting plus sitting in activity

Using the values showed on table 4, we estimated rank correlations (Spearman, Statistica 6.0) between those traits. Table 5 presents only the significant rank correlation estimates between behavioral and reproductive traits.

Table 5. Estimates of rank correlation (Spearman) between behavioral and reproductive traits of South American partridges (*Rhynchotus rufescens*), for the replications recorded and observed.

	Male Displacement	Number of laid eggs per female	Female Displacement	Female dominance	Broken eggs
Broken eggs		-1,00			
Female Displacement				1,00	
Male Stsit+Sitact	- 0,6	0,9	-	-	-0,9
Female Stsit+Sitact			-0,9	-0,9	

Stsit+Sitact = Standing sitting plus sitting in activity

The correlations estimated uphold the discussion previously done and also make possible to visualize other important information. Perfect correlation was estimated (r=1.00) between female displacement and female dominance behavior (Table 5). Therefore, this result allows to conclude that social dominance measures could be indirectly measured by displacement behavior in the study situation. Similarly the measures of Standing sitting plus sitting in activity could also be used for the same purpose.

Maximum but negative rank correlation (r= -1.00) was estimated between broken eggs and number of laid eggs per female (Table 5). It means that in replications where females laid more eggs there were less broken and discharged eggs. This result is still more relevant because broken eggs were not correlated to available area per animal (Tables 4 and 5). In addition, this variable (available area per bird) was not correlated to dominance.

The high correlation between broken eggs and frequency of activity of males, measured by male standing sitting plus sitting in activity (r=-0.90), leads to think that the process that culminates in broken eggs is also related to hierarchical arrangement and dominance. Females are the dominant birds and, in captivity, male displacement can be associated to movements of escaping from them

(Cromberg et al., 2003). So, an increase in the frequency of motionless behaviors of males like standing sitting and sitting in activity could be seen as a predisposition to confrontation. It seems a sensible way of thinking as in this specie the male is in charge of hatching the eggs and taking care of the youngs, biological processes that requires at least some degree of fearlessness. Other correlation values on Table 5 also could be used to support this discussion. The negative and high correlation (r=-0.60) found between standing sitting plus sitting in activity and male displacement behaviors and an even tight value (r=-0.90) for the correlation between these traits for females, show these behaviors are connected, and it seemed that females exhibit a higher stereotype process for this behavior.

Another result supporting our concerns of the great importance of social organization of these birds on their reproductive performance in captivity is that in the replications where males showed less activity resulted in a higher amount of eggs laid (standing sitting plus sitting in activity x number of laid eggs, r= -0.9, Table 5).

This research pointed out that the partridge male is not always able to exhibit its reproductive features in order to attract and eventually to stimulate the female oviposition when sharing a limited space with female(s). Therefore the arrangement of birds in harems using one male and several females did not seem to be a feasible way of lodging animals for reproductive purposes in this specie.

The study of partridge behavior in the experimental conditions of this research resulted in important advances in the biological knowledge of these animals, such as the relation between dominance and female displacement, amount of broken eggs and male displacement and number of laid eggs and amount of broken eggs. The features of dominant and subordinate animals were largely improved and this information seems to be very useful to be applied in the selection of sires and dams. The social behaviors of this species including the social hierarchical structure should to be taken in account in the domestication process of this bird.

References

BUMP, G., BUMP. J.W. (1969) A study of the Spottede Tinamous and the Pale Spotted Tinamous of Argentina. *Spec. Scienc. Rep. U. S. Fish Wildl. Serv.* 120: 1-160.

BRUNELI, F. A. T., THOLON, P., ISAAC, F.L., DAMASCENO, P. R., TONHATI, H, QUEIROZ, S.A**.** (2005) Caracterização da reprodução de perdizes (R*hynchotus rufescens*) em cativeiro. *Ars Veterinária*.21(2) (In press).

CARNIO, A., MORO, M. E. G., GIANNONI, M. L.(1999) Estudos para a criação e reprodução em cativeiro da ave silvestre, *Rhynchotus rufescens* (Tinamiformes), com potencial para exploração zootécnica. *Ars Veterinaria*.15:140-143.

CRAVINO, J.L. *La martineta, Rhynchotus rufescens, cria y explotacion.* Montevideo: Agropecuaria, Hemisferio Sur, 89 p., s.d.

CROMBERG, V.U., PEIXOTO, J.E., MORO, M.E.G.(2003) *Aspectos comportamentais da perdiz (Rhynchotus rufescens) em cativeiro*. In: SIMPÓSIO DE PRODUÇÃO DE PERDIZES (*Rhynchotus rufescens*) EM CATIVEIRO. 1º, 2003, Jaboticabal. *Anais...,* 14 p., 2003, CD-ROM.

HOSHIBA, M.A., TANAKA, A.L.R., RODRIGUES, G.A., FIGUEIREDO, G., THOLON, P., JUNQUEIRA, O.M., TONHATI, H., QUEIROZ, S. A. (2003) Resultados preliminares do consumo e desperdício de ração com diferentes tamanhos de péletes de perdizes (*Rhynchotus rufescens*) em cativeiro. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 40ª, Santa Maria, *Anais*…, 2003. CDRom.

LEHNER, P. N. (1992) Sampling methods in behavior research. *Poutry Science* 71: 643-649.

LOISELET, J.(2004) Behaviour and feather pecking are priority areas for selection. *World Poultry* 20:.22-23.

MORO, M.E.G., ARIKI, J., SOUZA, P.A., MORAES, V.M.B (2006) Rendimento de carcaça e composição química da carne da perdiz nativa (*Rhynchotus rufescens*). *Ciência Rural*.36:.258-262.

QUEIROZ, S.A., THOLON, P., FREITAS, E.C., BRUNELI, F.A.T. (2004) Comparison of growth curve models of partridges (*Rhynchotus rufescens*) raised in captivity. In: WORLD´S POULTRY CONGRESS, XXII, Istambul, *Abstracts*…, 2004. CDRom.

SICK, H. (1997) Ordem tinamiformes. In: *Ornitologia Brasileira*. Nova Fronteira, Rio de Janeiro, Rio de Janeiro, Brasil, p. 153-167.