Available online at www.sciencedirect.com
ScienceDirect
Applied Animal Behaviour Science xxx (2008) xxx–xxx
APPLIED ANIMAL BEHAVIOUR SCIENCE
www.elsevier.com/locate/applanim

Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*)

Marta E. Alonso [a,*], Raquel Prieto [a], Vicente R. Gaudioso [a], José A. Pérez [a], Daniel Bartolomé [b], Carlos Díez [c]

[a] *Departamento de Producción Animal, Fac. Veterinaria, Campus de Vegazana, 24071 León, España, Spain*
[b] *Instituto Tecnológico Agrario de Castilla y León, Paseo de Canalejas no. 77 2° A, 37001 Salamanca, España, Spain*
[c] *IBERCUN Cinegética, C/ Eduardo Julián Pérez 23 4° B, 49019 Zamora, España, Spain*

Accepted 15 May 2008

Abstract

Approximately four million red-legged partridges (*Alectoris rufa*) are released in Spain each year for repopulation or hunting purposes, all produced on intensive farming facilities under a forced pairing system. We studied the ethological response differences between two types of red-legged partridges couples: free and forced, using an experimental protocol with two groups of 20 couples each one: (A) group of forced pairing, one male and one female randomly chosen were introduced in the same cage and (B) group of free pairing, a female had the opportunity to chose between four males, using as female choice parameter the time spent by the female near each male. The behaviour of the couples during the first week they were together was evaluated. Female red-legged partridges chose males of higher weight and this males display more frequently patterns of feeding and vigilance behaviour. In the red-legged partridge alert and vigilance behavioural patterns are closely correlated to other feeding and cohesive behavioural patterns that increase the reproductive success of the couple. There was not aggressive behaviour in the free couples and only 2 attacks in the forced couples. In conclusion to have the opportunity to choose a partner increase the display of patterns of cohesive and feeding behaviour that increase the welfare of the females red-legged partridge on farm, but the environmental conditions of this study were not able to demonstrate differences in welfare due to pairing methods because there was a practically absence of aggressive behaviour of the male in both pairing options. We consider the cage design and space allowance together with the pairing methods as important factors that should be study in the future to improve welfare of farmed red-legged partridges.

Keywords: *Alectoris rufa*; Reproductive behaviour; Alert behaviour; Feeding behaviour; Forced and free pairing

* Corresponding author. Tel.: +34 987291243; fax: +34 987291187.
E-mail address: marta.alonso@unileon.es (M.E. Alonso).

0168-1591/$ – see front matter
doi:10.1016/j.applanim.2008.05.006

1. Introduction

In Spain, due to low levels of reproduction among the wild populations of red-legged partridge (*Alectoris rufa*), the number of partridges intensively reared on farms has risen. On these intensive farms there is no possibility of an element of choice in pairing by the partridges as the forced pairing method is used. This breeding system, combined with taming in captivity, results in numerous physiological and ethological modifications that produce severe problems of adaptation and integration into the wild, which, subsequently, have very negative repercussions upon the reproductive cycle (Robles et al., 2001; Gaudioso et al., 2002; Pérez et al., 2004).

One of the biggest problems from the animal welfare point of view of red-legged partridge intensive farming is the increase in agonistic patterns when birds have to cohabit in reproductive cages. Incompatibility problems or ‘‘divorce’’ have been described between the forced couples, with the female mortality rising to 5% at the end of the reproductive cycle (Nobilini et al., 1993).

Even when there are several aspects that could be manipulated to increase the reproductive performance in captivity, such as to choose the appropriate moment to establish the couples, the process could be compromised when the females are forced to pair with a mate they have no chosen (Drickamer et al., 2003; Bluhm, 1985). In the same way, Beani et al. (1992) stated that the forced pairing method at the end of reproductive season has more guaranties of success, but in the grey partridge (*Perdix perdix*) the percentages of nesting, incubation and chicks brooded were significant higher in the free couples than in the forced couples.

In order to introduce new adjustments in the pairing and rearing methods the knowledge of natural partridge behavioural patterns could constitute a decisive factor to improve animal welfare in the captivity breeding systems. It is well know that animal welfare and reproductive efficiency are closely connected and the appropriate management of social behaviour is the key to successfully reproduction (Swaisgood, 2006).

In many species the selection of a partner is not made randomly, and the pairing process involves several decision-making stages. Birds that have initially accepted a partner because of some ornamental aspect or some visually perceptible trait may change partner if there is a delay in egg laying or if the courting display of the male is inferior to that of other potential partners (Choudhury, 1995; Lendvai et al., 2004). Thus, females appear to use this information to evaluate the costs and benefits of possible alternative mates, determining in this way their selection (Castellano et al., 2004).

Rearing red-legged partridges in captivity is an important factor for the conservation of this species, because the wild populations are not able to sustain predators and hunting pressure because, for cultural and tradition reasons, this species is the favourite of small hunted animals in Spain (Alonso et al., 2005). But to do so with a sustainable system and under the best conditions from the animal welfare point of view is even more important in the long-term. Considering all this, the aim of this work is to study the influence of the pairing process in the behaviour and welfare of farming red-legged partridges during the period of formation and maintenance of the couple.

2. Material and methods

All the tests were carried out over two consecutive years, using 10-month-old birds without prior reproductive experience and from the same intensive game farm. They underwent at the same handling facilities, starting on last week of February to coincide with the reproductive season of the wild partridges in the study area.

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

When the birds arrived at the study facilities, in the Experimental Farm of the University of León, situated 42°37′53.70″N and 5°33′10.24″W, the state of health of all birds was checked, they were individually identified by numbered metallic rings, and all the males were weighed using a digital scale. All birds were then placed in their assigned study cages.

2.1. Animals

The following animals were used each year:

(A) Twelve forced couples: one male and one female were randomly chosen and placed in one couple experimental maintaining cage to completed 12 couples.
(B) Twelve free couples: made up of 48 males and 12 females, giving to each female the opportunity to choose between four males. To carry out this pairing process the following methodology was used.

2.1.1. Free pairing experimental cages

Males were placed randomly inside individual cages of 100 cm × 50 cm × 50 cm with sides of galvanised metal and wire mesh and floors and roofs of wire mesh. These cages were positioned so that the four neighbouring males could not see each other but had visual contact with a central space in which the female was placed. This central space was divided into five sections by a cross-shaped wooden structure with a common middle feeding and drinking space and four spaces in which the female could make contact across the wire mesh with each of the four males (Fig. 1). The whole structure was covered by wire mesh. A cereal (barley and wheat) feeding box and a drinking trough were placed in each cage.

2.1.2. Video recording and reproduction

A video camera was fixed at the top of each of the six groups of experimental cages in order to record the behaviour of the birds without human interaction. All the cameras were connected to a central video recording unit consisting of multiplexor, video recorder, 12-in. monitor, batteries and temperature control equipment (fan, heater and thermostats).

2.1.3. Free pairing experimental design

The tests were carried out in two consecutive series, using 24 males and six females in each test and were repeated in the identical format the following year using new birds. All males and females were placed in the free pairing experimental cages and remained there undisturbed for 8 days. Video recordings were made from 8:00 to 11:00 and from 16:00 to 19:00.

2.1.4. Study, evaluation and determination of pairs

One hour of the morning and afternoon recordings were processed to determine the male chosen by each female using as the defining parameter the amount of time spent by the female in the section of the cage near each male during the five recording days. We previously recorded 3 h during mornings and afternoon in case 1 h were not defining enough time for the female choice, but this was not necessary in any case.

Once the couples were formed the birds were placed in the couples experimental maintaining cages which were situated to avoid visual contact between adjacent cages.

2.2. Couples experimental maintaining cages

Twenty-four wire mesh and galvanised metal cages of 4 m^2 (2 m × 2 m × 1 m) were used each year and positioned on ground previously sown with cereal seeds (barley and wheat). Each cage had 2 sides of galvanised metal (1 m × 2 m × 1 m) in order to prevent visual contact between couples and 2 sides of wire mesh (2 m × 2 m × 1 m) to allow environmental visual contact. Each cage was furnished with a drinking trough, a cone-shaped brushwood shelter and a wooden nesting box with an Onduline® roof to protect against the rain.

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

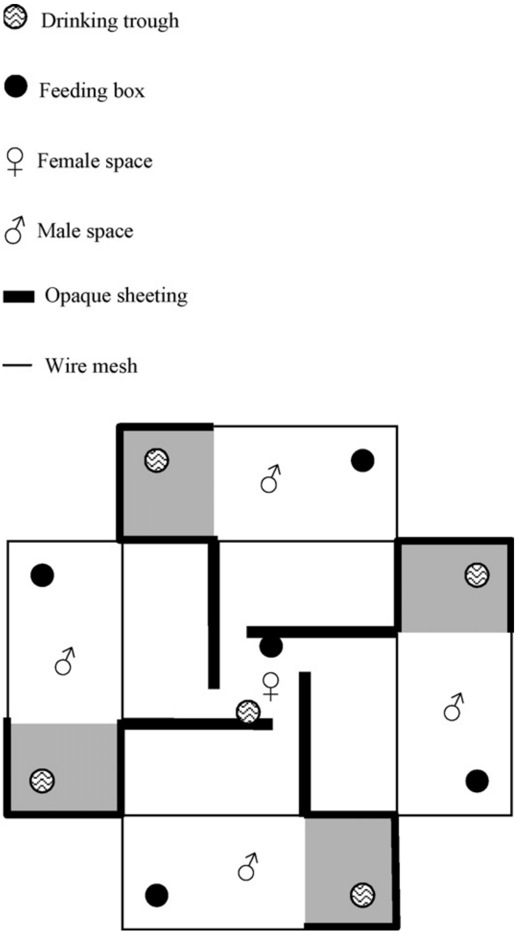

Fig. 1. An aerial view of a free pairing experimental cage. (◎) Drinking trough; (●) feeding box; (♀) female space; (♂) male space; (▬) opaque sheeting; (—) wire mesh.

2.3. Video recording and reproduction

Twenty laterally positioned video cameras were used to record the behaviour of the birds without human interaction, equally divided to record both 10 free choice pairs and 10 forced pairs. Two partridge couples were keep in reserve to be used in case that one of the 10 couples that was been taping failure, but none of the study year was necessary to replace any study couple. Each group of cameras was connected to the previously described central video recording unit. For 1 week video recordings were made for 4 h each day starting at 8:00 a.m.

2.4. Study and evaluation of behaviour

A computer program, developed for this purpose, was used to study the behaviour of each couple for 1 h, from 10 to 11 in the morning. The frequency and duration of 22 behavioural parameters (Table 1) described by Goodwin (1953, 1958), Jenkins (1961) and Pintos et al. (1985) were analysed.

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

Table 1
One-way ANOVA depending on the pairing method and the study year

	Free pair		Forced pair	
	F	Sig. *P*	*F*	Sig. *P*
Time together	0.11	N.S	1.003	N.S
Time apart	0.11	N.S	1.003	N.S
Time grooming	1.02	N.S	0.25	N.S
Grooming	4.57	N.S	1.16	N.S
Both grooming	0.53	N.S	0.19	N.S
Dust bath	1.00	N.S	–	–
Neutral posture	2.04	N.S	0.14	N.S
Both neutral	1.61	N.S	0.00	N.S
Resting	4.39	N.S	3.12	N.S
Both resting	1.75	N.S	0.11	N.S
Drinking	4.01	N.S	1.48	N.S
Both drinking	0.37	N.S	2.33	N.S
Pecking	9.12	0.009	3.16	N.S
Both pecking	5.38	0.036	1.60	N.S
Coming to peck	5.27	0.038	0.16	N.S
Follow-up	1.14	N.S	0.05	N.S
Alert	17.56	0.0009	0.40	N.S
Both alert	0.17	N.S	1.23	N.S
Agresion	–	–	0.00	N.S
Courtship	3.13	N.S	0.03	N.S
Copulation	0.07	N.S	1.00	N.S
Nesting	1.57	N.S	1.00	N.S
Both nesting	0.64	N.S	–	–

2.5. Data analysis

Data were analysed by one-way ANOVA (Dixon, 1983) in order to assess the significance of differences between pairing and year groups using the computer program SPSS© (version 10.0) for Windows©. Differences with $P < 0.05$ were considered significant.

3. Results

We use as ecologically reliable indicator of female choice (Millam, 2000; Bluhm and Gowaty, 2004) the amount of time that a female spent near to each male (Fig. 2). A one-way variance analysis (ANOVA) considering chosen and rejected males was undertaken and showed significant differences depending on time spent by the female near a male ($F_{(1,94)} = 169.538$; $P = 0.000$) and depending on the male body weight; males with higher weight were chosen by the females ($F_{(1,94)} = 4.889$; $P = 0.029$). There was a mean value of 489.32 g for the chosen males and one of 476 g for the rejected males (Fig. 3).

The influence of study year upon the behaviour of both groups of couples was analysed by one-way ANOVA, and the results showed a few significant differences (Table 1). During the second year the frequency of ‘‘pecking’’ food materials, frequency of simultaneous pecking by both members of the couple (‘‘pecking by both at the same time’’), frequency of one member moving to the place the other mate is pecking food and this member starting to ingest food when the other member is already doing so (‘‘coming to peck’’) and ‘‘alert’’ patterns were higher only

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

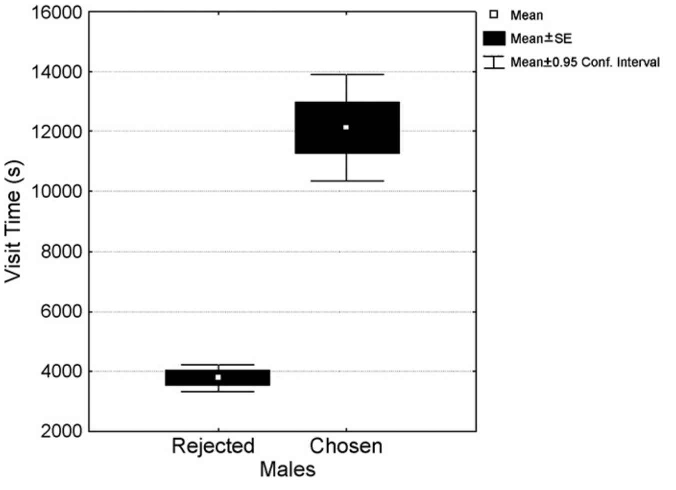

Fig. 2. Mean ± S.E. and mean ± 0.95 confidence interval of the time in seconds spent by the female with chosen and rejected males.

in the free pair group (Fig. 4). No significant difference being found between reproductive seasons for the forced group.

The results of the ANOVA depending on the pairing method (Table 2) presents statistically significant differences between free pairs and forced pairs for the following observed parameters: time spent by the couple together, frequency of ‘‘pecking’’, frequency of both pecking at the same time (‘‘both pecking’’), frequency of ‘‘coming to peck’’, frequency of one member following the other (‘‘follow-up’’), and frequency of the alert behavioural pattern.

Forced pairs spent more time together $F_{(1,30)} = 7.42$; $P = 0.011$) with a distance between them less than 50 cm.

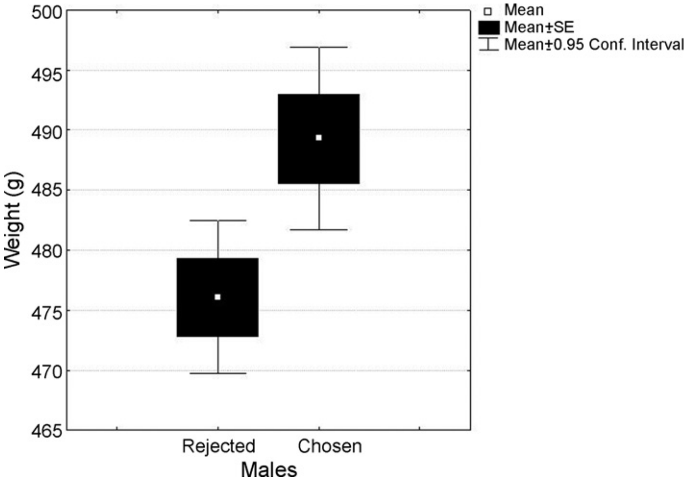

Fig. 3. Mean body weight (g) ± S.E. and mean ± 0.95 confidence interval of the chosen and rejected males.

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

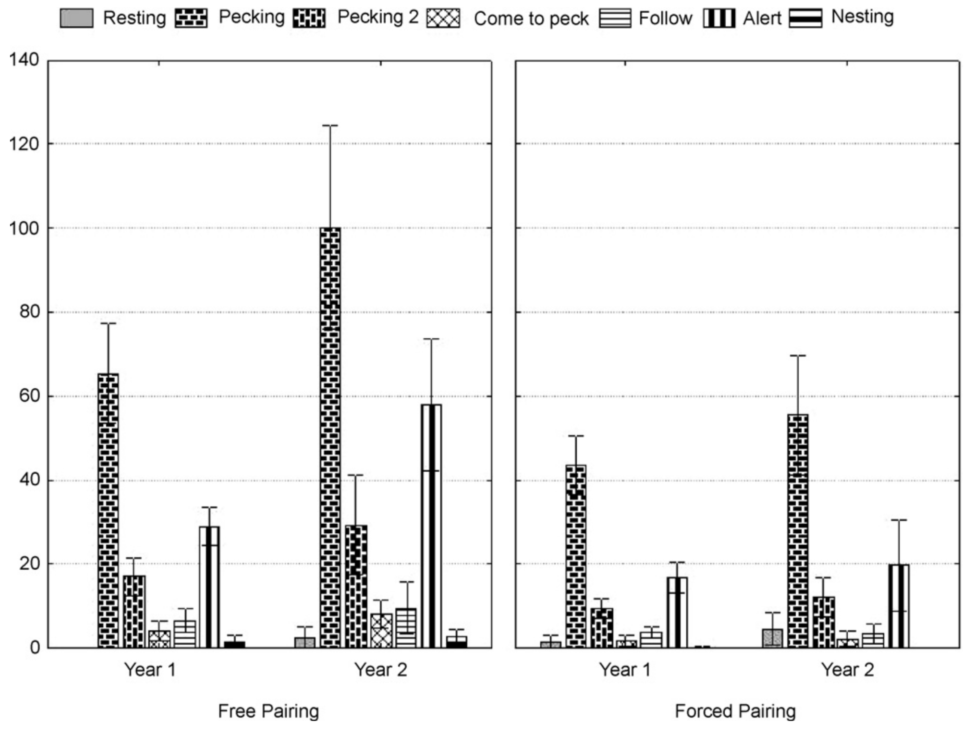

Fig. 4. Mean ± 0.95 confidence interval of the patterns, rest, pecking, both pecking at the same time, follow-up, alert and nesting, depending on the pairing type (forced or free) and year.

The frequency of ‘‘pecking’’, ‘‘both pecking’’ and ‘‘coming to peck’’ when the other member of the couple is pecking food were higher in the free pairs. Moreover, the frequency of the display of the pattern ‘‘follow-up’’ was higher ($F_{(1,30)} = 8.36$; $P = 0.007$) in the free pairs than in the forced ones (Fig. 5).

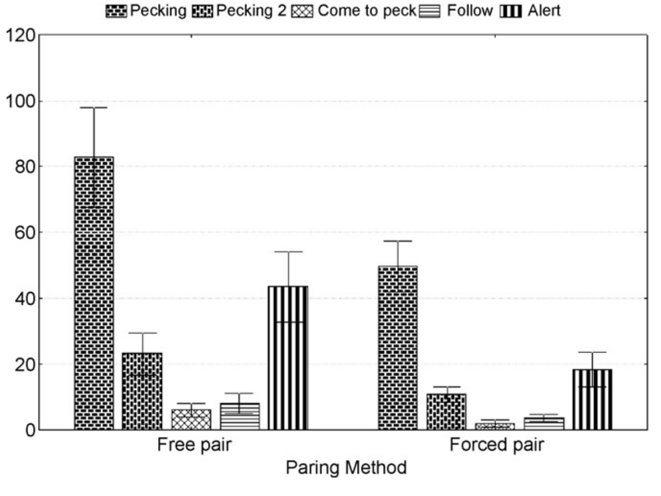

Fig. 5. Mean ± 0.95 confidence interval of the patterns pecking, both pecking at the same time, follow-up and alert, depending on the pairing type (forced or free).

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

Table 2
One-way ANOVA depending on the pairing method

	Mean ± standard deviation		F	P
	Free pair	Forced pair		
Time together	1459.8 ± 421.6	1820.56 ± 320.8	7.42	0.011
Time apart	2140.2 ± 421.6	1779.81 ± 320.8	7.42	0.011
Time grooming	91.44 ± 90.4	166.44 ± 154.3	2.81	0.104
Grooming	6.38 ± 5.7	7.88 ± 5.6	0.56	0.46
Both grooming	0.69 ± 1.0	1.19 ± 1.7	1.04	0.317
Dust bath	0.13 ± 0.5	0 ± 0	1	0.325
Neutral posture	12.94 ± 5.6	11.88 ± 5.1	0.31	0.581
Both neutral	1.69 ± 2.2	2.12 ± 1.7	0.39	0.536
Resting	1.19 ± 2.5	2.81 ± 3.8	2.05	0.162
Both resting	0.25 ± 0.8	0.44 ± 0.7	0.50	0.486
Drinking	1.56 ± 1.5	1.44 ± 1.5	0.06	0.813
Both drinking	0.19 ± 0.4	0.13 ± 0.3	0.22	0.64
Pecking	82.69 ± 28.5	49.56 ± 14.3	17.31	0.0002
Both pecking	23.13 ± 12.3	10.75 ± 4.4	14.43	0.0007
Coming to peck	6.00 ± 3.9	1.94 ± 1.8	13.90	0.0008
Follow-up	8.00 ± 5.7	3.63 ± 2.2	8.36	0.007
Alert	43.50 ± 20.1	18.19 ± 9.6	20.67	0.00008
Both alert	3.69 ± 3	1.44 ± 1.6	7.09	0.012
Agresion	0 ± 0	0.37 ± 1.0	2.14	0.154
Courtship	9.63 ± 8.2	5.69 ± 9.3	1.62	0.213
Copulation	0.56 ± 0.9	0.13 ± 0.5	2.93	0.097
Nesting	2.00 ± 2.0	0.06 ± 0.3	14.32	0.0007
Both nesting	0.38 ± 0.6	0 ± 0	5.87	0.022

The frequency of alert behaviour by one or, simultaneously, by both members of the couple was higher in the free pairs, particularly when solely the male displayed this behavioural pattern ($F_{(1,30)} = 20.67$; $P = 0.00008$) (Fig. 5). There were correlations between the parameters ‘‘alert’’ and ‘‘pecking’’ ($r = 0.825$, $P < 0.01$), ‘‘both pecking’’ ($r = 0.759$, $P < 0.01$), ‘‘coming to peek’’ ($r = 0.454$, $P < 0.01$) and ‘‘follow-up’’ ($r = 0.663$, $P < 0.01$) on the free couples. The same results occurs when both members of the free couple are alert (‘‘both alert’’) and ‘‘pecking’’ ($r = 0.577$, $P < 0.01$), ‘‘both pecking’’ ($r = 0.577$, $P < 0.01$) and ‘‘follow-up’’ ($r = 0.620$, $P < 0.01$).

Aggressive behaviour which resulted in attacks was only observed twice throughout the study, one occasion in each year, and both incidents involved forced pairs. The aggression consisted of the male pecking the female two or three times without causing injuries, nevertheless no subsequent incidents were observed.

The frequency of courtship patterns and copulation was low in both groups but the frequency of visit to the nest (‘‘nesting’’) was higher in the free pairs group.

4. Discussion

Females choose males of higher body weight, results that agree with those reported by Zuk et al. (1990) for the red jungle fowl, who concluded that female choice is based on the dimensions of some male morphological parameters. In this way, red-legged partridge females seem to choose heavier males using the body condition as a trail of higher male qualities, which agrees

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

with the hypothesis of sexual selection proposed by Hamilton and Zuk (1982) and are in accordance with the results of Bluhm et al. (2000) in mallards (*Anas platyrhynchos*). Moreover, other authors, such as Norris (1993) in great tits (*Parus major*), Petrie (1994) in Peacocks (*Pavo cristatus*), Von Schantz et al. (1989, 1994) in pheasant (*Phasianus colchicus*) and Gil et al. (1999) in zebra finch (*Taeniopygia guttata*), go even further, stating that the offspring of males with better secondary sexual characteristics could be more viable as the females can further improve some physical components of the offspring, directly through their predilection for males with better secondary sexual characteristics.

However, our results differ from those of Dahlgren (1990), who stated that female grey partridges (*Perdix perdix*) select their mate without demonstrating any preference for any of the morphological characteristics related to body size. Furthermore, our findings also differ from those of Gibson and Bradbury (1985) and Jonson and Marzluff (1990), who observed that female sage grouse (*Centrocercus urophasianus*) and pinyon jays (*Gymnorhinus cyanocephalus*), respectively, base their mate choice on morphological characteristics but do not necessarily choose the larger or heavier males.

During the first week the birds stay together the couples formed by females that had the opportunity to choose a male and both had the possibility to see each other showed higher feeding behaviour (‘‘pecking’’ and ‘‘both pecking’’), also observed by Bluhm (1985) in free pairing in Canvasbacks (*Aythya valisineria*), and also higher cohesive behaviours (‘‘comes to peck’’ or female ‘‘follows-up’’ the male). Feeding and cohesive patterns were associated with reproductive success and coordination among couple members in Canvasbacks (*Aythya valisineria*) (Anderson, 1984; Bluhm, 1985; Lovvorn, 1990). The males of this couples also displayed higher alert behaviour and this, together with the higher feeding behaviour, suggested that vigilant males are able to display more frequently patterns of ‘‘pecking’’ and alert behaviour, attracting the attention of the female that ‘‘comes to peck’’ or ‘‘follows’’ the male, because these ethological patterns are closely linked, as the correlations between them showed in the our results, coordinating the activity of the couple.

We consider that the vigilant behaviour carried out for a male is a trait that should be presented during the period the female made the mate choice. In this way, when the female selects a mate, a preference for vigilant males likely increases the chances of her own survival, because minimise the predation risk, increase her time to feed and improve her body condition, which, in turn, gives her greater opportunities to store reserves for use in egg production and incubation and, ultimately, maximising reproductive success, especially when birds are in the wild. These results agree with those of Dahlgren (1990) and Beani and Dessì-Fulgheri (1995), who stated that females grey partridges (*Perdix perdix*) might choose their partner on the basis of the vigilant behaviour of the male. On the other hand, Fusani et al. (1997) found significant correlation between testosterone plasma levels and vigilance behaviour of grey partridges. This supports the idea that to mate with a vigilant male has more advantages because he is not only able to develop behavioural patterns that represent more chances, but also he will have superior genetic quality because the sexual hormones are costly to produce and produced in higher quantity by the individuals with good body condition and better immune system quality (Pérez-Rodriguez et al., 2006). Our results seem to corroborate this as the female red-legged partridges choose the males with higher body weight (Fig. 3) but also spent more time in feeding and coordinate activities that reinforce the pair-bond with this males that also display alert behaviour more frequently (Table 2).

On the other hand, the fact that the chosen males showed higher frequency of alert behaviour could mean not only the anti-predatory strategy but also a way to protect their genes in the following generation trying to avoid other male access to their partners Anderson (1985). In this way, alert behaviour not only increases both member possibilities to survive to a predator attack but also protect male investment in the new generation.

The frequency of copulation, courtship behaviour and nesting was low at this early stage of the pair formation and this is in accordance with results obtained by Millam (2000) in Orange-winged amazons (*Amazona amazonica*) and Cockatiels (*Nymphicus hollandicus*), but slightly higher in the free couples and this reinforce the idea that to mate with a partner with which had social contact before increase the pair-bond.

Taking into account the behaviour of both, males and females, the female of the red-legged partridge seems to select her mate on the basis of both body weight and a variety of male behavioural parameters such as vigilance and feeding patterns, but for prove this we will need to conduct behavioural observations during the mate choice period. During the first week the couple stayed together the more vigilant males are able to display more frequently alert and feeding behavioural patterns that attract the attention of the female, which comes to peck or follows the male. All this suppose to increase her chances of survival and her body condition as well as her reproductive success when birds are in the wild, because, according to Bluhm (1985), a male that ‘‘allows’’ her mate to feed more during the pre-laying period may father a larger and or a better nourished clutch. These behavioural patterns should be considered as key variables in the pairing process of the red-legged partridge.

According to Mateos (1994) one of the ways to evaluate the welfare of birds in housing conditions is to determine the frequency they perform natural behaviours. In this way, higher frequencies of feeding, alert and cohesive patterns registered in free-couples could be used as an indicative of welfare and the absence or low frequency of these behaviours could be use for predicting situations of lower welfare levels. In this way free pairing also increases reproductive success because is positively influence by the welfare situations (Mateos, 1994).

On the other hand, to have the opportunity to choose a partner give the birds the possibility to become familiar with the other couple member and, according to Yamamoto et al. (1989), familiarity may increase the reproductive success by improving pair coordination. This could explain the high frequency of feeding, following and alert behaviours among the free couples. In this way free-pairing seem to increase, also in an indirect way, the reproductive success at the same time that increase the welfare of the farmed red-legged partridges couples.

For aggressive behaviour, our results do not agree with those of Nobilini et al. (1993), who found incompatibility between partners for grey partridge (*Perdix perdix*) forced pairings leading to a mortality rate of 5% of the females by the end of the reproductive season. In other species such as domestic pigeons (*Columbia livia*) (Klint and Enquist, 1981) and Canvasback ducks (*Aythya valisineria*) (Bluhm, 1985) free mate choice is important for successful breeding and forced pairing increase agonistic behaviour within the couple members. Taking into account the previously mentioned studies we expected that the pairing methods will have great influence in the display of aggressive patterns on the farmed red-legged partridges, but the low levels of this pattern showed by our results, only 2 peeking on the forced couples, made us to think that environmental conditions should be taking into account. There was a great difference in the cage size of the experiment carried out by Nobilini et al. (1993) and our study, and we think that this is the probable reason for the disparity between the two sets of results. In our study larger cages (4 m^2) were used in contrast to the intensive farming cages (0.5 m^2) used in the grey partridge (*Perdix perdix*) study. In the smaller intensive cages conflict situations could arise more frequently and there would be few possibilities for the female to escape. On the other hand, space restriction made agonistic behaviour increase in domestic chicken and other galliform species

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

(Rolling, 1995). In our study, free pairing couples did not display aggressive behaviour, as incompatibility between couples was less likely as the female had the opportunity to choose and the pairing process passed through various stages (Choudhury, 1995; Lendvai et al., 2004). Moreover, the influence of the space allowance and the pairing method on the aggressive behaviour need to be considers in future studies because the interaction between behaviour knowledge and management aspect will allow us to develop more respectful production systems to animal needs and sustainability.

5. Conclusion

To have the opportunity to choose a partner seems to increase the welfare of the female red-legged partridge on farms because they perform feeding and cohesive behaviour more frequently than forced pairs. The present study falls to probe the influence of the pairing method on the aggressive behaviour of the male toward the female due our cages design and more studies will be need to elucidate the influence of the space allowance and the pairing method on the agonistic behaviour.

Acknowledgments

This work was financially supported by the Excma. Diputación Provincial de Valladolid and the Junta de Castilla y León (Spain). We are grateful to Ann Gilsenan who kindly revised the English version and two anonymous referees for helpful comments that improved this manuscript.

References

Alonso, M.E., Pérez, J.A., Gaudioso, V.R., Díez, C., Prieto, R., 2005. Study of survival, dispersal and home range of autumn-released red-legged partridges (*Alectoris rufa*). Br. Poult. Sci. 46 (4), 401–406.

Anderson, M.G., 1984. Parental investment and pair-bond among Canvasback ducks (*Aythya valisineria*, Anatidae). Behav. Ecol. Sociobiol. 15, 81–90.

Anderson, M.G., 1985. Social behaviour of breeding Canvasbacks (*Aythya valisineria*): male and female strategies of reproduction. Ph.D.diss., Univ. Minnesota, Minneapolis.

Beani, L., Dessì-Fulgheri, F., 1995. Mate choice in the grey partridge, *Perdix perdix*: role of physical and behavioural male traits. Anim. Behav. 49, 347–356.

Beani, L., Cervo, R., Dessí-Fulgheri, F., 1992. Influence of mate choice on reproductive success of captive grey partridges (*Perdix perdix*). Gibier Faune Sauvage 9, 729–742.

Bluhm, C.K., 1985. Mate preferences and mating patterns of Canvasback (*Aythya valisineria*). Orithol. Monogr. 37. American Ornithologists'Union, Washington, DC.

Bluhm, C.K., Gowaty, P., 2004. Social constraint on female mate preferences in mallars, *Anas platyrhynchos*, decrease offspring viability and mother productivity. Anim. Behav. 68, 977–983.

Bluhm, C.K., Rozenboim, I., Silsby, J., El Halawani, M., 2000. Sex-Related Differences in the Effects of Late Winter Pairing Activity and Seasonal Influences on Neuroendocrinology and Gonadal Development of Mallards. General and Comparative Endocrinology 118, 310–321.

Castellano, S., Rosso, A., Giacoma, C., 2004. Active choice, passive attraction and the cognitive machinery of acoustic preferences. Anim. Behav. 68, 323–329.

Choudhury, S., 1995. Divorce in birds: a review of the hypotheses. Anim. Behav. 50, 413–429.

Dahlgren, J., 1990. Females choose vigilant males: an experiment with the monogamous grey partridge, *Perdix perdix*. Anim. Behav. 39, 646–651.

Dixon, W.J., 1983. BMDP Statistical Software. California University Press, Los Angeles, CA.

Drickamer, L.C., Gowaty, P.A., Wagner, D.M., 2003. Free mutual mate preferences in house mice affect reproductive success and offspring performance. Anim. Behav. 65, 105–114.

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006

Fusani, L., Beani, L., Lupo, C., Dessì-Fulgheri, F., 1997. Sexually selected vigilance behaviour of the grey partridge is affected by plasma androgen levels. Anim. Behav. 54, 1013–1018.

Gaudioso, V.R., Alonso, M.E., Robles, R., Garrido, J.A., Olmedo, J.A., 2002. Effects of housing type and breeding system on the reproductive capacity of the red-legged partridge (*Alectoris rufa*). Poult. Sci. 81, 169–172.

Gibson, R.M., Bradbury, J.W., 1985. Sexual selection in lekking sage grouse: phenotypic correlates of male mating success. Behav. Ecol. Sociobiol. 18, 117–123.

Gil, D., Graves, J., Hazon, N., Wells, A., 1999. Male attractiveness and differential testosterona investment in zebra finch eggs. Science 286, 126–128.

Goodwin, D., 1953. Observations on voice and behaviour of the red-legged partridge *Alectoris rufa*. Ibis 95, 581–614.

Goodwin, D., 1958. Further notes on pairing and submissive behaviour of the red-legged partridge *Alectoris rufa*. Ibis 100, 59–66.

Hamilton, W.D., Zuk, M., 1982. Heritable true fitness and bright birds: a role for parasites? Science 218, 384–387.

Jenkins, D., 1961. Social behaviour in the partridge (*Perdix perdix*). Ibis 10, 155–189.

Jonson, K., Marzluff, J., 1990. Some problems and approaches in avian mate choice. Auk 107, 296–303.

Klint, T., Enquist, G., 1981. Pair formation and reproductive output in domestic pigeons. Behav. Proc. 6, 57–62.

Lendvai, Á.Z., Kis, J., Székely, T., Cuthill, I.C., 2004. An investigation of mate choice based on manipulation of multiple ornaments in Kentish plovers. Anim. Behav. 67, 703–709.

Lovvorn, J.R., 1990. Courtship and aggression in canvasbacks: influence of sex and pair-bonding. The Condor 92, 369–378.

Mateos, C., 1994. El bienestar animal. Una evaluación científica del sufrimiento animal. In: Carranza, J. (Ed.), Etología: Introducción a la ciencia del comportamiento. Publicaciones de la Universidad de Extremadura, Cáceres, pp. 493–527.

Millam, J.R., 2000. Neonatal handling, behaviour and reproduction in Orange-winged amazons and Cockatiels. International Zoo Yearbook 37 (1), 220–231.

Nobilini, N., Sannipoli, C.G.T., Coletti, M., 1993. Differenti prestazioni riproduttive di starne accopiate forzatamente e per simpatia. Riv. di Avic. 6, 39–41.

Norris, K., 1993. Heritable variation in a plumage indicator of viability in male great tits *Parus major*. Nature 362, 537–539.

Pérez, J.A., Alonso, M.E., Gaudioso, V.R., Olmedo, J.A., Díez, C., Bartolomé, D., 2004. Use of radiotracking techniques to study a summer repopulation with red-legged partridge (*Alectoris rufa*) chicks. Poult. Sci. 83, 882–888.

Pérez-Rodriguez, L., Blas, J., Viñuela, J., Marchant, T.A., Bortolotti, G.R., 2006. Condition and androgen levels: are condition-dependent and testosterone-mediated traits two sides of the same coin? Anim. Behav. 72, 97–103.

Petrie, M., 1994. Improved growth and survival of offspring of peacocks with more elaborate trains. Nature 371, 598–599.

Pintos, R., Braza, F., Álvarez, F., 1985. Etograma de la perdiz roja (*Alectoris rufa*) en libertad. Doñana, Acta Vertebrata 12 (2), 231–250.

Robles, R., Alonso, M.E., Sánchez, J.M., Olmedo, J.A., Gaudioso, V.R., 2001. Nesting type choice in the red-legged partridge (*Alectoris rufa*). Anim. Sci. 72, 29–34.

Rolling, B.E., 1995. The poultry industry. In: Farm Animal Welfare: Social, Bioethical and Research Issues, Iowa State University Press, p. 168.

Swaisgood, R.R., 2006. Current status and future directions of applied behavioural research for animal welfare and conservation. Appl. Anim. Behav. Sci. 102, 139–162.

Von Schantz, T., Göransson, G., Andersson, G., Fröberg, I., Grahn, M., Helgee, A., Wittzell, H., 1989. Female choice selects for a viability-based male trait in pheasants. Nature London 337, 166–169.

Von Schantz, T., Grahn, M., Göransson, G., 1994. Intersexual selection and reproductive success in the pheasant *Phasianus colchicus*. Am. Nat. 144, 510–527.

Yamamoto, J.T., Shields, K.M., Millam, J.R., Roudybush, T.E., Grau, C.R., 1989. Reproductive activity of force-paired cockatiels (*Nymphicus hollandicus*). The Auk 106, 86–93.

Zuk, M., Johnson, K., Thorhill, R., Ligon, J.D., 1990. Mechanisms of female choice in red jungle fowl. Evolution 44 (3), 447–485.

Please cite this article in press as: Alonso, M.E., et al., Influence of the pairing system on the behaviour of farmed red-legged partridge couples (*Alectoris rufa*), Appl. Anim. Behav. Sci. (2008), doi:10.1016/j.applanim.2008.05.006