AVIAN BIOLOGY RESEARCH

PUBLISHED BY
SCIENCE REVIEWS 2000 LTD

VOLUME 5 NO.3 2012
ISSN 1758-1559

First evaluation of different captive rearing techniques for the re-establishment of the red legged partridge populations

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ABSTRACT

In Tuscany, the red-legged partridge (*Alectoris rufa*) became extinct at the beginning of the 20th century. Recently, some attempts have been made to re-establish wild populations in Tuscany using farm reared birds, but in most cases the released populations have shown difficulties in reaching sufficient viability, even in areas where the habitat can be considered suitable. Modern technologies for rearing game-birds may be not suitable for reintroduction purposes. For this reason we carried out preliminary research to evaluate the survival of red legged partridges reared under natural condition (Natural) compared to those farm reared (Artificial). Natural rearing occurred in a large pen where birds were allowed to mate freely and to nest. Natural reared birds reached a larger size than artificially-reared birds. Partridges were released in a 7.56 sq km protected area located in the province of Leghorn (western Tuscany, Italy). We followed the fate of 22 young radio-tagged red-legged female partridges (half Natural and half Artificial) and 56 young red-legged partridges (25 Artificial and 31 Natural) marked with different coloured ponchos. The survival of Natural radio-tagged red-legged partridges was double that of the Artificial red-legged partridges. After six months, the re-sighting rate of the Natural poncho-marked birds reached 22.6% whereas none of the Artificial stock was re-sighted. The preliminary results of this research suggest that Natural rearing may be an important tool to improve the success of partridge reintroduction.

Keywords: *Alectoris rufa*, reintroduction, natural rearing, survival

1. INTRODUCTION

The red-legged partridge (*Alectoris rufa*) is a native species of south-western Europe, occurring naturally in Portugal, Spain (including the Balearics), France, north western and central Italy. It has been successfully introduced in other European countries, including the UK (Aebischer and Lucio, 1996). The status of the species is considered 'Vulnerable' in Europe (Aebischer and Potts, 1994), and it has been classified into SPEC category 2 (Species of European Conservation Concern), based on their marked population decline and the limitation of their population.

In Tuscany, the species became extinct during the first decades of the 20th century (Massi, 1990; Baccetti, 1996; Foschi *et al.*, 1996) with the exception of the population of Elba Island. The extinction of the species can be related to the habitat change that occurred at the beginning of the 20th century: the red-legged partridges probably occupied shrubby areas, which developed in woodlands as a consequence of the decrease of the farm animal grazing. Moreover, increased hunting pressure may also have had a role (Aebischer and Lucio, 1996).

In recent decades, some attempts have been made to re-establish red-legged partridge populations in Tuscany using farm-reared birds (Casanova and Zalli, 1994; Mazzoni della Stella and Burrini, 1993; Mazzoni della Stella, 1995; Masseti, 2003). Actually the only self-sustained population derived from this reintroduction is in the province of Siena (Meriggi and Mazzoni della Stella, 2004). In the other areas, the released populations have had difficulties in reaching sufficient viability even where the habitat can be considered suitable and they tend to become re-extinct after few years from the last releases (Santilli *et al.*, 2005). Farm-reared birds show genetic and behavioural differences from wild birds (Dowell, 1992, Deeming *et al.* 2011). Captivity selection may significantly reduce the fitness of the wild populations (Ford, 2002). Consequently the survival and the reproduction rates of the captive-reared animals produced with modern technologies are dramatically low (Bagliacca *et al.*, 2006). Recently, Browne *et al.* (2009) reviewed the scientific and gamekeeper literature describing traditional methods for rearing and releasing grey partridges. Some of these methods can re-used today for conservation purposes. In fact, the survival of released individuals may be improved if

 doi: 10.3184/175815512X13441821968945

they are reared under natural and semi-natural conditions, e.g. parent- or cross-fostering (Cade and Temple, 1995; Buner and Shaub, 2008; Buner and Aebsicher, 2008; Buner *et al.*, 2011).

For this reason we carried out preliminary research to evaluate the short-term survival of red-legged partridges reared under natural condition compared to those commonly farm-reared. The rearing technique can be considered natural when eggs and chicks are cared for by their natural parents (Scott and Carpenter, 1987, Buner and Schaub, 2008, Sokos *et al.*, 2008).

2. MATERIAL AND METHODS

Birds

Natural rearing took place in a large pen of 4,000 sq m at "Poggio ai Sorbi Experimental Game Farm" (Campiglia Marittima - south western Tuscany). The pen had a soft netting canopy between 2.5 m and 12 m high. The ground was covered by Mediterranean shrubs (about 50%) and open grass. The breeding stock (25 female and 25 male) was obtained from the Casolino Game Farm, (Scarlino - Grosseto). This farm adopts the typical artificial system: the imposed pairs are kept in cages and the eggs are artificially incubated. The farm activity started its production in 1998 using a strain imported from France (the strain was checked for absence of hybridisation with *A. chukar* by mtDNA analysis) and the breeding pairs are replaced with its own offsprings every two or three years.

Our breeding stock was introduced into the pen in autumn 2009 and allowed to mate freely and nesting. Giving the opportunity to choose a partner seems to increase the welfare of the female red-legged partridge on farms because they exhibit better feeding and cohesive behaviour than when in forced pairs (Alonso *et al.*, 2008). In October 2010, we captured the birds for release. Capture occurred at night using a large landing net and a hand-held spotlight of 500, 000 candles power. This method allowed us to quickly capture the red-legged partridges with a very reduced risk of injury.

The captive-reared group, Artificial stock, hatched in incubator with chicks artificially heated, was obtained from the same farm as the breeding stock.

After capture necklace radio-tags (Bio-track TW-3 with 10–28 battery, weight 12 g) were attached to 22 young female (half Natural partridges and half Artificial red-legged partridges); differently coloured and numbered ponchos were applied to 56 young Artificial red-legged partridges (25 Artificial and 31 Natural). Every partridge was weighed and measured (Ferretti *et al.*, 2011) then, very early in the following morning, groups were released in the same protected no-hunting area. Release took place directly in two points at a distance of about 200 m from each other around the centre of the study area. The partridges (half at each releasing points) were free to leave their boxes immediately. Food (corn and wheat) was provided around the releasing sites for one week. In the Natural poncho group seven birds were adults, all the other birds were juveniles.

Study area

The protected no-hunting area used for the study, 7.56 sq.km (43° 16′ N, 10° 35′ E) is located in the province of Leghorn (western Tuscany) at a distance of about 4 km from the line coast (Figure 1). The climate can be defined as Mediterranean tempered-warm, with a mild winter. The annual mean temperature is 15°C with a maximum of 28°C in July and a minimum of 5°C in January. Rainfall is quite scarce, less than 700 mm per year. Land use classes (detected by aerial photographs at a scale of 1:10,000 and direct surveys then summarised and categorised) included olive tree groves (31.3%), crops (winter wheat, sunflowers and lucerne, 27.5 %), vineyards (12.5%), ploughed fields (8.0%), set-aside fields (7.1%), uncultivated (fallow) fields (3.5%), grasslands (2.8%) human settlement (mainly farmsteads with the surface within 50 m radius, 2.0 %), and woods (mainly holms – *Quercus ilex,* 0.8%); hedgerows covered 4.7% of the study area. Hunting was not allowed within the study area. Fox (*Vulpes vulpes*) control was carried out by shooting at bait sites whereas ravens (hooded crows *Corvus corone cornix* and magpies *Pica pica*) were controlled by Larsen traps. Pheasant *Phasianus colchicus* was quite abundant (about 50 subject/kmq) and 2–3 red-legged coveys were still present in the area as a results of previous releases.

Data collection

The birds were located at least once a week using IDS receivers and hand-held three element Yagi antennas from October to July in order to evaluate survival and reproduction. We also carried out simultaneously the observations of the poncho marked birds. The birds were also intensively checked around the edges and across the fields using a four-wheel-drive vehicle. Every observation was registered with a GPS instrument and later digitised using GIS software. If a dead bird was found, we noted the cause of death as assessed by inspection of the carcass.

The home range was calculated through the extension "Animal Movement" for Arcview (Seaman and Powell, 1996; Hooge and Eichenlaub, 1997).

The land use was calculated in respect to the availability (Aebisher *et al.* 1993; Pendleton *et al.* 1998; Manly *et al.* 2002;). Random points were used like centres of circles with an area equal to the average red-legged partridge home ranges (Kernel-95%) to calculate the environmental availability used in the composition analysis (Fearer and Stauffer, 2004).

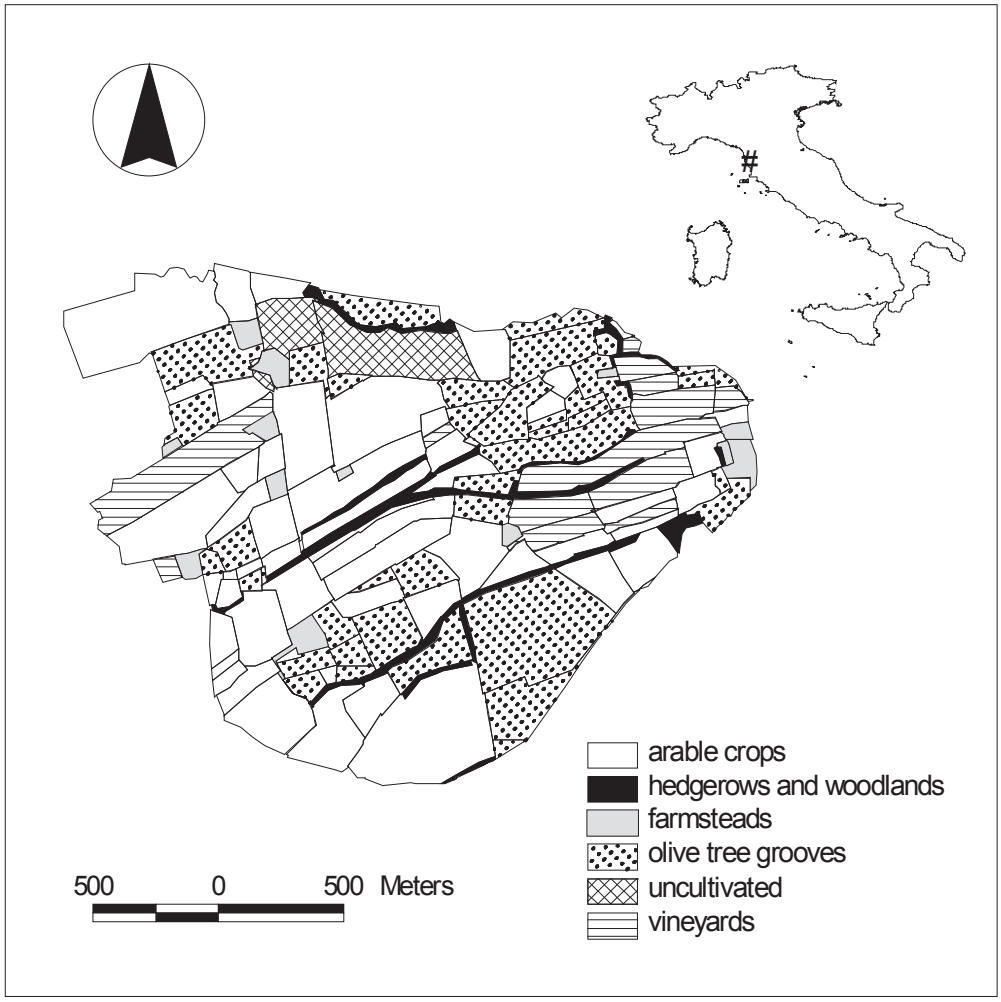

Figure 1 Study area.

3. RESULTS

Production and morphological characteristics

During the winter, before reproduction, 10 dead partridges were found (six males and four females). The causes of death were mainly due to trauma (collision with fence, poles). The remaining breeding stock produced 77 juveniles. No birds were injured during the capture nor the release since capture was carried out after dusk and partridges were released from corrugated paperboard boxes very early the following morning.

The live weights, the tarsus length and diameter, the remiges length, the tarsus diameter and the spur + tarsus diameter, for each (means and standard errors), are shown in the Table 1 and the results of the statistical analysis are shown in Table 2. From these observations, we can see, in addition to the expected differences between sexes and age-classes, a tendency to larger sizes in the Natural stock ($P < 0.05$ between males for live weights, tarsus, spurs and remiges length).

Survival and dispersion

The survival of Natural radio-tagged red-legged partridges was double that of the Artificial red-legged partridges, but the differences did not reach the minimum significant level (Table 3). Re-sighting rate of Natural poncho marked birds reached 22.6% whereas no birds from the Artificial stock were re-sighted after six months (Table 4). In the first month after release, the maximum distance from the releasing site of the Natural red-legged partridges was always greater than the Artificial red-legged partridges (Table 5). The winter home range (October to January) was similar for both groups of partridges.

Predation by mammals appeared more frequent: (7 = 43.8%) than predation by avian predators (3; 18.8%). For five partridges (31.3%) the predator could not be identified (Table 6). We lost contact with four radio-tagged birds (two Natural and two Artificial). Four Natural radio-tagged partridges repeatedly crossed the border of the protected study area (reaching a maximum distance of 150 m from the border of the protected area). One radio-tagged bird was lost (shot) outside of the protected area during the hunting season.

Table 1 Morphological traits of the red-legged partridges in relationship to the system of rearing

Red-legged Partridges		Natural				Artificial	
Age		Adult		Young		Young	
Sex		Males	Females	Males	Females	Males	Females
Body weight	g	505	394	428	336	417	354
	e.s.	10.5	10.9	12.2	21.1	8.27	11.2
Tarsus length	mm	55.6	49.9	51.9	47.9	51.3	50.9
	e.s.	0.617	0.456	0.317	1.18	1.04	1.02
Tarsus diameter (max)	mm	6.798	6.66	6.00	5.92	6.50	5.81
	e.s.	0.258	0.228	0.519	0.232	0.355	0.361
Tarsus diameter (min)	mm	5.33	4.70	5.75	4.69	5.35	5.27
	e.s.	0.253	0.138	0.202	0.165	0.306	0.316
Spur length	mm	9.84	-	6.35	-	-	5.86
	e.s.	0.228		0.086			0.278
Remiges length	cm	16.82	15.64	16.00	14.65	15.69	15.17
	e.s.	0.108	0.209	0.288	0.208	0.107	0.203

Table 2 Results of *post hoc t*-test on morphological traits of the red-legged partridges in relationship to the system of rearing

Within		Between			Body weight	Tarsus l.	Tarsus SD max	Tarsus SD min	Spur length	Remiges length
					t-test					
Natural	Adult	Females	*vs*	Males	*	*	NS	NS		*
Natural	Young	Females	*vs*	Males	*	NS	NS	NS		NS
Artificial	Young	Females	*vs*	Males	*	NS	NS	NS		*
Young	Females	Artificial	*vs*	Natural	*	NS	NS	NS		NS
Young	Males	Artificial	*vs*	Natural	*	*	NS	NS	*	*

* Difference between means statistically significant per $P < 0.05$; NS, Difference not statistically significant.

Table 3 Survival and reproductive succes of radiotagged hen red-legged partridges

Red-legged partridges		Natural	Artificial
Released	*n*	11	11
Survived after 1 month	*n*	9	4
	%	81.8	36.4
Survived after 3 month	*n*	5	2
	%	45.5	18.2
Survived after 6 month	*n*	2	1
	%	18.2	9.1
Successfully reproduced (hens partridges)	*n*	1	0
	%	9.1	0.0
Clutch size (about 20 days old chicks)	*n*	9	0
Lost contacts	*n*	2	2
	%	18.2	18.2

Table 4 Survival and reproductive success of poncho marked red-legged partridges

Red-legged partridges		Natural	Artificial
Released	*n*	31	25
Re-sighted after 3 month	*n*	10	2
	%	32.3	8.0
Re-sighted after 6 month *	*n*	7	0
	%	22.6	0,0
Successfully reproduced (hens partridges)	*n*	3	0
	%	9.7	0.0
Clutch size (about 20 days old chicks)	*n*	3.0	0

* Difference statistically significant per $P < 0.05$ (Fisher's exact test).

Table 5 Distance from releasing point and home range of released red-legged partridges

Red-legged partridges		Natural		Artificial	
		n	Mean ± SE	*n*	Mean ± SE
Distance from releasing point *	m	10	921 ± 92.8	7	508 ± 133.3
Home range – Kernel (95%)	ha	7	58.5 ± 12.9	5	64.6 ± 27.9
Home range – Kernel (50%)	ha	7	11.1 ± 2.7	5	13.9 ± 6.2

* Difference statistically significant per $P < 0.05$ (Unpaired *t*-test).

Table 6 Causes of death of the radio-tagged red-legged partridges

Red-legged partridges	Natural		Artificial	
	n	%	*n*	%
Mammalian predation	3	42.9	4	44.4
Avian predation	1	14.3	2	22.2
Man shooting	1	14.3	0	0.0
Not identified	2	28.6	3	33.3

Land use

No difference was observed in the land uses between the two groups of red-legged partridges. For both groups, hedgerows and the ploughed fields were the more common type of land used by the red-legged partridges. In contrast, the vineyards, the farmsteads, the olive tree groves, the woods, and the grasslands, were less represented. Regarding the presence of the red-legged partridges within their own home range (choice of home range) the number of fixes in the hedgerows, the set-aside fields, the grassland and the crops were more than expected while in the olive tree groves, the vineyards, the farmsteads, and the woods, the number of fixes were less than expected (Table 7).

4. DISCUSSION

The preliminary results of this research suggest that the maximum partridge growth can be obtained without the totally controlled rearing conditions of the Artificial system. The Natural system seems to promote even better growth rates of the offspring. Since the same genetic origin and kind of nutrition (commercial pellets) was used for both groups, the larger body size of the Natural birds may be related solely to the free mating system adopted. Garcia-Fernandez *et al*. (2010) observed that female gray partridges allowed to choose their mate, laid eggs with a higher yolk testosterone concentration than did females of imposed couples. Maternal testosterone levels in the egg yolk influences both the embryo and chick development.

The survival rates of both groups were quite low even if all the red-legged partridges were released in October when the adaptation to predators was easier, since the birds were in coveys rather than in pairs (Buner and Schaub, 2008). An adverse effect of radio-tags on survival cannot be excluded as observed for gray partridge *Perdix perdix* (Bro *et al.*, 1999). However, the survival rates of the red legged partridges released for re-establishment of a wild population was improved by the Natural rearing system. Since the main cause of mortality in partridges is predation, the different survival skills of the two treatment groups is probably due to differential anti-predators behaviour induced by the different rearing systems. In fact the free sexual selection of parents can improve the behaviour of the offspring (Dowell, 1992; Wedekind, 2001). Dowell (1990) observed that post-release behaviour of captive-reared partridges was similar to that of wild grey-partridges, except that intensively-reared

Table 7 Land uses of the red-legged partridges (analysis carried out on log-values, Aebischer *et al*., 1993)

Red-legged partridges	Natural	Artificial	Both groups
Home range choices[a]			
Hedgerows	2.22	4.04	3.00*
Set-aside fields	1.30	1.46	1.37NS
Ploughed fields	2.15	0.03	1.24*
Crops (winter and spring)	0.97	1.45	1.18NS
Vineyards	0.49	0.80	0.62*
Farmsteads	0.64	0.58	0.61*
Olive tree groves	0.75	0.41	0.60*
Woods	0.40	0.44	0.42*
Grasslands	0.32	0.46	0.38*
Choices in the home range[b]			
Ploughed fields	>10	2.05	>10NS
Hedgerows	1.17	2.92	1.92*
Set-aside fields	1.95	1.55	1.78*
Grasslands	0.00	3.56	1.53*
Crops (winter and spring)	1.01	1.73	1.32NS
Olive tree groves	0.61	0.22	0.44*
Vineyards	0.15	0.53	0.31*
Farmsteads	<0.01	<0.01	<0.01*
Woods	<0.01	<0.01	<0.01*

[a]Home range choice: (Kernel – 95% in respect to the overall land uses).
[b]Choices in the home range: location of the partridges fixes in respect to the land use incidence.
Values greater than the unit show uses greater than the available; values smaller than the unit show uses smaller than the available.
* Use significantly differing from available per $P<0.01$; NS, use not significantly differring from the available.

birds were reluctant to move away from hedgerows and trees at field margins, making them more vulnerable to predators. Slaugh *et al*. (1992) found that post-release survival of captive-reared Chukar partidges (*Alectoris chukar*) imprinted on conspecific adults and exposed to simulated predators, was higher than partridges reared under conventional methods. Red-legged partridges, reared in commercial game farms, showed differences in their escape reaction which can explain the low ability of these birds to survive in the wild (Pèrez *et al*., 2010). Gaudioso *et al*. (2011) showed that subjecting captive-reared red-legged partridges to an anti-predator training improves their ability to survive after release. The beneficial effect of semi-natural rearing methods was also shown in the pheasant (Phasianus colchicus) resulting in an improved survival and/or breeding success (Brittas *et al*., 1992; Ferretti *et al*., 2011)

It is of interest that the only artificially-reared radio-tagged partridge which survived after the breeding season spent the winter time in a group formed by Natural reared birds. The higher distance from releasing point observed in the Natural group (even if we used only the data collected for the first month, due to the low survival of the Artificial stock) suggests that these birds have a better fitness that allow them to quickly select favourable habitats. On the other hand, this fact implies a greater dispersion of these partridges and increases the risk of their being shot outside the protected releasing areas during the hunting season.

Land use analysis showed that, in winter, red-legged partridges tend to select habitat characterised by fields with a sparse or not too thick cover (ploughed fields, set-aside, and grasslands) alternated with hedgerows. The first land use offers food and allows an easy flight from predators, the second land use offers protection from weather and avian predators. Ploughed fields in the study area were mainly formed by clod and spars herbaceous cover. This kind of habitat is probably the most similar to the original habitat of the species which is a species of Mediterranean grassland with small bush and bare patches. The avoidance of vineyard and olive tree grooves may be due to the human disturbance. The study period partially coincided with the pruning works in the vineyards and the olive harvest.

In conclusion, the Natural captive-reproduction of the red-legged partridges in large pen seems to be useful in order to improve the survival rates of the captive-raised red-legged partridges. In addition the Natural rearing system adopted, which allows free choice of mate, might be more genetically useful than the random mating (typical of the commercial farms) because it may promote offspring health and enable host populations to react to co-evolving pathogens. This kind of supportive rearing may improve the long-term success of breeding programs for reintroduction or conservation (Wedekind, 2002; Sokos et al., 2008).

However, as observed by Buner and Shaub (2008) for the grey-partridge, since captive-reared birds have not normally encountered predators prior to release, they may

not yet have sufficient skill to survive in the wild. This fact can explain the low survival rate of our Natural red-legged partridges. For this reason, once a minimum population level is established, it may be better to adopt the system suggested by Game and Wildlife Conservation Trust for grey- partridge which consist of fostering of captive parent-reared chicks to wild barren pairs (Buner and Aebischer 2008). This system seems to work even with the red legged partridge (Sánchez-García *et al*., 2011).

ACKNOWLEDGMENT

We would like to thank Konrad Swingestein and Francesco Furloni respectively owner and manager of the "Poggio ai Sorbi" Experimental Game Farm (Campiglia M.ma, Italy) who provided the "Natural" stock of partridges for free.

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