Wildl. Biol. Pract., 2014 June 10(1): 1-13
doi:10.2461/wbp.2014.10.4

ORIGINAL ARTICLE

Evaluation of some Habitat Improvement Actions in a Mediterranean Area Through Observation of Reared Pheasant and Red-Legged Partridge Land Uses

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Keywords
Red-legged partridge; *Alectoris rufa*; Pheasant; *Phasianus colchicus*; Habitat Improvement Actions; Feeders; Hedgerows.

Abstract
Red-legged partridge (*Alectoris rufa*) and pheasant (*Phasianus colchicus*) have suffered population decline in the last decades. Research suggested that decline is mainly related to the intensification of agricultural techniques and land abandonment. We evaluated habitat use and distribution of reared red-legged partridge pairs and cock pheasants in an estate representative of most of the agricultural Mediterranean areas from 2007 to 2012. Particular attention has been addressed to the effect of artificial habitat improvement actions (HIAs) and other management options such as supplemental feeding and hedgerows maintenance. We compared habitat use with its availability and analyzed spatial distribution by comparing points with pheasant cocks and partridge pairs with random ones.
HIAs were used more than their availability by both species and resulted to have an important role in their distribution like hedgerows. Feeders resulted to have a strong effect on pheasant distribution, but not on pairs of red-legged partridges.
Our results show that habitat management could be a fundamental tool for game-bird conservation, though the effects of feeders on red-legged partridge distribution need to be further investigated.

Introduction

Last century has witnessed a marked decline of red-legged partridge (*Alectoris rufa*) all through its range [1-4], including Italy [5]. In Tuscany (Central Italy), this species has become extinct at the beginning of the 20th century with the exception of a population still found in Elba Island. Several attempts to reestablish wild populations have been recently conducted, though not all of them turned out to be successful, probably due to the low quality of captive-reared birds [6-8]. In the last years, bag records of pheasants have shown a dramatic decline despite no significant variation in releasing rate and hunting pressure. In agreement with the trend observed in Italy, wild pheasant populations have declined since 1960s both in Europe and USA [9-13], although this is often masked by the repeated release of captive-reared birds.

This general decline may be variously explained. Still, the main reason behind it is the impact of agricultural intensification and subsequent land abandonment [14-16]. The increase of field size and monocultural farming, the reduction of grassy field margins, hedgerows and tree-rows, the large employment of herbicides and pesticides, and a general reduction of permanent cover have caused a dramatic loss of habitat heterogeneity [15-18].

Game birds management in Italy and other European countries is often based on restocking with captive-reared birds. This practice, however, is controversial and mostly ineffective [19-25], especially when it is not coupled with habitat management and proper predators control. Many studies suggest that the management of agricultural areas might be most effective for game-birds conservation when combined with a reduced predation pressure [26-29]. Habitat management is the basis for any recovery program of wildlife populations: not only may releasing alone be ineffective, but it may also pose significant sanitary and genetic risks.

For this reason, a deeper understanding of the habitat preference of these species may contribute to identify areas suitable for reintroduction of red-legged partridges, the possible spatial competition between the two galliformes, and habitat management strategies to preserve both species. Currently, habitat management choices mostly applied to improve food availability, shelter, and nesting covers are: crops for game (cereal or other unharvested crops, hay-fields mowed only outside the breeding season), overwinter stubble maintenance, beetle banks, and conservation headlands [30-33]. Supplemental feeding as well is a technique widely used especially to enhance game birds populations [34-37].

We evaluated habitat use of red-legged partridge pairs and cock pheasants in an estate of southern Tuscany which can be considered representative of many farmland areas of Central Italy where cereal cultivation has been substituted by fallow fields and trellis system vineyards. Most importantly, we aimed at evaluating the effectiveness of the habitat improvement actions (HIAs) and other management options such as supplemental feeding and hedgerows maintenance. In fact, all these improvements are often planned only on a theoretical basis, but the scientific evaluation of their effect on the behaviour of the released animals needs to be verified.

Study area

Study area is located in Grosseto province (South-western Tuscany, Italy; 10°59'E, 49°55'N). Climate can be defined as warm Mediterranean [38] and the annual mean temperature is 15.7°C (max=30°C in July; min=3°C in January). Average rainfall is 655 mm per year. The area covers 2.9 km^2 and is part of a wider hunting estate of 4.1 km^2. Of the study area, 16.6% is covered by Olm oaks (*Quercus ilex*), while 83.4% by arable land. This last is composed of crops (winter wheat and beans, and sunflowers; 22.0%), fallow fields (24.5%), vineyards (39.2%), and fields of olive tree groves (4.0%). Vineyards are cultivated with trellis driving system. Soil is regularly ploughed and grasses are controlled with herbicides. The remaining fields (10.3%) are formed by HIAs (the minimum requested by the provincial regulation is 3% of the agricultural area). These areas are composed of winter cereals, spring crops (sorghum and maize) and hay fields (lucerne and clover mixed with grasses). Cereal and spring crops remain unharvested until following winter or spring, while hay fields are mowed once a year in late March.

About 400 juvenile pheasants and 100 juvenile red-legged partridges, both captive-reared (artificial incubation), are released by the estate managers every summer for hunting purpose. Birds are purchased in a local farm and gradually released in summer using two open top pens of about 1 ha each. Pheasants are released in the pens at 80-90 days of age, partridges at 120-140 days. As releases started in 2005, the partridge and pheasant populations are the result of a mix of released and wild-born birds. The main population parameters of the two populations are reported in Tables 1 and 2.

Table 1: Main population parameters of pheasants in the study area from 2008 to 2012.

Year	Pheasants released	Pheasants shot	Spring cocks	Spring hens	Spring density	Broods	Broods production rate	Broods size (arithmetical mean)
2008	400	25	18	25	26.6	3	12.0	6.5
2009	400	55	20	15	25.2	5	33.3	5.8
2010	400	34	20	35	32.1	7	20.0	4.5
2011	400	70	20	31	30.7	8	25.8	3.3
2012	400	69	16	64	38.1	10	15.6	5.0

Table 2: Main population parameters of red-legged partridges in the study area from 2007 to 2012.

Year	Red-legged partridges released	Red-legged partridges shot	Spring pairs	Spring pairs density	Broods	Brood production rate	Broods size (arithmetical mean)
2007	300	10	20	6.9	11	60.0	4.6
2008	300	5	18	6.2	11	61.1	5.3
2009	100	7	32	11.0	14	43.8	4.2
2010	100	11	19	6.6	6	31.6	6.7
2011	100	10	25	8.6	10	40.0	7.2
2012	100	12	17	5.9	10	58.8	6.1

Supplemental food is provided all year round by means of 33 feeders set in the study area. Feeders contain a mix of grains (wheat, sorghum and cracked corn) and are put on wooden pallets at least 1.3 high to prevent wild boar and porcupine depredation. Pheasants can pick up on these feeders quite easily [36], while this is more difficult for partridges. Nonetheless, photo trapping showed red-legged partridges feeding on them too.

Every year, about 50 pheasants and 10 partridges are shot during the hunting season. Fox culling is practiced, and corvids (mainly magpies) are controlled by Larsen traps in accordance with Tuscan legislation.

Methods

Pairs of red-legged partridges were monitored from 2007 to 2012, while pheasants from 2008 to 2012. Counts were carried out by means of mapping methods [39,40]. Searching effort was equally distributed by a net of 4 transects totalling 21.9 km in length which covered the whole study area (Fig. 1). Each transect (average length 5.5 km) was completely conducted once a week from 15 March to 15 May and it took about 2 h to complete it. Surveys were carried out during the first 3 h after dawn and the last 3 h before dusk by two trained people (a gamekeeper and a technician) using a 4x4 vehicle. Playback recalls were not used since they could negatively affect red-legged partridge detection in low-density populations [41].

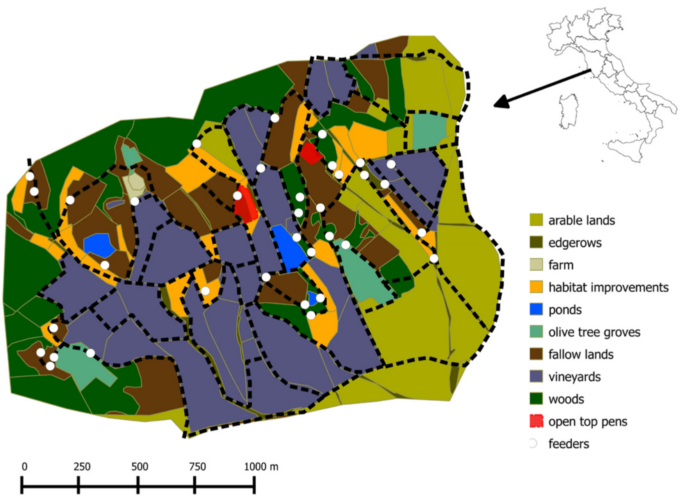

Figure 1: Study area. The dashed line represents the net of transects.

Each observation reporting the type of habitat was registered using a hand hold GPS. Observations of pairs were considered as single observations to avoid their dependence. As for pheasants, we considered only territorial cocks because they can be detected more easily than hens and no-territorial cocks. By so doing, the risk of underestimating the presence of pheasants in closer habitats was reduced. Surface areas covered by different types of habitat were measured from aerial photographs at 1:10.000 using a GIS software (QGIS 1.8.0).

The investigation of the two species' habitat preference was carried out using two different procedures. First, we used $\chi 2$ analysis for independent samples to test the hypothesis that partridges and pheasants occupy different habitats in relation to their availability [42]. When $\chi 2$ reached the minimum significant value ($P<0.05$), the hypothesis was rejected and Bonferroni simultaneous confidence intervals for observed occupying proportions were calculated through the formula:

$$P_i \pm Z_{\alpha 2k} \ \sqrt{Pi\,(1-P_i)/n} \ [43\text{-}45]$$

where P_i is the observed occupying proportion for the i^{th} habitat, Z is the upper standard normal table value corresponding to a probability tail area of $\alpha/2k$ with $\alpha=0.05$ or 0.01 and k=no. of considered habitats, and n is the total number of observations. When the expected occupying proportions felt outside calculated intervals, differences between expected and observed occupying proportions were considered significant. Second, we verified the null hypothesis that the observed distribution of birds was not different from a random distribution. For this purpose, we created a number of random points equal to the number of observations. Then, we measured the distance between each observation and random point from the nearest kind of habitat including the variables that were difficult to analyze with the forward method (*i.e.* hedgerows, woodland edges, water points and feeders). We compared the two distributions by Mann-Whitney test, and we performed Logistic Regression Analysis between points with partridge pairs and pheasant cocks and an equal number of random points, using the distances from the nearest habitat as predictor variables [46]. Logistic Stepwise regression was first performed using the forward method of selection and then the backward one; the probability to enter was set to 0.25 and that to leave to 0.10. Pheasant or partridge presence was coded as 1, while absence as 0. In the end, we compared the distances between feeders and the nearest HIAs with the distances between feeders and the equal number of random points in order to verify the relationship between them (Unpaired t test).

Results

Distances between feeders and HIAs (60.7, SE 9.77) turned out to be significantly shorter than those between feeders and random points (113.6, SE 18.71) ($P<0.05$). Habitat use was significantly different from what expected both for red-legged partridge pairs and pheasant cocks. Partridge pairs showed a high preference for HIAs, while woods and fallow fields were significantly avoided. Nonetheless, the avoidance of woods and fallow fields in our study may be the result of birds being hardly detectable in close habitats. The use of the other habitats did not differ from their availability (Table 3). Pheasant cocks as well showed a higher use of HIAs than the other habitats (Table 4). As compared with random points, partridge pairs were significantly closer to hedgerows, HIAs, and fallow fields (Table 5), while pheasant cocks were significantly closer to HIAs, hedgerows, feeders, fallow fields, and woodland edges (Table 6).

Table 3: Habitat use by red-legged partridge pairs (pooled years: 2007-2012).

Habitats	Availability (km^2)	Expected occupying proportions (km^2)	Observed occupying proportions (km^2)
Arable crops	0.18	0.19	0.22
HIAs	0.09	0.09	0.23**
Olive tree groves	0.03	0.03	0.05
Fallow fields	0.20	0.20	0.14*
Vineyards	0.33	0.32	0.36
Woods	0.17	0.17	<0.01**
Total	2.69	-	n=124

HIAs, habitat improvement actions. *$P<0.05$; **$P<0.01$.

Table 4: Habitat use by pheasant cocks (pooled years: 2007-2012).

Habitats	Availability (km^2)	Expected occupying proportions (km^2)	Observed occupying proportions (km^2)
Arable crops	0.18	0.19	0.17
HIAs	0.09	0.09	0.28**
Olive tree groves	0.03	0.03	0.03
Fallow fields	0.20	0.21	0.14
Vineyards	0.33	0.32	0.28
Woods	0.17	0.16	0.11
Total	2.69		n=94

HIAs, habitat improvement actions. **$P<0.01$.

Logistic regression analysis between partridge pairs observation and random points showed a negative effect of distances from HIAs, hedgerows, vineyards and fallow fields, and a positive one from woods, arable crops, and olive tree groves (Table 7). For pheasants, a negative effect of distances was registered from HIAs, hedgerows, feeders, woods, and fallow fields, and a positive one from arable crops (Table 8).

Table 5: Average distance (±SE) of partridge pairs between random points and habitat variables (Mann-Whitney U test).

Habitat variables	Mean distances		U	P
	Partridge pairs	Random points		
HIAs	148±12.7	181±12.9	6531	<0.05
Hedgerows	40±3.1	64±4.9	5246	<0.0001
Feeders	188±12.1	212±12.5	6802	n.s.
Vineyards	64±9.3	78±11.8	7248	n.s.
Arable crops	244±21.3	200±21.1	6763	n.s.
Fallow fields	97±11.4	127±11.0	6544	<0.05
Olive tree groves	303±14.8	287±14.5	7153	n.s.
Water points	354±19.2	376±18.4	6974	n.s.
Woodland edges	268±21.2	225±224.8	6698	n.s.
Releasing points	1334±521	1535±507	6698	n.s.

HIAs, habitat improvement actions; n.s., not significant.

Table 6: Average distance (±SE) of pheasant cocks between random points and habitat variables (Mann-Whitney U test).

Habitat variables	Mean distances		U	P
	Pheasant cocks	Random points		
HIAs	133±16.0	182±14.7	3293	<0.01
Hedgerows	50±4.2	75±6.7	3290	<0.01
Feeders	159±13.1	221±15.4	3230	<0.01
Vineyards	69±13.2	83±14.2	4212	n.s.
Arable crops	221±25.3	212±24.6	4155	n.s.
Fallow fields	91±10.5	137±14.3	3623	<0.05
Olive tree groves	303±18.1	291±17.3	4198	n.s.
Water points	358±23.6	389±22.9	4022	n.s.
Woodland edges	138±17.0	245±22.7	3210	<0.01
Releasing points	1337±550	1466±515	6698	n.s.

HIAs, habitat improvement actions; n.s., not significant.

Table 7: Results of logistic regression analysis on distances between points with partridge pairs and random ones.

Habitat variables	Estimate	SE	P
HIAs	+0.004	0.0012	<0.001
Hedgerows	+0.017	0.0038	<0.0001
Vineyards	+0.003	0.0014	<0.05
Arable crops	-0.002	0.0008	<0.01
Fallow fields	+0.004	0.0013	<0.01
Olive tree groves	-0.002	0.0010	<0.05
Woodland edges	-0.002	0.0007	<0.05
Constant	+0.712	0.372	<0.05
Log likelihood=147.4; R_{adj}^2=0.142			
Area under curve=0.745; model χ^2=P<0.0001			

HIAs, habitat improvement actions.

Table 8: Results of logistic regression analysis on distances between points with pheasant cocks and random ones.

Habitat variables	Estimate	SE	P
HIAs	+0.003	0.0012	<0.05
Hedgerows	+0.009	0.0035	<0.05
Feeders	+0.003	0.0013	<0.05
Arable crops	-0.003	0.0010	<0.01
Fallow fields	+0.004	0.0016	<0.01
Woodlands edges	+0.003	0.0011	<0.001
Constant	+2.019	0.443	<0.001
Log likelihood=107.13; R_{adj}^2=0.178			
Area under curve=0.766; model χ^2=P<0.0001			

HIAs, habitat improvement actions.

What did not contribute significantly to the model fit in partridges were feeders and water points, while ti was water, olive and vine points in pheasants. In both species the releasing points were discarded from the model during the logistic stepwise regression. Regression models [Rsquare (U)] explained 14.2% of the variance for partridges pairs and 16.0% of pheasants. The area under curve was 0.75 using pairs as the positive level and 0.77 using cock.

Discussion

Patterns of habitat use and selection recorded for red-legged partridges and pheasants in the area under study are consistent with others known for these game birds. Also, despite their importance [47], availability of water and water sources were not considered as a significant variable. This happened probably because drop irrigation was distributed in all vineyards and feeders (equipped with drinkers) provided water during summer. The effect of the releasing point was forgot by both species, probably on account of the time interval between release and counts (birds are released in summer and counts are carried out the next spring) and the small dimension of the area (2.9 km^2) with only two releasing points.

Partridges avoided the dense cover of woods that may also favor predation by mammals [48,49]. Fallow lands were avoided too, even if pairs seemed to stay close to these fields, as confirmed by the logistic regression model. This finding is only seemingly contradictory. Like gray partridges, red-legged are *birds of edges* which are attracted by field margins offering protection, like hedgerows [50,51]. Fallow fields are probably used only in part, but their presence seems to be important to provide cover and protection to aerial predators [52,53]. This also explains the strong effect of hedgerows on the distribution of the spring pairs. Other studies reported hedgerows as the most selected habitat by these species [8,54,55]. Conversely, the role of permanent crops as vineyards and olive tree groves in red-legged partridge presence and distribution remains unclear. Borralho *et al*. [50] found a positive effect of olive tree groves on the probability detection of red-legged partridges, but their use is probably related to the kind of cover at ground level. Vargas *et al*. [56] found that olive groves are a very important nesting habitat, but in summer they may represent an *ecological trap* when the herbaceous cover is dramatically reduced due to agricultural work. However that may be, in our case study olive groves represent a very small part of the study area and do not allow reliable assumptions. Traditional vineyards are known to positively act on red-legged partridge populations [57,58]. The highest abundance of partridges within the Mediterranean part of France was found in agricultural areas highly dominated by vineyards and/or cereal crops [57]. The habitat importance of vineyards is probably more related to its structure as shelter habitat, which ensures a good protection for partridges rather than to its food resource. In our study vineyards were the most important crops for partridges.

The effect of woodland edges, hedgerows and fallow lands on pheasant distribution in the study area was consistent with the ecology of this game bird, while permanent crops, vineyards and olive tree groves did not affect the pheasant positions. In fact, these habitats were excluded by the stepwise selection of the best parameters which affected the pheasant positions with respect to the random points.

Pheasants are primarily birds of woodland edge. In winter they spend most of the time within 30 m from the open ground. Woodland edges also are important features of pheasant breeding territories in spring, although some birds establish their territory along hedgerows, ditches, or in areas of rough ground [9]. In northern Italy, Nelli *et al*. [46] found that re-afforestation has an important role in determining pheasant male distribution.

Supplemental feeding is a popular and easy tool in game birds management. In our study, artificial feeding points seemed to have a strong effect on pheasant distribution, whereas this effect was weaker on partridge behaviour as feeders were discarded by stepwise selection. Possibly, the *suspended* feeders are less suitable for partridges, although these birds were seen feeding on them. Feeders were established mainly for pheasants and they might have been in wrong places for partridges (*i.e*. near woods). In addition, a competition between the two species for the use of feeders cannot be excluded. Despite supplemental feeding is a very common practice, the use of hoppers by partridges needs further investigation, at least when pheasants are present. Hoppers may save the time commonly spent for the feeding activities, thus reducing the risk of predation [29], yet some possible disadvantages cannot be ignored. Feeding with wheat which is low in fiber and protein may reduce the functionality of the internal organs of partridges (heart and caeca) [59].

Both species confirmed to show a high selection of HIAs. Many studies showed that these actions may improve density and/or reproductive success of wild galliformes [13,46,60-64], especially if they are scattered in the landscape [65]. In the study area, different types of crops (winter cereals, spring crops and hay fields) were cultivated side by side, so they could offer both food (seeds and insects) and shelter. Furthermore, HIAs were not treated with herbicides so that they yielded more weeds than seeded crops. Seeds used for HIAs are probably a good and safe food source for birds since they are not treated with pesticides: recently, pesticides-treated seeds have been shown to represent a risk for farmland birds [66]. HIAs remain unharvested and mowing (for grasslands) is postponed until the end of the nesting season (late July) providing food and cover when there is no plentiful supply [67].

Conclusions

In a landscape dominated by intensive agriculture (here vineyards), habitat improvements were confirmed to act as key factors. Indeed, HIAs were used significantly more than favorable crops such as vineyards, having a positive impact not only on game-birds but also on the biodiversity of the agricultural zones [68-70]. However, since feeders were often located close to the HIAs, we cannot exclude that the effect of HIAs on the distribution of the game-birds in our study area was affected by the presence of feeders (and vice versa), even if there was no correlation between distances from feeders and distances from HIAs.

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