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Do helminths increase the vulnerability of released pheasants to fox predation?

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Abstract

The success of ring-necked pheasant (*Phasianus colchicus*) restocking in Asturias, northern Spain was assessed, and the role of parasites and predators in the mortality of released birds was studied. The experimental release of 56 radio-tagged pheasants showed that 98% of birds died within 12 days. As soon as 72 h after release, 67.5% of males and 55.0% of females were found dead. Foxes (*Vulpes vulpes*) killed 63% of the birds. The survival of those birds killed by foxes was lower than for birds which died due to other causes, and pheasants depositing eggs of the nematode *Eucoleus contortus* (Creplin, 1839) survived less than those apparently non-parasitized. No impact of the parasite on the pheasants' condition was found, but foxes preyed upon parasitized birds more than expected by random. The results suggest that: (i) the current pheasant releases in this area are unsuccessful and need to be improved; (ii) this is mainly due to intense predation by red foxes; and (iii) parasites could have some influence on the predation of released birds by foxes. However, the way parasites affect pheasant vulnerability remains unclear.

Introduction

During the last century, human activities have promoted large habitat transformations, leading to changes in the abundance and composition of animal communities (e.g. Gortázar *et al.*, 2000a). Asturias (northern Spain) is not an exception. The decline of autochthonous small game species such as the red-legged partridge (*Alectoris rufa*) or hares (*Lepus* spp.), along with the increase of wild ungulates (mainly the wild boar *Sus scrofa*) has lead hunters to search for alternative aloctonous small game species able to survive in the Atlantic climate of this region. Therefore, releasing ring-necked pheasants (*Phasianus colchicus*) in autumn for hunting purposes is nowadays a common practice, and it is estimated that some 8000 farm-raised pheasants are purchased yearly in Asturias (Principado de Asturias, 2001). However, little is known about the success of these releases and the causes of non-hunting losses.

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Survival of released gamebirds has received some attention in recent years (e.g. Gortázar *et al.*, 2000b). Some papers have criticized negative aspects such as sanitary and genetic risks, behavioural changes due to captive-breeding, physiological differences with wild birds, and specially the increased predation risk of reared individuals as compared to wild ones (see review by Dowell, 1992).

Some studies have shown that predators take a disproportionately large number of parasitized prey (Temple, 1987; Hudson *et al.*, 1992). In released farm-reared hen pheasants, anthelminthic treatment improved the survival during incubation compared with undosed birds (Woodburn, 2000). However, there is a lack of studies regarding the impact of pathogens on the survival of gamebirds immediately after their release.

Consequently, the aim of this study was to assess the actual success of current restocking practices for pheasants in Asturias, and to study the role of parasites and predators in the mortality of released pheasants. We hypothesize that: (i) pheasant releases may have low effectiveness; and (ii) parasitized pheasants will survive less than non-parasitized ones.

Materials and methods

Study area

The fieldwork was performed in an 8600 ha regional hunting area located in Colunga council (north-east of Asturias region, northern Spain; 5°34′W 43°48′N). The climate is wet temperate with warm summers and average temperatures of 10–12.5°C in November. In this month, average rainfall ranges from 150 to 200 mm, and the total annual rainfall is between 1200 and 1400 mm (Ministry of Public Works and Tourism, 1991).

The study area is a mix of eucalyptus (*Eucalyptus globulus*) woodlands, bramble (*Rubus* sp.) and gorse (*Ulex* sp.) scrubs, and grassland. Cattle raising, small dairy farms and a few plots devoted to apple orchards and mixed crops are the only production in the area other than wood.

The red fox (*Vulpes vulpes*) is the most abundant carnivore, but the European wildcat (*Felis sylvestris*), feral cat (*F. catus*), stone marten (*Martes foina*), weasel (*Mustela nivalis*) and genet (*Genetta genetta*), among others, are also present. Raptors observed most frequently during the fieldwork included goshawk (*Accipiter gentilis*), buzzard (*Buteo buteo*) and barn owl (*Tyto alba*), but a number of other species were observed occasionally. Predator control is uncommon in Asturias, and is limited to some casual fox shooting during the hunting season.

Field methods and data analysis

Animal translocations are usually conducted without monitoring, so reasons for their success or failure are frequently uncertain (Bright & Morris, 1994). Radio-tracking is the most appropriate method for studying the mortality causes of wildlife (Houseknecht, 1970). In the present study, a total of 400 young ring-necked pheasants were ringed and released on the whole Colunga regional hunting area. Fifty-six of these pheasants (38 males and 18 females) were randomly selected and fitted with radio-tags (Biotrack, Dorset, UK). All pheasants were acquired from the main breeding facility in the region, placed 15 km away from the release site. Prior to their release, the pheasants had been maintained in a 2500-m^2 pen with natural vegetation and abundant perches, and fed with commercial pelleted food. They were routinely treated against coccidia but not with anthelminthics.

Radio-tagged pheasants were measured and a faecal sample was obtained from each one the day before their release. We quantified the deposition of parasitic stages by flotation and counting in a MacMaster chamber (Melhorn *et al.*, 1992). Prevalence and egg shedding were calculated with Quantitative Parasitology 1.0 (Rózsa *et al.*, 2000). The residual of the regression of body weight on the cube of tarsus length was taken as condition index (Andersson, 1992).

Predator relative abundance (kilometric abundance index, KAI) in the study area was estimated through 16 nightspotting surveys on a fixed 7-km route surrounding the release site. Surveys were carried out the night before and the three nights after the releases, whenever the weather made it suitable.

In the study area, gamebird releases are carried out at noon. They are direct (without acclimatization pens) and grouped. Hence, we imitated this procedure. Radio-tagged birds were released on 3 November (11 pheasants), 22 November (19), 1 December (12) and 9 December (14). Legal hunting was suppressed in a 2500-m radius around the release site, but continued elsewhere in Colunga. All radio-tagged birds were tracked using a hand-held antenna and receiver (Wagener Telemetrieanlagen, Köln, Germany). They were located at least twice a day during the first 3 days, and at least once daily thereafter. If any mortality sensor became active, we searched for the transmitter almost immediately. Locations of the birds were noted on 1:5000 aerial photographs. When a radio-tagged bird was found dead, we tried to identify the predator by looking for faeces, feathers and footprints and by inspecting carcasses and transmitters for toothmarks or any other relevant signs. We also noted whether the bird was buried and if the death could be attributed to foxes or not.

The 344 non-radio-tagged pheasants were released in the whole hunting area. In addition to the 56 tagged pheasants, 44 were released inside the part where pheasant hunting was prohibited.

Survival of radio-tagged pheasants was estimated by aid of the Kaplan-Meier product limit estimate, and logrank tests were used to test against the null-hypothesis of lack of differences between groups (Church, 1993). This procedure allows us to distinguish between complete data (i.e. time of death known) and censored ones (i.e. transmitter failure or loss), and to test for survival differences between study groups. We used ANOVA to test if fox-predated pheasants were in poorer condition, and if this was affected by the presence/absence of parasites. Helminths with prevalences less than 5% were not included in the analysis. Qualitative data were tested for homogeneity with the Chi square test or Fisher's exact test (Siegel, 1970). All statistics were performed with the software SPSS for Windows v10.0.6.

Results

Parasites

The coprological analysis of the pheasants revealed low prevalences of *Trichostrongylus* sp. (0.02, 95% CI = 0.00–0.11), *Heterakis* sp. (0.08, 0.02–0.20), and *Syngamus* sp. (0.02, 0.00–0.11) eggs, and low numbers of *Eimeria* sp. oocysts (140.0 ± 563.3). High prevalences and abundances of excretion were found only for *Trichuris*-like eggs. Necropsies revealed that these eggs belonged to *Eucoleus contortus* (Creplin, 1839), a nematode parasite of the crop and oesophagus (Anderson, 2000). The prevalence was 0.24 (0.12–0.41) in males and 0.40 (0.12–0.74) in females, and egg shedding was 25.8 ± 80.6 eggs per gram of faeces (mean ± SD) in males and 56.7 ± 160.8 in females. Sex-related differences in *Eucoleus*-egg prevalence and shedding were not significant ($Chi^2 = 1.38$, 1 d.f., $P > 0.05$ and K-W, $Chi^2 = 0.03$, 1 d.f., $P > 0.05$, respectively).

Predators

During the spotlight surveys, 0.45 ± 0.24 foxes per km

Table 1. Causes of death of 52 radio-tagged pheasants (*Phasianus colchicus*) released in Asturias (Spain) in November 2000.

Cause of death	Males		Females		Total	
	n	%	n	%	n	%
Fox predation	22	62.9	13	76.4	35	67.3
Small carnivore predation	3	8.5	0	0	3	5.7
Raptor predation	1	2.9	1	5.9	2	3.8
Unidentified predation	1	2.9	1	5.9	2	3.8
Total predation	27	77.2	15	88.2	42	80.7
Disease	3	8.5	0	0	3	5.7
Poaching	0	0	1	5.9	1	1.9
Unexplained cause	5	14.3	1	5.9	6	11.5

were detected. Feral cats, European wildcats, and genets were observed in very low abundance (KAI < 0.07 in all cases). Foxes were the only carnivore species seen in the release site.

Causes of death

Radio-tag failures occurred on four occasions, three males and one female. The causes of death of radio-tagged pheasants are shown in table 1, most cases being attributed to foxes. In fact, foxes were the apparent cause of death of 84.6% of the males (n = 11) and of all the females (n = 7) that died in the first 24 h after release (see fig. 1). On 24 of 35 occasions (69%), only the buried head and neck of the pheasant were found together with the radio-tag. Three pheasants appeared dead without signs of predation, almost emaciated and with signs of severe enteritis. These were assumed to be disease cases. In one occasion a radio-tag was found with evident signs of human manipulation. We defined this case as poaching.

Survival

Despite 300 birds being released in parts of the hunting area where pheasant shooting was allowed, the local hunting club returned only four rings of non-radio-tagged pheasants shot until January 2001. Regarding radio-tagged pheasants, the logrank test did not discard the null-hypothesis of no difference between survival probabilities observed depending on the date of release (Logrank test, $Chi^2 = 2.31$, 3 d.f., $P > 0.05$ and $Chi^2 = 1.08$, 2 d.f., $P > 0.05$ for males and females, respectively). Thus, all data were pooled together in the following results.

There were no significant differences in survival between both sexes (Logrank test, $WW = -1.5$, test statistic -0.58, $P > 0.05$). As soon as 72 h after release, 67.5% of males and 55.0% of females were found dead. With the exception of one male, which flew to an apple orchard 2000 m away from the release spot and survived 28 days, no pheasants were alive 12 days after their release.

We found that the survival of those birds killed by foxes was lower than for birds which died of other causes ($WW = 6.32$, test statistic 2.84, $P < 0.01$). On the other hand, we found significant differences in the survival depending on the presence of *Eucoleus* eggs: pheasants without parasite eggs in their faeces survived longer than those parasitized by the nematode ($WW = -5.59$, test statistic -2.40, $P < 0.05$). Moreover, we found a positive association between *Eucoleus* excretion prevalence and the cause of death (fox/not fox): pheasants shedding eggs of this nematode were more frequently killed by foxes than by other causes (Fisher's test, $P = 0.005$). Regarding the body condition of dead pheasants, surprisingly, foxes did not tend to predate on substandard individuals (two-way ANOVA, $F_{(1,39)} = 0.02$, $P > 0.05$), and the body condition was apparently unaffected by the presence/absence of *E. contortus* (two-way ANOVA, $F_{(1,43)} = 0.94$, $P > 0.05$).

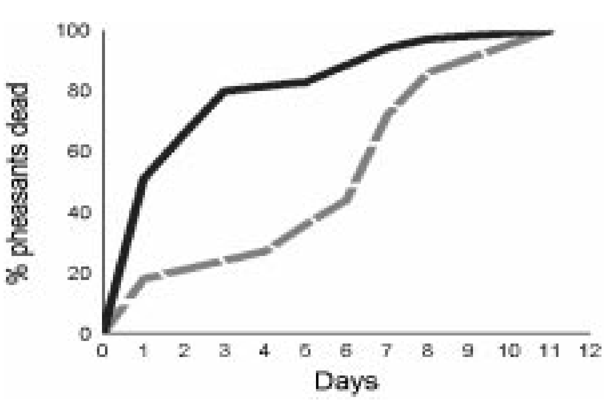

Fig. 1. Cumulative mortality of radio-tagged pheasants (*Phasianus colchicus*) released in Asturias (Spain) in November 2000, depending on the cause of death (—, foxes; ---, other causes). Radio-tag failures and unidentified causes are not included.

Discussion

As expected, the survival of released pheasants was extremely low. In fact, the survival rates reported here are, to our knowledge, the lowest ever described for this gamebird (e.g. Burger, 1964; Hessler *et al.*, 1970; Sodeikat *et al.*, 1995). It is well known that the mortality of farm-reared gamebirds is particularly high during the first days after release (e.g. Burger, 1964; Gortázar *et al.*, 2000b), and in pheasants usually less than 60% survive the first month (Hessler *et al.*, 1970; Robertson, 1988; Sodeikat *et al.*, 1995).

Few ringed pheasants were shot in the Colunga hunting area during the period of investigation, but some cases may have not been reported by the hunters. Nevertheless, we do not believe that the survival of non-tagged birds was better than that of tagged ones as discussed in Thirgood *et al.* (1995). Reasons for the failure of current pheasant restockings in Asturias may include: (i) unsuitability of the habitat; (ii) a high predation rate, due to the abundance of foxes and the release design; and (iii) the eventual effects of parasites such as the nematode *Eucoleus contortus*.

Habitat quality has been suggested to be a main factor determining the success of translocations (Wolf *et al.*, 1996), and the loss of traditional agriculture along with modern forestry practices have been claimed as causes for

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the decline of some gamebirds in northern Spain (Lucio *et al.*, 1992) and elsewhere (Klaus & Bergmann, 1994). At the time of release, the scarcity of food and intense rainfall may have affected the condition of the birds, making them more vulnerable.

The present results show a high total predation rate. In some studies, predators accounted for all the deaths of pheasants (Snyder, 1985). Compared with other authors (e.g. Sodeikat *et al.*, 1995), we found a very low raptor predation rate (only two cases, probably due to one buzzard and one goshawk). Nevertheless, previous research has shown that mammals are the most important predators of pheasants, and the red fox has been identified as their primary predator (see Riley & Schulz, 2001). In our case, the number of buried carcasses support the hypothesis of multiple hunting by foxes taking place. Moreover, fox abundance in the study area was much higher than that found in other Spanish regions (Millán *et al.*, 2001).

Disease-associated problems have been cited among the causes of restocking failures (Dowell, 1992). However, little is known about the non-lethal effects of pathogens in gamebirds (Woodburn, 2000). Hudson *et al.* (1992) demonstrated that red grouse (*Lagopus lagopus scoticus*) hens dosed against the nematode *Trichostrongylus tenuis* were detected by dogs at a lower rate than undosed hens. They also reported that grouse killed by predators harboured more caecal worms than birds that were shot (but see Moss *et al.*, 1990).

Here, we found an association between fox predation and parasitization by *E. contortus*. Taking into account that we found no relation between *E. contortus* egg shedding and the bird's condition, nor between condition and fox predation, the way the parasite affects pheasant mortality remains unclear. Nevertheless, the low sample size and the power of the statistical test used makes it difficult to detect a subtle negative effect of the parasite on the pheasant's body condition.

Hudson *et al.* (1992) hypothesized that the nematode *T. tenuis* induces more smelly, detectable faeces, making grouse more vulnerable to predation. However, *E. contortus* inhabits the crop and oesophagus, and not the lower part of the digestive tract. On the other hand, parasites can affect prey vulnerability through some other mechanism, e.g. changing the host's behaviour or appearance. This is most common when a prey species is the intermediate host of a predator's parasite (Quinn *et al.*, 1987). An alternative possibility is that parasites compete for the pheasant's resources and thus the birds must spend more time feeding on the ground, which would make them more vulnerable to fox predation.

In conclusion, the effectiveness of gamebird releases relies not only on factors such as habitat suitability or predation avoidance, but also on the health of farm-reared gamebirds. Given the results, more studies regarding the impact of parasites on wildlife releases are needed.

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