Survival and Reproduction of Pen-Reared vs Translocated Wild Pheasants Phasianus colchicus

Authors: Musil, David D., and Connelly, John W.

Source: Wildlife Biology, 15(1) : 80-88

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/07-049

Wildl. Biol. 15: 80-88 (2009)
DOI: 10.2981/07-049

www.wildlifebiology.com

Original article

Survival and reproduction of pen-reared vs translocated wild pheasants *Phasianus colchicus*

David D. Musil & John W. Connelly

We compared vital rates of two different ring-necked pheasant *Phasianus colchicus* stocks (pen-reared and wild) and assessed effects of predator control on these pheasants released into current range. Wild (31 males and 112 females) and pen-reared (230 males and 1,059 females) ring-necked pheasants were released in spring into two areas in southern Idaho during 2000-2001 to augment low resident populations. Wild female survival (value $\pm$95% CI) from 1 March-1 October was significantly greater than that of pen-reared females in both 2000 (0.40 ± 0.14, N=62 vs 0.04 ± 0.07, N=49) and 2001 (0.43 ± 0.16, N=40 vs 0.08 ± 0.10, N=40). Of 134 documented deaths of radio-marked female pheasants, 54% were due to unknown predation, 26% to mammalian predators, 12% to avian predators, 4% to natural causes, and 4% were human caused. Wild females had a 0.23 ± 0.09 (N=88) nesting rate and pen-reared females 0.28 ± 0.18 (N=25). During 2001, predators were removed within our study areas. Survival of wild male pheasants increased after predator removal (0.20 ± 0.35, N=6 vs 0.70 ± 0.28, N=10), but survival did not increase for either stock of female pheasants after predator removal. Predator control did not increase the number of hens surviving to reach the nesting season (1 May), nesting rate or nest success. Wild female pheasants were seven times more likely to survive translocation to 1 October, 10 times more likely to survive to the nesting season, eight times more productive, and one-third as expensive per egg hatched than pen-reared females. Low survival, poor productivity and higher costs of spring-released pen-reared female pheasants strongly suggest that this is an inappropriate management tool for increasing pheasant numbers.

Key words: costs of releases, pen-reared vs wild, Phasianus colchicus, pheasants, predation, reproduction, survival, translocation

David D. Musil, Idaho Department of Fish and Game, 324 South 417 East, Jerome, Idaho, 83338 USA - e-mail: dmusil@idfg.idaho.gov
John W. Connelly, Idaho Department of Fish and Game, Department of Biological Sciences, Idaho State University, Pocatello, Idaho 83209 USA - e-mail: jcsagegrouse@aol.com

Corresponding author: David D. Musil

Received 5 July 2007, accepted 7 April 2008

Associate Editor: Laurence Ellison

Declines in ring-necked pheasant *Phasianus colchicus* numbers in many parts of the species' range in North America and Europe during the last two decades have caused controversy about pheasant management and resulted in suggestions to release pen-reared pheasants to augment low populations. Habitat loss due to farming practices, changes in predator species and abundance, increased use of pesticides, or combinations of these factors have been identified as reasons for pheasant declines (Trautman 1982, Leptich 1992). Despite this, members of the public often demand that pheasant populations be supported by stocking of pen-reared birds and predator removal (Brittas et al. 1992, Strickland et al. 1994, Connelly et al. 2005).

Response of pheasants to predator removal has been documented for wild resident birds (Chesness et al. 1968, Trautman et al. 1974, Nohrenberg 1999, Frey et al. 2003), but not while augmenting populations simultaneously with pen-reared and translocated wild pheasants. Release of pen-reared and wild pheasants has been used by several state agencies in attempts to repopulate former pheasant ranges, supplement low populations, start new populations (Trautman 1982), and augment hunting opportunities in the fall (Hill & Robertson 1988). Releasing pen-reared stock has not been an effective or efficient method of increasing populations, because these birds are vulnerable to predators (Trautman 1982, Leif 1994) and reproduce poorly (Hill & Robertson 1988). To our knowledge, no investigators have evaluated the combination of translocating wild pheasants and predator removal. Thus, the purpose of our study was to compare vital rates of two different pheasant stocks (pen-reared and wild) and determine the effects of predator control on these pheasants. We hypothesized, based on past literature, that survival and reproduction of wild pheasants would be greater than pen-reared pheasants released into the same habitats. We also predicted that predator control would have no effect on survival of either stock of pheasants.

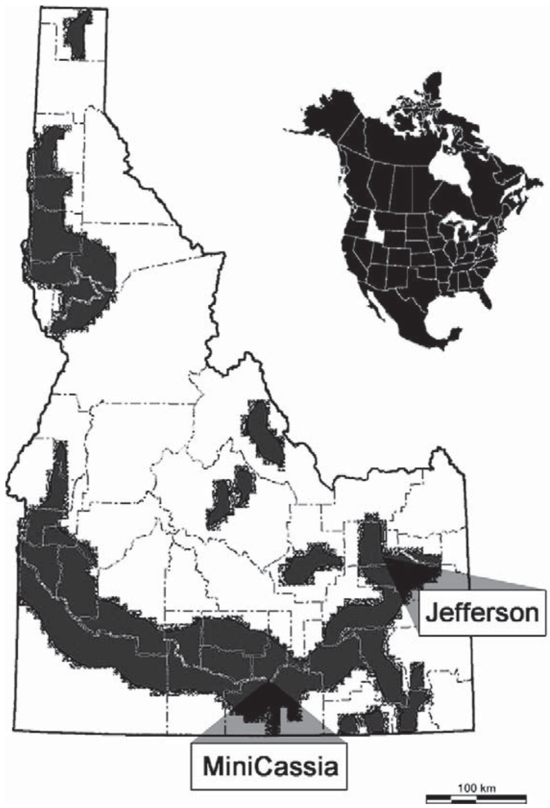

Figure 1. Study areas in Idaho where pheasants were released and monitored in 2000-2001. Shading denotes pheasant distributions.

Material and methods

Study areas

Wild and pen-reared pheasants were released in two study areas (MiniCassia and Jefferson) privately owned in southern Idaho on the Snake River Plain within the range of pheasants in the state (Fig. 1). The study areas are relatively flat (1,260-1,450 m a.s.l.) with an annual precipitation of 20-30 cm. Although the Snake River Plain was originally dominated by sagebrush *Artemisia tridentata* steppe vegetation, much of the area is now dominated by irrigated agricultural crops. Agricultural crops and habitat types include wheat *Triticum aestivum*, alfalfa *Medicago sativa*, sugar beet *Beta vulgaris*, grass pastures, grass road ditches, isolated patches of shrubland, and narrow riparian zones with trees and berry producing shrubs.

Release areas were chosen by local advisory groups, appointed by state legislators to represent the interests of the local sport-hunting public. Release areas were based on the hunting experience of the advisory groups and, in their opinion, areas currently having adequate habitat but too low pheasant numbers.

Wild pheasant translocation

Wild pheasants were captured in Oregon (Malheur National Wildlife Refuge) with mist nets and walk-in baited traps (Nohrenberg 1999) and in California (Sacramento Valley) by night-lighting (Giesen et al. 1982, Wakkinen et al. 1992). During 2001, birds were only captured by night lighting and only in California.

Prior to transport to release sites, we equipped the pheasants with battery-powered 14-g necklace radio transmitters (Riley & Fistler 1992), programmed with 4-hour mortality sensors (Advanced Telemetry Systems, Isanti, MN 55040). Only pheasants weighing >700 g were radio-marked to keep transmitters $\leq 2\%$ of body mass (Kenward 1987).

Pen-reared pheasant releases

In both years, 10-month-old pen-reared stock was purchased (US $9.50/bird) from local game farms. During 2000, birds were held overnight, fitted with aluminum bands and radio-collars, nasal blinders removed, and released the next day. During 2001, we radio-marked pheasants three days prior to release allowing them to acclimate to the radios at the game farm before being released. The same style of radio transmitter was used on pen-reared as on wild pheasants.

Telemetry and survival

We monitored radio-marked birds from the ground with 3-element yagi antennas twice per week in 2000 and 3-5 times per week in 2001 from day of release to 1 October each year. We determined cause of death by characteristics presented by Einarsen (1956). We defined time of death as the mid-point between the first mortality signal and the last live contact. We estimated survival using the Kaplan-Meier staggered entry method (Pollock et al. 1989) with the computer program STAGKAM (Kulowiec 1988). Multiple comparisons among survival estimates were protected by significant χ^2 tests with program CONTRAST (Hines & Sauer 1989, Sauer & Williams 1989). Comparisons of body mass were made using the GLM procedure and Tukey's Studentized Range Test (HSD) for multiple comparisons. Overlap of 95% confidence intervals (Fleis 1981) was used to test for differences in the proportions of birds dying over time. All values are presented with 95% confidence intervals (value $\pm$ 95% CI).

Pheasant production

We recorded number of eggs hatched immediately after termination of the nesting attempt. Additionally, in 2001, we determined clutch size by flushing the female from the nest during the last week of incubation. We considered a nest attempt successful if at least one egg hatched. Brood survival was determined by counting flushed chicks at four and eight weeks post-hatch (Nohrenberg 1999) in 2001. We used overlap of 95% confidence intervals (Fleis 1981) to test differences in proportions of females surviving to the nesting season (1 May), nesting rates and nest success. Nesting rate was defined as the proportion of hens attempting to nest of those alive at the beginning of the nesting season.

Predator control and abundance

After establishing baseline vital rates for translocated pheasant stocks in 2000, losses to predation were deemed unacceptably high and an adaptive management approach was implemented in late March 2001 through July 2001 by contracting two trappers, one for each study area. Trappers were given a list of target species and trapped within a 4.8-km (72 km^2) radius of the release sites. Just prior to pheasant releases, trappers concentrated on mammalian predators within 1.6 km of release sites. Padded leg-hold traps (size #1.5, #3) were provided for trapping near residences to avoid harming domestic pets (Olsen et al. 1988, Onderka et al. 1990, Hubert et al. 1997). Unpadded steel jawed traps, snares and conibear traps (size #120) were used in remote areas. Walk-in circular live traps (Alsager et al. 1972) were used to remove corvids after pheasants were released. No other avian predators were removed.

We informed landowners of the predator control project and trappers were restricted to those granting permission. All captured predators were disposed of according to procedures established by the Idaho Department of Fish and Game. House cats without identification collars were euthanized and collared cats were released. Trappers recorded their time spent trapping, number of trap nights, and number and species of predators trapped for 2-week periods throughout the trapping season (March-July).

In 2001, we used roadside spotlight counts at night and scent station surveys on a 40-km route in each area immediately surrounding the release site to assess predator activity and effectiveness of predator control. Roadside spotlight counts were conducted in June-July and involved driving a vehicle 20 km/hour while an observer scanned with a 1-million candle power spotlight and binoculars. Scent surveys (Roughton & Sweeny 1982, Travaini et al. 1996, Sargeant et al. 1998) were conducted with 20 stations per study area during the first week of August, after predator removal ceased. Stations were monitored for four evenings of exposure.

Results

Translocation

Wild pheasants were passively released in both years. Padded lids (to avoid scalping) of the transport crates were pulled open simultaneously with a string by concealed observers and birds walked or flushed from the site without disturbance. From 29 February-31 March 2000, 92 wild pheasants (71 females and 21 males) were released within three days of capture (Table 1). On 28 March 2001, 51 wild pheasants (41 females and 10 males) were released six days after capture. Wild birds were held in captivity longer in 2001 because results of mandatory blood tests were delayed. All wild birds had to test negative for disease before legally released into

Table 1. Number of wild and pen-reared pheasants translocated into Idaho, USA. M = males and F = females. Number of birds with radio-transmitters are given in parentheses.

	Year released							
	2000				2001			
	Wild		Pen-reared		Wild		Pen-reared	
Study area	M	F	M	F	M	F	M	F
Jefferson	12 (6)	37 (33)	20 (4)	119 (24)	5 (5)	20 (20)	100 (5)	450 (20)
MiniCassia	9 (0)	34 (29)	10 (4)	40 (25)	5 (5)	21 (20)	100 (5)	450 (20)
Total	21 (6)	71 (62)	30 (8)	159 (49)	10 (10)	41 (40)	200 (10)	900 (40)

Idaho. We radio-marked 74% of wild birds in 2000, and 98% in 2001.

Pen-raised birds were actively released by pouring them out of the transport crates, because they tend to remain in the crates even if opened. On 6-7 April 2000, 159 female and 30 male pen-reared pheasants were released in MiniCassia and Jefferson study areas (see Table 1). On 16 March (MiniCassia) and 30 March (Jefferson) 2001, 900 female and 200 male pheasants were released. We equipped 30% of the pen-reared birds in 2000 with radios, and 5% in 2001. Wild females were significantly lighter than all other birds, with no detectable effect of year on body mass (Table 2). For males, we detected no effect of release stock or year on body mass.

Predator control

Because of frozen ground conditions in MiniCassia, predator control could not begin earlier than two days before release of pen-reared birds and 14 days before that of wild birds in 2001. In Jefferson, predator control started 11 days and 9 days before pen-reared and wild releases, respectively. Trapping in MiniCassia removed 271 black-billed magpie *Pica pica*, 35 striped skunk *Mephitis mephitis*, 13 coyote *Canas latrans*, five mink *Mustela vison*, two red fox *Vulpes fulva*, two badger *Taxidea taxus*, and one feral cat *Felis domesticus* for 2,358 trap nights costing US $3,119. In Jefferson, predator trapping removed 189 black-billed magpie, 53 striped skunk, 33 red fox, 11 feral cat, and two coyote for 1,526 trap nights costing US $5,441. Predator trapping cost US $13.87/animal removed and US $2.20/trap night. Only the contracted labor was included in the estimate, not the cost of traps.

Table 2. Mean body mass of pheasants released into Idaho, USA. GLM F statistic = 40.0, P < 0.001, multiple comparisons (Tukey's Studentized Range Test) with same letter are similar at 0.05 level of significance.

	Year released					
	2000			2001		
Gender/Stock	Mean	95% CI	N	Mean	95% CI	N
Females						
Pen-reared	1046	1011-1081	49 a	1050	1008-1092	40 a
Wild	874	847-901	57 b	929	905-953	40 b
Males						
Pen-reared	1238	1163-1313	8 c	1265	1181-1349	10 c
Wild	1145	1261-1029	13 ac	1258	1161-1355	20 c

Survival

From time of release to 1 October, wild female pheasants had greater 6-month survival than pen-reared females during both years (Table 3). Wild males survived better than pen-reared males in 2001, but not in 2000. Wild male pheasants had greater overall survival in 2001 than 2000, but there were no differences between years within the same stock and gender for wild females or for pen-reared females and males.

A higher proportion of pen-reared female pheasants died during the first seven days post-release in 2000 than in 2001 (0.59 ± 0.15 vs 0.22 ± 0.14). Moreover, the proportion of females that died during these seven days in 2000 was greater among pen-reared than wild hens (0.06 ± 0.08). Proportionally more wild female mortalities than pen-reared occurred > 30 days post-release in 2000 (0.88 ± 0.11 vs 0.14 ± 0.10), but not in 2001 (0.68 ± 0.19 vs 0.36 ± 0.16). All pen-reared male mortalities (100%, N =

Table 3. Translocated pheasant survival (1 March-1 October) and comparisons for pre- (2000) and post-predator (2001) removal in Idaho, U.S.A.

Gender/	Pen-Reared			Wild			
Year	Survival	95% CI	N	Survival	95% CI	N	P^a
Females							
2000	0.04	0.0-0.11	49	0.40	0.26-0.54	62	< 0.0001
2001	0.08	0.0-0.18	40	0.43	0.27-0.59	40	0.004
P^b	0.5407			0.7901			
Males							
2000	0.0	0.0-0.0	8	0.20	0.0-0.55	6	0.2636
2001	0.0	0.0-0.0	10	0.70	0.42-0.98	10	< 0.0001
P^b	1.0			0.03			

[a] χ^2 comparisons between stocks within same year and gender.
[b] χ^2 comparisons between years within same stock and gender.

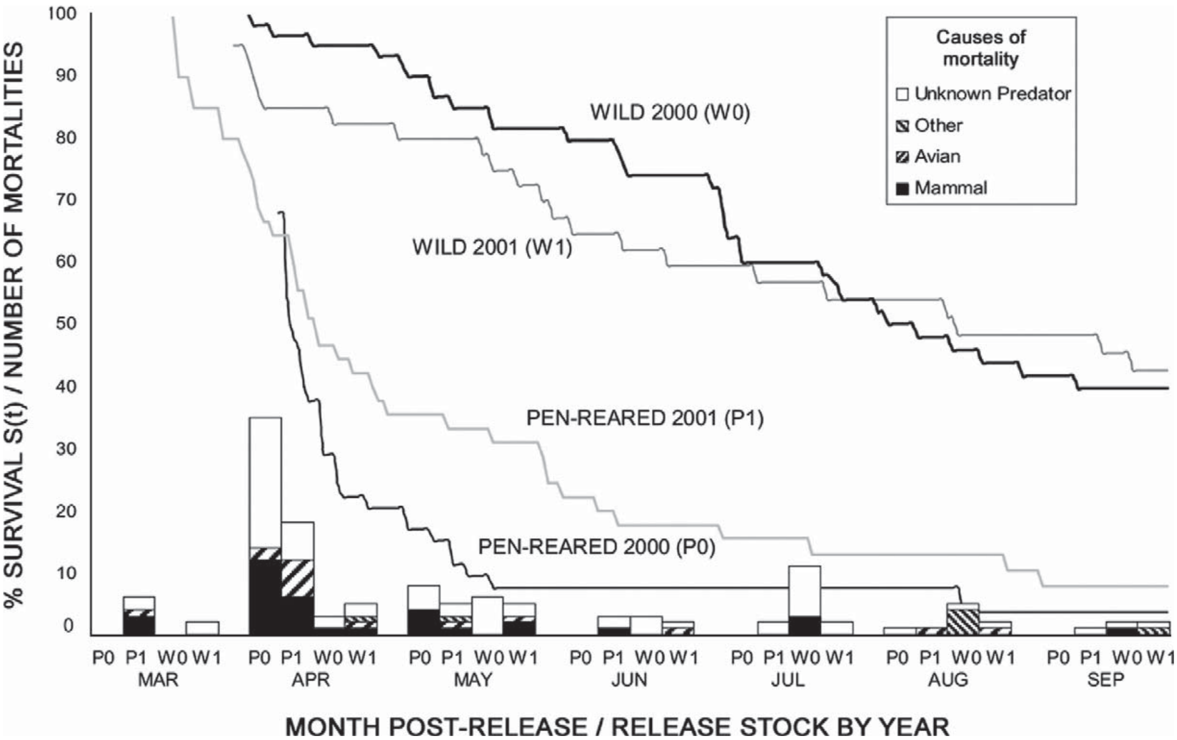

Figure 2. Survivorship functions and causes of mortality by month for wild and pen-reared female pheasants released during 2000 and 2001 in Idaho, USA.

17) occurred within 30 days post-release and most (50-86%) occurred within seven days of release. No other differences for males could be detected due to low sample sizes. Survival of pen-reared females appeared to decline more rapidly during the first two months post-release for the year prior to predator removal (2000) than after predator removal (2001), but survival approached the same estimate for both years by 1 October (Fig. 2).

Most of the mortality was caused by predation of pen-reared (99%) and wild (82%) released female pheasants (see Fig. 2). Predator-specific mortality could not be determined for the majority (54%) of documented female pheasant deaths, therefore, cause-specific mortality rates were not computed. At least 26% of the mortalities were caused by mammalian predators, 12% by avian predation, 4% from natural causes, and 4% were human caused.

Nesting

The proportion of radio-marked pen-reared female pheasants surviving to the nesting season (1 May) was not different before predator control (0.18 ± 0.11, N=49) and after (0.40 ± 0.15, N=40). Survival to the nesting season for wild females also remained constant with 0.89 ± 0.08 (N=62) before and 0.83 ± 0.12 (N=40) after predator control. Both years combined, more wild females (0.86 ± 0.07, N=102) survived to the nesting season than pen-reared (0.28 ± 0.09, N=89) birds. However, perhaps due to small sample sizes, we could not detect a change in nesting rate or survival to produce chicks for either pen-reared or wild females before and after predator control. For both years combined, nesting rates were similar for pen-reared (0.28 ± 0.09, N=25) and wild (0.23 ± 0.09, N=88) released pheasants, but, a smaller proportion of pen-reared (0.01 ± 0.02, N=89) than wild (0.10 ± 0.06, N=102) radio-marked females survived to produce chicks. We could not detect differences in nest success and average clutch sizes due to small samples sizes of nests (seven for pen-reared and 20 for wild nests for both years combined).

Predator abundance

The goal of monitoring predators was to document their presence during the later part of the trapping period and after trapping was concluded. Spotlight counts were conducted during the last two months of predator trapping, June-July, 2001. House cat presence in MiniCassia increased from 0.13/km-0.99/km during June through July. Detection of striped skunk in Jefferson increased from 0.08/km-0.39/km for the same period. Scent station surveys were conducted within seven days of the end of the trapping season. In MiniCassia, we detected attendance by house cats (0.36 visits/station), domestic dogs *Canis familiarus* (0.13 visits/station), unknown canids (0.03 visits/station), and striped skunks (0.02 visits/station). Scent station attendance in Jefferson included house cats (0.08 visits/station), coyotes (0.06 visits/station) and red fox (0.01 visits/station). Of all the predators removed in 2001, 11% of the black-billed magpies, 7% of the striped skunks, and 3% of the red fox were removed during the last two weeks of trapping in July. These predator surveys and trapping records clearly indicate that a variety of predators were still relatively abundant throughout the summer in 2001, and continued to cause pheasant mortality (see Fig. 2) despite the implementation of predator control.

Pheasant costs

We did not determine cost estimates for wild pheasant trapping in 2000, but in 2001, an estimated US $53/bird was needed to capture, transport and release wild pheasants (D. Musil, unpubl. data). Pen-reared pheasants cost US $9.50/bird to be released. Using production estimates from radio-marked pheasants and the cost of release in spring, it cost US $170/pen-reared egg hatched and US $62/wild egg hatched. Estimates for brood survival were too limited to estimate cost/bird available for the fall harvest.

Discussion

Translocation

In Idaho, pen-reared pheasants released into the same habitats as translocated wild pheasants had significantly lower survival. In fact, wild females were seven times more likely to survive from spring to 1 October than pen-reared females. In 2001, we acclimated pen-reared pheasants to radio-collars and reduced transportation time, but did not detect an increase in overall survival. Our study provided similar survival results to those of Leif (1994) for radio-marked pen-reared (0.08 ± 0.05) and wild (0.55 ± 0.12) females released in South Dakota in early April and monitored until October. Similarly, Anderson (1964) had 0.28 game-farm and 0.52 wild pheasant survival from winter to May, while Wilson et al. (1992) reported 0.26-0.42 survival (February-June) for translocated wild female pheasants. Brittas et al. (1992) also reported significantly higher survival for translocated wild female pheasants (0.74) than pen-reared (0.52) for three months post-release (May-July).

High mortality commonly occurs immediately after release as birds become acclimated (Hessler et al. 1970, Wilson et al. 1992) and this finding is supported by our data, especially for pen-reared stock. Translocated wild game birds may be more vulnerable to predation immediately after release due to increased movements while searching for adequate habitat (Kurzejeski & Root 1988, Musil et al. 1993). Burger (1964) attributed heavy initial mortality of game-farm stock to 'release shock' rendering pheasants more vulnerable to predation. Pen-reared pheasants may be more susceptible to predation, because they are unfamiliar with wild foods, thus increasing their foraging time and reducing predator avoidance behavior.

Other studies (Giudice & Ratti 2001) have shown average clutch sizes for first attempts of >12 eggs/nest and later attempts were closer to our average. Mean clutch size for wild pheasants in our study (8.6 eggs/nest) was similar to that reported by Nohrenberg (1999) for resident pheasants in southern Idaho (8.8 eggs/nest) and may be the normal response to habitat conditions rather than the result of translocation.

Many studies have demonstrated the inability of game-farm stock to augment wild populations. In our study, the production of a successful nest required either 11 wild or 89 pen-reared females pheasants. Similarly, Haensly et al. (1985) found it required seven game-farm females released in spring to produce one rooster in fall while Wilson et al. (1992) suggested a February release of 150 translocated wild female pheasants was needed to have 50 survive to nest. Hill & Robertson (1988) determined that breeding success was 2-5 times greater for wild than hand-reared male pheasants. They also found wild females were four times more productive than hand-reared females and hand-reared females were three times more vulnerable to predation than wild birds during April-August. Hill & Robertson (1988) estimated that wild pheasants produced seven times more 12-week-old chicks than hand-reared females. Although Brittas et al. (1992) found no difference in breeding success between wild and pen-reared stock, they indicated that wild brood size was significantly larger 40 days after hatch than brood size of pen-reared females. Leif (1994) concluded, "Releasing pen-reared females in spring to augment wild ring-necked pheasant populations is not a practical management option in South Dakota" and our results indicate that his conclusion can be applied more broadly than just to South Dakota.

Similar results have been reported for translocation of game-farm birds of other gallinaceous species. Parish & Sotherton (2007) examined the fate of released grey partridge *Perdix perdix* in Scotland and concluded that birds released in autumn had poor over-winter survival. Hess et al. (2005) demonstrated that pen-reared Attwater's prairie chickens *Tympanuchus cupido attwateri* had deficiencies in flight endurance and predator avoidance compared to wild greater prairie chickens *T. c. pinnatus*. Snyder et al. (1996) stated that captive breeding should be considered a last resort for species recovery and not a long-term or prophylactic solution to problems. Finally, Svedarsky et al. (2000) recommended that translocations should only be conducted in areas with adequate habitat where problems that caused the original population decline have been corrected.

Predator control

We could not detect an increase in overall survival of wild female pheasant transplants as a result of our short-term and small-scale predator removal, but it may have improved survival of wild male pheasants. Predator control appeared to decrease mortality for pen-reared female pheasants early after release, but did not ultimately increase overall survival.

Several studies have measured effects of predator removal on pheasant vital rates. Chesness et al. (1968) concluded that predator removal, even though it did increase nest success of pheasants, was not economically feasible for increasing pheasant numbers over large agriculturally dominated areas. Similarly, Trautman et al. (1974) found that multi-species predator control substantially increased pheasant numbers, but, intensive control of only foxes showed little effect on pheasants. In contrast, Nohrenberg (1999) could not demonstrate significant increases in pheasant abundance after multi-species predator removal in southern Idaho and his April-July wild female survival (0.51 ± 0.27 with predator control vs 0.34 ± 0.24 without) was similar to our wild female survival with (0.54 ± 0.16) and without (0.54 ± 0.14) predator removal for April-July.

Management implications

Wildlife managers cannot expect comparable survival and production from pen-reared pheasants relative to wild stock. It is clearly more cost effective to release wild birds to supplement wild populations. In our study, the capture and release of a wild bird costs 5.6 times more than the purchase and release of a pen-reared bird. But the cost of producing a young bird in summer was about three times greater for pen-reared than for wild stock. Wild female pheasants were 8.1 times more productive (hatched nests/female) than pen-reared females. If the intention is strictly to increase hunting opportunity, releasing before the gun is a much more efficient and practical use of pen-reared stock. Artificially supplementing game birds for harvest was criticized by Leopold (1933:394), when he said, "A proper game policy seeks a happy medium between a game supply and that which deteriorates its quality or recreational value" and "The recreational value of a head of game is inverse to the artificiality of its origin."

Predator control immediately before translocation appeared to slow the rate of mortality for pen-reared pheasants in our study, but did not increase overall survival for either pen-reared or wild translocated female pheasants. Predators were still relatively common after trapping ended and predation on pheasants still occurred, therefore, predator control was an extra added cost that was not effective in our study. If managers decide to use predator control, they must be committed to the cost of long term removal (Beasom 1974, Duebbert & Kantrud 1974) over large areas (Frey et al. 2003), and on multiple species (Chesness et al. 1968, Trautman et al. 1974) to be effective in reducing predator populations. The severity of the predator impacts (Balser et al. 1968), cost-benefit (Jimenez & Conover 2001) and social impacts (Rollins & Carroll 2001) must be determined by managers before predator control is implemented.

Acknowledgements - this project was funded, in part, by the US Fish & Wildlife Service Federal Aid in Wildlife Restoration Project W-160-R-31. We thank all the Idaho Department of Fish & Game (IDFG) personnel that worked on this project including field technicians: B. Atkinson, C. Fiorey, B. Harper, R. Hilton, R. Kolstad, A. Lewis, J. Pappani, J. Stirling and T. Taylor. Dr. M. Drew trained us in proper necropsy techniques. Regional support came from: B. Compton, T. Ferguson, D. Koehler, D. Kemner, J. O'Neill, B. Palmer and R. Smith, as well as from office staff in the Magic Valley and Upper Snake

Regions. Several IDFG reservists volunteered their time including L. Ames, E. Johnson, R. Runyon, W. Wallace and G. Wright. D. Megargle and S. Gamo assisted with statistical advice. K. Reese and D. Hawley (University of Idaho) provided technical and administrative assistance, respectively. We greatly appreciate the assistance of P. Blake, J. Garcia and K. Jones (and staff at the health laboratory) of California Fish & Game, R. Jones of the Sacramento Regional Wastewater Treatment Plant, University of California at Davis for blood testing, and M. Laws at Malheur National Wildlife Refuge. Many landowners allowed access to their private land and their cooperation is greatly appreciated especially N. Erickson, D. Johnson, J. Skaar and D. Skaar. Several members of local Pheasants Forever chapters served on the advisory boards and assisted with releases including: B. Cameron, B. Caywood, T. Dailey, N. Dansie, D. Scott and G. Snapp in MiniCassia, and D. Adams, R. Hix, K. Hudman, K. Lee and B. Murray in Jefferson. We greatly appreciate the help and patience of game-farm owners D. Dorris and B. Simpson. Contract trappers M. Olson and J. Reynolds conducted their activities in a professional manner and provided excellent records. Early drafts of the manuscript were greatly improved by reviews from T. Hemker, K. Reese and D. Leptich. The manuscript was also enhanced by three anonymous reviewers and associate editor L. Ellison.

References

Alsager, D.E., Stenrue, J.B. & Boyles, R.L. 1972: Capturing black-billed magpies with circular live traps. - Journal of Wildlife Management 36: 981-983.

Anderson, W.L. 1964: Survival and reproduction of pheasants released in southern Illinois. - Journal of Wildlife Management 28: 254-264.

Balser, D.S., Dill, H.H. & Nelson, H.K. 1968: Effect of predator reduction on waterfowl nesting success. - Journal of Wildlife Management 32: 669-682.

Beasom, S.L. 1974: Intensive short-term predator removal as a game management tool. - Transactions North American Wildlife and Natural Resources Conference 39: 230-240.

Brittas, R., Marcström, V., Kenward, R.E. & Karlbom, M. 1992: Survival and breeding success of reared and wild ring-necked pheasants in Sweden. - Journal of Wildlife Management 56: 368-376.

Burger, G.V. 1964: Survival of ring-necked pheasants released on a Wisconsin shooting preserve. - Journal of Wildlife Management 28: 711-721.

Chesness, R.A., Nelson, M.M. & Longley, W.H. 1968: The effect of predator removal on pheasant reproductive success. - Journal of Wildlife Management 32: 683-697.

Connelly, J.W., Gammonley, J.H. & Peek, J.M. 2005: Harvest management. - In: Braun, C.E. (Ed.); Techniques for wildlife investigations and management. 6th edition. The Wildlife Society, Bethesda, Maryland, USA, pp. 658-690.

Duebbert, H.F. & Kantrud, H.A. 1974: Upland duck nesting related to land use and predator reduction. - Journal of Wildlife Management 38: 257-265.

Einarsen, A.S. 1956: Determination of some predator species by field signs. - College Press, Oregon State University, USA, 34 pp.

Fleis, J.L. 1981: Statistical methods for rates and proportions. - John Wiley & Sons. Second Edition, 321 pp.

Frey, S.N., Majors, S., Conover, M.R., Messmer, T.A. & Mitchell, D.L. 2003: Effect of predator control on ring-necked pheasant populations. - Wildlife Society Bulletin 31: 727-735.

Giesen, K.M., Schoenberg, T.J. & Braun, C.E. 1982: Methods for trapping sage grouse in Colorado. - Wildlife Society Bulletin 10: 224-231.

Giudice, J.H. & Ratti, J.T. 2001: Ring-necked pheasant (*Phasianus colchicus*). - In: Poole, A. & Gill, F. (Eds.); The birds of North America, No. 572, 32 pp.

Haensly, T.F., Meyers, S.M., Crawford, J.A. & Castillo, W.J. 1985: Treatments affecting post-release survival and productivity of pen-reared ring-necked pheasants. - Wildlife Society Bulletin 13: 521-528.

Hess, M.F., Silvy, N.J., Griffin, C.P., Lopez, R.R. & Davis, D.S. 2005: Differences in flight characteristics of pen-reared and wild prairie-chickens. - Journal of Wildlife Management 69: 650-654.

Hessler, E., Tester, J.R., Siniff, D.B. & Nelson, M.M. 1970: A biotelemetry study of survival of pen-reared pheasants released in selected habitats. - Journal of Wildlife Management 34: 267-274.

Hill, D. & Robertson, P. 1988: Breeding success of wild and hand-reared ring-necked pheasants. - Journal of Wildlife Management 52: 446-450.

Hines, J.E. & Sauer, J.R. 1989: Program CONTRAST - a general program for the analysis of several survival or recovery rate estimates. - Fish and Wildlife Technical Report 24: 1-7.

Hubert, G.F., Hungerford, L.L. & Bluett, R.D. 1997: Injuries to coyotes captured in modified foothold traps. - Wildlife Society Bulletin 25: 858-863.

Jimenez, J.E. & Conover, M.R. 2001: Ecological approaches to reduce predation on ground-nesting game birds and their nests. - Wildlife Society Bulletin 29: 62-69.

Kenward, R. 1987: Wildlife radio tagging - equipment, field techniques, and data analysis. - Academic Press, New York, USA, 222 pp.

Kulowiec, T.G. STAGKAM Kaplan-Meier survivorship analysis program v. 1.0. - Missouri Department Conservation Wildlife Research Section, 1110 S. College Ave., Columbia, Missouri, USA.

Kurzejeski, E.W. & Root, B.G. 1988: Survival of reintroduced ruffed grouse in north Missouri. - Journal of Wildlife Management 52: 248-252.

Leif, A.P. 1994: Survival and reproduction of wild and pen-reared ring-necked pheasant hens. - Journal of Wildlife Management 58: 501-506.
Leopold, A. 1933: Game management. - Scribner's, New York, USA, 481 pp.
Leptich, D.J. 1992: Winter habitat use by hen pheasants in southern Idaho. - Journal of Wildlife Management 56: 376-380.
Musil, D.D., Connelly, J.W. & Reese, K.P. 1993: Movements, survival, and reproduction of sage grouse translocated into central Idaho. - Journal of Wildlife Management 57: 85-91.
Nohrenberg, G.A. 1999: The effects of limited predator removal on ring-necked pheasant populations in southern Idaho. - M.Sc. thesis, University of Idaho, Moscow, USA, 88 pp.
Olsen, G.H., Linscombe, R.G., Wright, V.L. & Holmes, R.A. 1988: Reducing injuries to terrestrial furbearers by using padded foothold traps. - Wildlife Society Bulletin 16: 303-307.
Onderka, D.K., Skinner, D.L. & Todd, A.W. 1990: Injuries to coyotes and other species caused by four models of foot holding devices. - Wildlife Society Bulletin 18: 175-182.
Parish, D.M.B. & Sotherton, N.W. 2007: The fate of released captive-reared grey partridges *Perdix perdix*: implications for reintroduction programmes. - Wildlife Biology 13: 140-149.
Pollock, K.H., Winterstein, S.R., Bunck, C.M. & Curtis, P.D. 1989: Survival analysis in telemetry studies: the staggered entry design. - Journal of Wildlife Management 53: 7-15.
Riley, T.Z. & Fistler, B.A. 1992: Necklace radio transmitter attachment for pheasants. - Journal of Iowa Academy of Science 99: 65-66.
Rollins, D. & Carroll, J.P. 2001: Impacts of predation on northern bobwhite and scaled quail. - Wildlife Society Bulletin 29: 39-51.
Roughton, R.D. & Sweeny, M.W. 1982: Refinements in scent-station methodology for assessing trends in carnivore populations. - Journal of Wildlife Management 46: 217-229.
Sargeant, G.A., Johnson, D.H. & Berg, W.E. 1998: Interpreting carnivore scent-station surveys. - Journal of Wildlife Management 62: 1235-1245.
SAS Institute 2001: SAS version 8. - SAS Institute Inc., Cary, North Carolina, USA.
Sauer, J.R. & Williams, B.K. 1989: Generalized procedures for testing hypotheses about survival or recovery rates. - Journal of Wildlife Management 53: 137-142.
Snyder, N.F.R., Derrickson, S.R., Beissinger, S.R., Wiley, J.W., Smith, T.B., Toone, W.D. & Miller, B. 1996: Limitations of captive breeding in endangered species recovery. - Conservation Biology 10: 338-348.
Strickland, M.D., Harju, H.J., McCaffery, K.R., Miller, H.W., Smith, L.M. & Stoll, R.J. 1994: Harvest management. - In: Bookhout, T.A. (Ed.); Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesda, Maryland, USA, pp. 445-473.
Svedarsky, W.D., Westemeir, R.L., Robel, R.J., Gough, S. & Toepher, J.E. 2000: Status and management of the greater prairie chicken *Tympanuchus cupido pinnatus* in North America. - Wildlife Biology 6: 277-284.
Trautman, C.G. 1982: History, ecology and management of the ring-necked pheasant in South Dakota. - South Dakota Department of Game, Fish and Parks. Wildlife Resource Bulletin 7, 118 pp.
Trautman, C.G., Fredrickson, L.F. & Carter, A.V. 1974: Relationship of red foxes and other predators to populations of ring-necked pheasants and other prey, South Dakota. - Transactions of the North American Wildlife Natural Resources Conference 33: 241-252.
Travaini, A., Laffitte, R. & Delibes, M. 1996: Determining the relative abundance of European red foxes by scent-station methodology. - Wildlife Society Bulletin 24: 500-504.
Wakkinen, W.L., Reese, K.P., Connelly, J.W. & Fischer, R.A. 1992: An improved spotlighting technique for capturing sage grouse. - Wildlife Society Bulletin 20: 425-426.
Wilson, J.R., Drobney, R.D. & Hallet, D.L. 1992: Survival, dispersal, and site fidelity of wild female ring-neck pheasants following translocation. - Journal of Wildlife Management 56: 79-85.