Survival and Habitat Use of Wild Pheasant Broods on Farmland in Lower Austria

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Wild pheasants (*Phasianus colchicus*) have declined throughout much of their European distribution. The influence of habitat composition on survival and habitat use of wild pheasant broods is not well understood, but is important for population management. We studied the brood-rearing ecology of pheasants using radio-tagged hens on a 2,400 ha farming estate in Lower Austria during 2001-2003. Brood survival , $\geq$1 chick surviving to 3 weeks, (n = 36) were: 74.4% (15.6 SE), 91.9% (7.8 SE), and 65.7% (13.8 SE), during 2001-2003, respectively. Complete brood loss (n = 7) occurred between 2 -17 days after hatching with predation (n = 5) accounting for 71.4% of losses. Survival of broods was influenced by composition of habitats within fixed kernel home ranges . Proportion of planted game crop, mixture of legumes and grasses, within the home range had a positive effect on survival, whereas age and condition of females did not influence brood survival. To improve brood survival rates of pheasants in agricultural landscapes farmers and game managers should consider planting specialist brood rearing mixtures in areas close to nesting habitat.

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Key words: Austria, brood survival, compositional analysis, habitat, home range, *Phasianus colchicus*, wild pheasant

Introduction

Populations of wild pheasant (*Phasianus colchicus*), although widely distributed, are in a state of decline across their European distribution during the past half-century (Hill and Robertson 1988, Tapper 1999, Csànyi 2000) as farming practices have shifted to more intensive row crop agriculture and management targeted at wild pheasants has declined (Jarvis and Simpson 1978, Hill 1985, Potts 1991). Previous research examining population dynamics of pheasants have suggested that at least part of the decline is related to the availability of brood habitat which is important for recruitment (Chiverton 1994, Warner et al. 1999), and brood survival which is a poorly understood component of pheasant life history (Warner et al. 1984, Hill and Robertson 1988).

The most crucial time for broods is the first 14 days post hatch (Hill 1985, Meyers et al. 1988, Riley et al. 1998). Studies suggest that broods select home ranges containing weedy areas and grasslands (Hill 1985), but changes in crop management and pesticide use has reduced weedy plants and insects which are vital for chick development and growth (Potts 1980, Hill 1985, Sotherton et al. 1985, Rands 1985, Sotherton and Robertson 1990). Previous studies of European gamebirds associated with agriculture suggest that abundance of weedy areas, grasslands and insects are inversely related to home range size, and positively correlated with survival of pheasant (Hill 1985), red-legged partridge (*Alectoris rufa*), and gray partridge (*Perdix perdix*) chicks (Green 1984).

Currently, little information on wild pheasant population dynamics is available for Lower Austria, which like the rest of Europe, has seen a precipitous decline in the harvest of wild pheasants during the past 30 years (Draycott et al. 2002). Most research has been undertaken in Britain and North America, but these areas have different farming practices, climate, and other land use composition compared to Austria. Therefore, in this study we examined brood habitat use within home ranges to determine its af-

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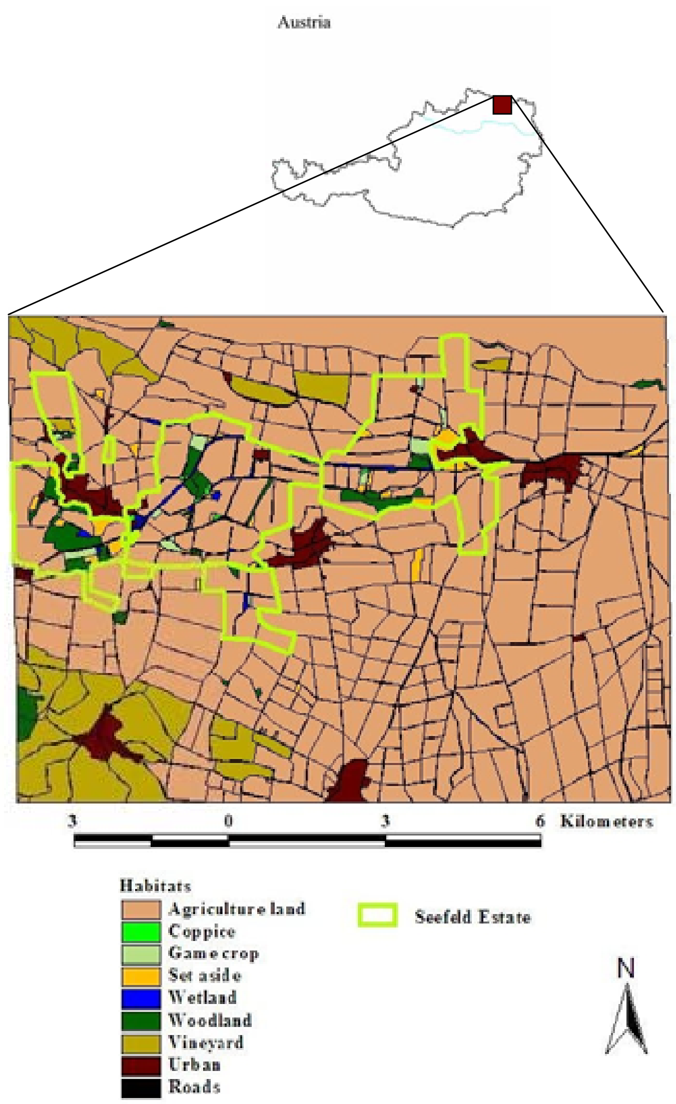

Figure 1: Map of Austria and habitat map of Seefeld Estate and surrounding area, Lower Austria, Austria.

fect upon chick survival within agricultural landscapes of Austria.

Study Area

This study was conducted in the state of Neiderösterich (Lower Austria), Austria on Seefeld estate (1). The estate is a 2,400 ha farm in the town of Seefeld-Kadolz approximately 150 km northeast of Vienna on the border with the Czech Republic. Seefeld estate has been farmed by the Hardegg family since the 15th century and is situated on converted marsh lands with 72% of the estate planted in annual crops. Winter wheat is the dominant crop with an average yield of 5 tons/ha; other crops include barley (winter and summer), sugar beet, potatoes, oil seed rape, and vineyards. Specially planted short-term rotational game crops, long-term set aside (planted grassland), wetland, woodland, and coppice occupy the remaining 28% of the estate. Wine is produced and bottled on the estate along with an indoor pig farm.

The Pulkau River runs the length of the estate and provides water for center pivot irrigation which is distributed by a series of open ditches. During the 1950's the Pulkau was channelized, but since 2000 the meandering flow has been re-established along with wetlands and associated reed (*Phragmites* spp.) beds. Supplemental feed is provided to pheasants by grain hoppers spaced throughout the estate in woodlands and game cover plots during the winter and along woodland edges and hedgerows in the spring to increase the quality of male breeding territories. The red fox (*Vulpes vulpes*), along with crows (*Corvus* sp.) and magpies (*Pica* sp.) are the main predators found on the estate, and are intensively controlled throughout the year.

Seefeld estate has a mid-continental climate with a temperature range of 6 to 37 °C in summer and -25 to 5 °C in winter. Elevation is 190 m and receives an average of 480 mm of precipitation yearly with 160 mm received in May and June. The surrounding land is occupied by small villages, private vineyards and family farms. Family farms have an average size of 14.6 ha and occupy approximately 80% of the land outside the villages (Molterer 1997).

Methods

Pheasant hens were captured from 1 March - 10 April in 2001 - 2003 using baited walk in funnel traps. Captured hens were aged, weighed, tarsus measured, and fitted with a numbered aluminum patagial tag, and a 9.9 g necklace collar (Holohil model RI-2B). The condition of each hen was determined by the condition index established by Robertson et al. (1985). Radio-tagged hens were located 3 times weekly by radio telemetry until nesting at which time they were located every other day. Once a nest hatched it was examined to determine number of chicks that hatched. Broods were located twice daily from a distance of ≥15-30 m for the first 21 days to determine exact habitat use. A brood was considered lost if a brood caution or gathering call (Giudice and Ratti 2001) were not heard during consecutive observations or if the hen died.

We calculated a UTM coordinate from topographic maps for each brood location which was overlaid on a habitat map using ArcView 3.1. Bootstrapping with replacement was performed using the Animal Movement Extension 2.04 (Hooge and Eichenlaub 2000) to estimate number of locations needed to construct home ranges. The 100% minimum convex polygon (MCP) (Mohr 1947) and 95% fixed kernel (Worton 1989) home range were calculated using the Animal Movement Extension 2.04 (Hooge and Eichenlaub 2000) for the first 21 days post hatch.

We used analysis of variance (ANOVA) for unequal sample size (Sokal and Rohlf 1969) using PROC GLM (SAS Institute, Inc. 1999) to determine if home ranges differed between year and age, Tukey's test was used to compare post-hoc results.

Proportion of habitats within each home range was calculated in ArcView and compositional analysis (Aebischer et al. 1993) was used to estimate habitat preference at the 2nd and 3rd order (Johnson 1980) using BYCOMP.SAS (Ott and Hoovey 1997) for MCP and 95% fixed kernel home ranges. Wilk's λ was used to determine if habitat use was not random by running 1000 iterations of the data; habitat preference was ranked by a series of paired *t*-tests.

For home range analysis, land cover on the estate was combined into 4 categories to represent land use patterns that should have biological significance to pheasants (Aebischer et al. 1993); 1) Agriculture including all row crops and vineyard (89%), 2) set aside: planted grassland and game crop (1.9%), 3) wetland shrub (1.2%), and 4) woodland: wooded areas, coppice, and wind breaks (2.1%). Any values missing at the 2nd or 3rd order were replaced following criteria established by Aebischer et al. (1993).

Brood survival (the proportion of broods in which at least one chick survived to fledging) was calculated using the Kaplan-Meier method ((Kaplan and Meier 1958) using the known fate model in Program Mark (White and Burnham 1999) using the logit scale for each year 2001-2003. Broods were left censored and constant survival (S[.]) model estimate was used.

Table 1: Habitat ranking matrix of 4 defined habitat types based upon 2nd order (A) and 3rd order (B) compositional analysis of MCP home ranges. Higher ranking indicates greater use compared to availability. Within the matrix, a (+) means that the row habitat is used relatively more than the column habitat, whereas a (-) means the opposite and a +++ or — mean that they are different at (P<0.05).

A.

Habitat	Woodland	Set aside	Wetland	Agriculture	Rank
Woodland	.	—	—	—	0
Set aside	+++	.	+	-	2
Wetland	+++	-	.	-	1
Agriculture	+++	+	+	.	3

B.

Habitat	Woodland	Set aside	Wetland	Agriculture	Rank
Woodland	.	—	+	+	2
Set aside	+++	.	+++	+++	3
Wetland	-	—	.	+	1
Agriculture	-	—	-	.	0

Non-habitat variables and landscape variables were then used as covariates within the model to determine their affect upon brood survival. Non-habitat variable include age and condition of hen at time of capture. Landscape variables include nest habitat and proportion of agricultural land, game crop, set aside, wetland, woodland, and amount of edge (m/ha) within each home range. Habitat proportions calculated within 95% fixed kernel ranges were used since a minimum of 10 locations can be used (Kenward 2001). Broods with less than 10 locations the arithmetic mean was calculated then buffered by the average 95% fixed kernel home range. Edge was calculated using Patch Analyst 3.1 (Rempel and Carr 2003). Survival constant (S[.]) and by year (S[g]) were chosen *a priori* to determine the effect the covariates had upon survival since covariates were not measured over time and broods were left censored. To determine which models fit best and the effect of each covariate upon survival Akaike's Information Criteria for small sample size (AIC_c) was used (Anderson et al. 2000). Slope (β), unconditional standard error (SE) and 95% confidence interval (CI) were calculated by model averaging for each covariate. If the CI for a covariate included zero we considered it to have no influence on survival.

Results

One hundred and twenty-seven pheasant hens were radio-tagged during 2001-2003 which produced 36 broods. Home range size for successful broods (n = 28) was 11.1 ha (±2.13 SE) and 14.6 ha (±2.45 SE) for MCP and adaptive kernel methods, respectively. No difference was found in home range between years ($F_{2,25}$ = 1.99, P = 0.16), or age of the hen ($F_{1,26}$ = 0.02, P = 0.90).

Our habitat analysis suggested that habitat use by hen pheasants with broods was not random at the 2nd (Wilk's λ = 0.59, $F_{3,30}$ = 6.92, P = 0.001) or 3rd (Wilk's λ = 0.44, $F_{3,30}$ = 12.66, $P < 0.0001$) order for MCP home ranges. At the 2nd order agricultural land ranked highest, but 3rd order analy-

Table 2: Habitat ranking matrix of 4 defined habitat types based upon 2nd order (A) and 3rd order (B) compositional analysis of 95% fixed kernel home ranges. Higher ranking indicates greater use compared to availability. Within the matrix, a (+) means that the row habitat is used relatively more than the column habitat, whereas a (-) means the opposite and a +++ or — mean that they are different at (P ¡ 0.05).

A.

Habitat	Woodland	Set aside	Wetland	Agriculture	Rank
Woodland	.	—	—	—	0
Set aside	+++	.	+	-	2
Wetland	+++	-	.	-	1
Agriculture	+++	+	+	.	3

B.

Habitat	Woodland	Set aside	Wetland	Agriculture	Rank
Woodland	.	-	-	+++	1
Set aside	+	.	-	+++	2
Wetland	+	+	.	+++	3
Agriculture	—	—	—	.	0

sis showed that set aside was most preferred habitat within home ranges (1). Adaptive kernel home range results indicated that habitat use was not random at the 2nd (Wilk's λ = 0.66, $F_{3,30}$ = 5.20, P = 0.005) or 3rd (Wilk's λ = 0.64, $F_{3,30}$ = 5.69, P = 0.003) order. Habitat rankings at the 2nd order were identical to MCP with agricultural land ranked highest, but 3rd order differed from results for MCP in that wetland habitat was preferred (2).

Survival of broods for the first 21 days was estimated at 74.4% (±15.6 SE), 91.9% (±7.8 SE), and 65.7% (±13.8 SE) in 2001, 2002, and 2003, respectively (2). Over the 3 years 7 complete broods were lost between 2-17 days after hatching with average loss occurring 11 days after hatch (±2 days SE). Predation by fox (n = 4) and other mammalian predation (n = 1) were responsible for the loss of 5 (71.4%) broods; the other 2 (28.6%) were lost to exposure and during harvest operations.

Non-habitat covariates estimated did not have an affect upon brood survival. Game crop was the only habitat variable with a 95% CI (β = 609.04, 95% CI 472.3 - 745.8) that did not include zero. Our model showed broods that utilized game crop had a 100% survival. For all other habitat covariates tested, the 95% CI contained zero, but several were highly skewed. Although not significant woodland and long-term grassland set-aside appeared to have a negative impact upon brood survival, whereas our data suggested wetlands had a positive relationship to brood survival (3).

Discussion

We found that pheasant broods in agricultural landscapes of Austria had home ranges greater than the 4.8 ha (Hill 1985) reported for England and were at the upper end of the range of 2 - 11 ha observed in the U.S. (Kuck et al. 1970, Hanson and Progulske 1973, Warner 1979). One probable reason broods had larger home ranges than observed in England is that broods were followed for 21 instead of 14 days. Hanson and Progulske (1973) found that home range size increases with brood age.

Habitat selection at the 2nd order showed that agricultural land was incorporated into home

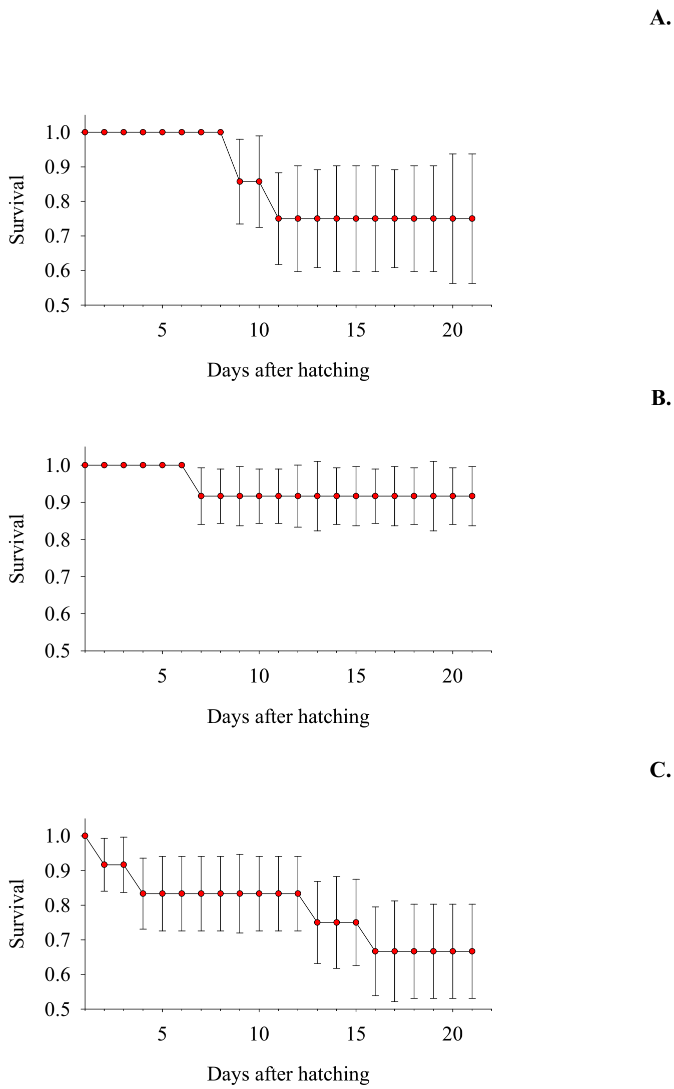

Figure 2: Kaplan-Meier survival estimates (+ SE) of radio-tagged pheasant broods during (A) 2001 (n = 9), (B) 2002 (n = 14), and (C) 2003 (n = 12) at Seefeld Estate, Lower Austria, Austria.

ranges and supports previous research that observed pheasant broods in cereal crops (Warner 1979, Hill 1985, Enck 1986). Aebischer and Blake (1994) suggested that the structure of cereal crops allows for easy movement of broods and provides protection from predators and that the first 5 m of the field edge also contain more insects and weeds (Chiverton 1994) where gray partridge broods are often found (Green 1984). Third order habitat analysis revealed that set aside was preferred habitat. Aebischer and Blake (1994) reported that properly managed set aside has a greater diversity of plants that attract a wide range of insects and produce small seed that is critical for chick development. This corroborates other studies that found broods in undisturbed grassland and weedy areas (Warner 1979, Hill 1985, Riley et al. 1998).

We found that brood loss occurred during the

Table 3: AICc value, delta AICc, slope (β), and 95% Confidence Interval (CI) of non-habitat and habitat covariates upon 21 day survival of radio-tagged pheasant broods at Seefeld Estate, Lower Austria, Austria during 2001 - 2003. Inclusion of zero within the 95% CI suggests there is no significant slope.

				95% CI	
Pheasant hen covariates	AICc	Δ AICc	Slope (β)	Lower	Upper
Condition index	80.247	0	0.187	-0.308	0.683
Age	80.289	0.042	0.382	-1.222	1.986
Habitat covariates					
Game crop (%)	74.516	0	609.037	472.284	745.79
Wetland (%)	75.735	1.219	36.578	-9.696	82.851
Edge (m/ha)	75.995	1.479	-0.347	-0.929	0.235
Woodland (%)	78.777	4.261	-14.586	-32.924	3.753
Agriculture (%)	80.558	6.042	-1.128	5.265	3.009
Set aside (%)	80.801	6.285	-0.219	-3.604	3.167

first 17 days post hatch and that most losses were attributable to mammalian predation, with minor loss to exposure and harvest. This is similar to previous studies that found brood loss was greatest within 14 days after hatching (Hill 1985, Meyers et al. 1988, Riley et al. 1998). Mammalian predation has been implicated as an important cause of brood loss in previous studies (Riley et al. 1994, 1998). Other studies in Iowa found that the dominant predator upon pheasants is the red fox (Riley and Schulz 2001). Losses to avian predation has been observed in other studies (Carroll and Sayler 1990), but was not observed during our study. Removal of predators can increase recruitment while implemented, but often return to pre-treatment levels when predator removal ceased (Chesness et al. 1968, Jensen 1970).

Brood survival rates of 65-92% we observed during the first 21 days are similar to survival rates reported in North America (Gates and Hale 1974, Warner et al. 1984, Carroll and Sayler 1990, Riley et al. 1998, Nohrenburg 1999), but greater than values reported in the United Kingdom (Hill 1985). In Illinois and Iowa abundance of grassland was correlated to increased chick survival (Warner et al. 1984, Riley et al. 1998). Game crop likely offers concealment from predators and a higher abundance of arthropods over cereal crops (Sotherton et al. 1985). At Seefeld Estate the planted game crops contained a number of different species including legumes and grasses planted at low seeding rates and were managed to provide both an abundance of food and the correct structure to allow ease of movement of broods through the base of the crop. Conversely, the permanent grassland set-aside areas were based on tussock forming grasses including cocksfoot (orchardgrass *Dactylis glomerata*) which although ideal for nesting (Bliss 2004) are not suitable for young foraging broods. Indeed our data suggested that there may be a negative relationship between survival and permanent grassland set-aside. Our results also suggest that wetland habitat may positively affect survival, since it may provide cover and food for broods once crops are harvested. Woodland seemed to negatively affect brood survival and support results from Hill (1985). Woodland edge can negatively impact herbaceous vegetation in adjacent habitats and increase the number of predators (Wasilewski 1986) and has been shown to affect habitat selection by pheasants (Wasilewski 1986) and gray partridge (Dudzinski 1992).

Management Implications

We advocate habitat management in conjunction with predator control to enhance pheasant populations on in Lower Austria. During brood rearing season hens with broods preferred set-aside habitat within their home ranges and those that utilized game crop had 100% survival. When game crop is properly managed it has low stem density and contains little ground debris which allows for easier movement. Game crop also attracts a wider variety of insects than found in crops which is important for chick survival (Hill 1985). We also determined that woodland habitat had a detrimental affect upon survival and therefore set aside and game crop habitat should not be placed next to woodland.

We found that the majority of brood loss was to mammalian predation even though predation control is exercised on Seefeld Estate. Therefore we advocate further research on broods by marking individual chicks at time of hatch as (Riley et al. 1998) conducted in Iowa. This would allow for a detailed estimate of chick survival and impact of predators upon broods to be assessed.

This work in conjunction with habitat management for winter, breeding, and nesting and future chick research at Seefeld Estate will allow for development of management plans for wild pheasant populations in their mid-European distribution.

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