HABITAT USE AND NESTING ECOLOGY OF RING-NECKED PHEASANT (*Phasianus colchicus*) ON A LANDSCAPE DOMINATED BY AGRICULTURE IN LOWER AUSTRIA

by

BRANDON COBB ANDERSON

(Under the direction of Dr. John P. Carroll)

ABSTRACT

The basic ecology of ring-necked pheasants in Eastern Europe has received little to no research attention. The intention of our study was to provide some insight into the basic ecology of hen pheasants at two critical periods in their life cycle, these being the over-wintering and recruitment. These periods are characterized by high mortality throughout much of the current range for ring-necked pheasants. Using radio telemetry, habitat use, survival, nest site selection, nest and brood success were determined. Our research contrasts traditional beliefs that woodlands are primary winter habitat. Our work indicates that wetlands are a preferred habitat type during the months. Recruitment research on Hardegg Estate revealed that uneven dispersal of nesting and brooding habitats where suitable brooding habitat may not be adjacent to nesting habitat. The current distribution pattern of these two habitat types may be increasing mortality due to predation.

INDEX WORDS: Ring-necked pheasant, Austria, Habitat use, Home range

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This thesis is dedicated to my loving wife

who bears the burden of being married to me quite well.

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CHAPTER 1

GENERAL INTRODUCTION

SPECIES HISTORICAL PERSPECTIVE

The formal scientific name of the common (ring-necked) pheasant is *Phasianus colchicus*. This is a testament to the mythological journey of Jason and the Argonauts to the Phasis Valley in Colchis, which is on the Black Sea, searching for the Golden Fleece. Jason allegedly returned to Greece with pheasants around 1300 BC (Robertson 1997). Greeks and Romans reportedly kept pheasant as table fowl much like the chicken (Robertson 1997). The range of the common pheasant was extended from its native range in China, Korea, Vietnam, Taiwan and the Japanese archipelago to virtually all of Europe through anthropogenic means (Robertson 1997). It is believed that the Romans played a considerable role in pheasant introductions throughout Europe including Italy, Germany and France (Robertson 1997). North American introduction has been relatively recent by comparison. The earliest attempt was in New York in 1730, when the governor released six pairs, which subsequently failed to establish a population (Silverstein and Silverstein 1974). In 1882, the first successful introduction occurred in the Willamette Valley in Oregon. The American Consul General to Shanghai, had a number of pheasant shipped to the United States from China, whereupon 26 pheasants became established after their release (McAtee 1945).

The common pheasant has followed human agricultural expansion into much of its introduced range. The species has adapted to land use changes when numerous native species have faltered. The capercaillie (*Tetrao urogallus*) and black grouse (*Tetrao tetrix*) have suffered severe declines and the great bustard (*Otis tarda*) has a severely restricted range where it once occupied much of the European grasslands (Robertson 1997). The pattern is strikingly similar in North America. Greater prairie chicken (*Tympanuchus cupido*) and sharp-tailed grouse (*Tympanuchus phasianellus*) populations dwindle in the face of declining open grasslands, while common pheasants expanded their populations with the extension of arable lands (Robertson 1997).

The habitat created by agricultural practices prior to the late 1950's was the driving force behind the success of the pheasant. At this time, arable lands exhibited a mosaic of agriculture practices and plantings (Clark *et al*. 1999). However, the 1960's saw the advent of more intensive agricultural practices and an abrupt decline in pheasant populations (Etter *et al.* 1988). More intensive row-cropping displaced grazing lands, hay fields and rotational farming. A ten-year study at the Sibley Study Area, Illinois, USA shows the rapid transition to intensive row- cropping. The Sibley Study Area (SSA) experienced a 60% decline in acres planted to small grains and hay in just three years (1962 – 1965). Corn and soybeans comprised 80% of the study area in 1965, an increase of 15% in just three years (Etter *et al*. 1988). The SSA pheasant population experienced a significant decline after 1963. The population trend closely followed the reduction in cropland diversion programs and grazing lands combined with sharply increasing row-cropping acreage. Pheasant numbers dropped from 3,400 birds in 1963 to 1,100 in late winter of 1965 (Etter *et al*. 1988).

Drastic changes in agricultural practices in the 1960's included increased mechanization and immense monoculture plantings. Fencerows, hedges and most permanent cover were eliminated to allow for these massive monoculture plantings. As a result, pheasant harvest in the midwestern United States declined 46% from 1961 to 1986 (Hill and Robertson 1988). Similar patterns of intensification also occurred in Europe. For example, field size also increased in England where average field size went from 6.5 ha in 1945 to 11.0 ha in 1972. The increased field size resulted primarily from hedgerow removal. Nesting cover also declined approximately 50% in England from 1945 to 1985 (Potts 1986). Concurrent changes in land use and land use related activities undoubtedly were the principal factors influencing pheasant population fluctuations (Edwards 1983).

A study from the southern Moravian district of the Czech Republic emphasizes the relationship between the pheasant and its local food resources (Kubišta 1990). Numerous studies have supported a relationship between arthropod biomass in a given year and the subsequent size of the pheasant population within that given year (Potts 1970, Hill 1985). Changes in arthropod density within the home range of pheasant chicks, in the study by Hill (1985), explained 75% of the changes in survival rate. Many scientists attribute pheasant declines to the use of pesticides and the subsequent plummet of arthropod biomass on agricultural lands.

Herbicide use increased dramatically after World War II. In England, crop sprayer numbers increased from an estimated 2,000 in 1944 to more than 51,000 by 1962 (Potts 1986). By 1973, nearly all cereal fields in Germany were receiving herbicide applications (Fröde 1977). Startling increases in herbicide use in the former Czechoslovakia and Hungary began in the 1970's and early 1980's (Potts 1986). This trend toward heavy herbicide use had a dramatic effect on weed populations. In Europe, more than 55 species of weeds found in cereal fields are listed as endangered. Herbicide use is one of the primary factors attributed with their decline (Potts 1986).

Studies have shown that the reduction of weed species within agricultural fields results in significant decline of arthropod fauna (Heydemann 1956, Southwood and Cross 1969, Ulbrizy 1968). Young gallinaceous species, such as pheasant and partridge, require substantial arthropod biomass in their diet. The decline of arthropod fauna has been linked directly to chick mortality (Warner *et al*. 1999). Potts (1986) illustrates the effect of pesticides on gray partridge chick mortality. In 1952, prior to pesticide use, chick mortality rates for the pheasant were 32% for England, 29% for mainland Europe, and 25% for North America. The period from 1953 – 1961 (characterized by some herbicide use) saw the mean mortality rate for partridge chicks in England rise to 45%, mainland Europe to 37%, and North America to 28%. Finally, the period from 1962 – 1985 (characterized by extensive herbicide use and some insecticide use) saw partridge chick mortality rise to 60% in England, 45% in mainland Europe, and 36% in North America (Potts 1986).

STUDY AREA HISTORICAL PERSPECTIVE

The 2400 ha Hardegg Estate in Seefeld, Lower Austria was reclaimed from an old marsh (Seefeld translates literally to “Sea Field”) (Figure 1.1). The estate lies in the shadow of the former “Iron Curtain” on the border between Austria and the Czech Republic. The area has fertile, sandy soils and warm, continental summers which are both considered primary features of prime wild pheasant habitat (Robertson 1997). The average annual temperature is 9.4°C (48.9°F) and average annual rainfall is 643mm (25in). Woodlands, wetlands, reed beds and the Pulkau River are intermingled within the arable lands (Table 1.1). Throughout the 1960’s, the estate realized its highest pheasant population levels. The success of this era is attributed to farming practices that were sympathetic to pheasant ecology, woodland establishment, predator management, and the fact that the estate served as a winter refuge for birds from surrounding lands (Robertson 1997).

In the mid – 1970’s farming practices in Austria became more mechanized. Pesticides became more widespread in agriculture and fields were typically enlarged leading to the reduction of hedgerows (Robertson 1997). As a result, pheasant populations began a steady decline. Pheasant harvest in Lower Austria was at 18 pheasants per 100 ha in 1972. Harvest had decreased in this region to approximately four pheasants per 100 ha by 2000 (Draycott *et al*. 2001). Spring densities of pheasants on the best areas of the estate are some of the highest recorded anywhere. Annual spring pheasant counts from the 1990's revealed that certain areas of Hardegg Estate held more than 100 hens per 100 ha (Draycott *et al.* 2001). Excellent habitat for pheasant is determined to be suitable for one pheasant per 1.2 to 1.6 ha (Edminster 1954). The Hardegg Estate population levels, by this standard, are exceptional. Robertson (1997) states that, "pheasant breeding densities in the best areas of Hardegg Estate were the second highest ever recorded." At the time of Robertson's (1997) observation, Hardegg Estate had one hen per 0.81 hectares in the best available habitat. This is just under the breeding density levels on Pelee Island in Lake Erie, Canada, which boasts one hen per 0.41ha and subsequently is the highest breeding density ever recorded (Robertson 1997). It is noteworthy to mention that Pelee Island had virtually no mammalian predators.

Rising concern over pheasant population declines on the estate and throughout the region led the owners of Hardegg Estate to begin a proactive management plan to restore pheasant population levels (Robertson 1997). Using the liberal Austrian regulations for set-aside lands, the estate owners began a program of habitat management by planting a mixture of cereals, rape, sunflowers and maize. These crops were not harvested and approximately one half of each set-aside was replanted every 2 years. The replanting was performed in strips across the set-aside land. Thus providing a mosaic of older, more established areas and newly sown areas. The resulting habitat was comparable to a stand of extremely weed-infested cereal with areas of older vegetation of substantial height (Robertson 1997). Set-asides treated in this manner produced ample spring forage, nesting site structure, insect availability for broods and winter cover (Robertson 1997).

Additionally, innovative irrigation practices were utilized. Austrian summers are quite dry and efficient use of water stores is required for sufficient irrigation (Robertson 1997). Hardegg Estate chose to abstain from the common practice of creating sterile lagoons and instead dug a network of ponds in areas where pheasant habitat was most promising (Robertson 1997). Pond creation has an influence on surrounding vegetation and these actions influenced the distribution of reeds and shrubby vegetation, which are both considered highly desirable pheasant habitat (Robertson 1997).

The owners of Hardegg Estate have also undertaken an extensive wetland restoration project. The Pulkau River, which essentially bisects the estate, was channelized for agricultural purposes during the 1950's. Beginning in the late 1990's, the estate owners began to restore Pulkau River to a more sinuous and natural state. Wetlands have been created as they might have naturally occurred prior to channelization (B. C. Anderson pers. obs. 1999). This restoration project is being made possible in part by grants from the European Union. Habitat restoration of this design will produce appreciable gains in reed grass (*Phragmites* spp.) stands, which are generally considered excellent pheasant habitat.

Hardegg Estate has maintained consistently high pheasant densities while the surrounding region has suffered steady declines. In the last decade, annual harvest on Hardegg Estate has ranged from 16 to 54 birds/ km^2 while the mean annual harvest for the region remains 4 birds/ km^2 (Draycott *et al*. 2001). The habitat management practices on Hardegg Estate are of substantial benefit to nongame species as well. The species diversity is astounding for a functional farm of this era. Anecdotal observations of avifauna revealed more than 85 species benefiting from pheasant habitat management (Appendix A.4) (Berg and Pock pers. obs. 1998 and B. C. Anderson pers. obs. 2000).

STUDY OBJECTIVES

The knowledge of pheasant ecology in Lower Austria is largely anecdotal. Therefore the intent of this study was to obtain empirical data that would direct future research and management decisions. We proposed the following objectives to be addressed with the research on Hardegg Estate:

- Determine relative use of habitat types in relation to their availability and determine hen mortality within each habitat type.
- Determine possible indirect and direct causes of mortality.
- Establish home ranges by season for female pheasant and determine if home range size is related to habitat quality.
- Determine the survival by season for the female pheasant population.
- Determine the nesting success for the female pheasant population.

- Determine relative abundance of insect food for broods.

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Table 1.1. Description of habitat types used for all compositional analyses of the study area.

Habitat Type	Description	Area (ha)
0 – excluded area	area excluded from analyses	544.16
1 – woodland	all mature woodland	170.46
2 – coppice	all coppice and elderberry scrub	12.16
3 – setaside	all EU sanctioned setaside land	126.85
4 – gamecrop	all arable land planted to game mixtures	41.91
5 – wet areas	all land adjacent to water (i.e. irrigation, wetland, river)	87.85
6 – arable lands	all land planted to crops	3143.29
8 – roads	all paved roadways and primary estate roads	38.13
10 - infrastructure	all farm buildings, villages and storage facilities	249.86
11 - vineyards	all significant vineyards	49.51

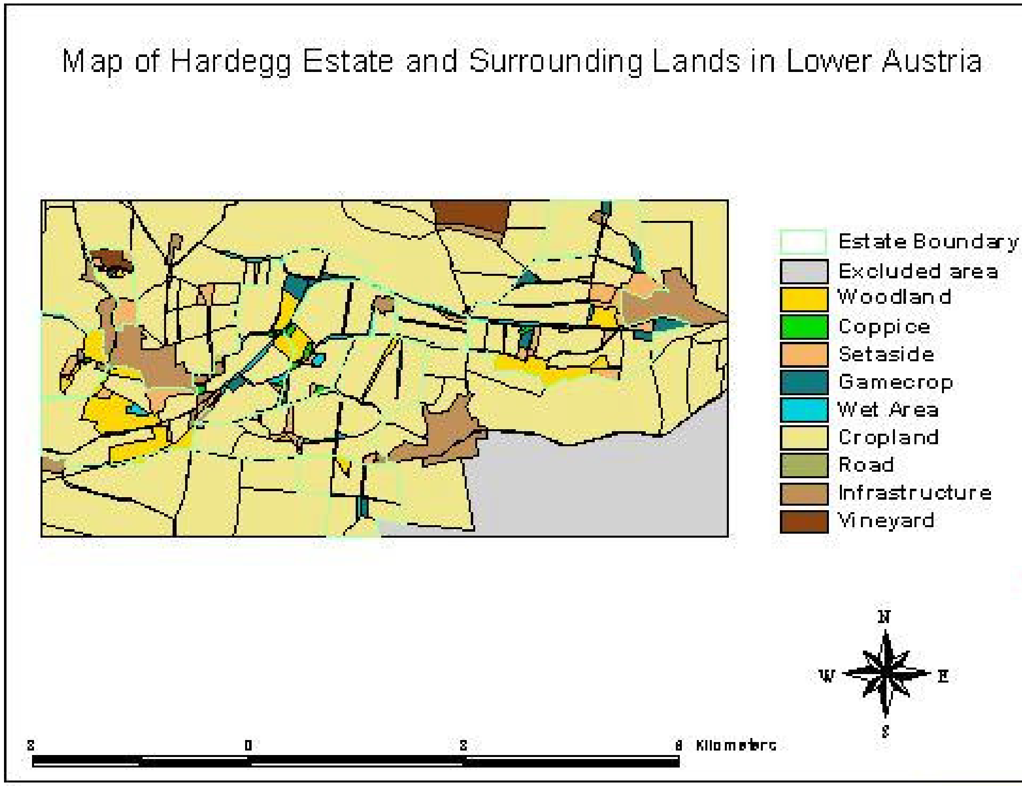

Figure 1.1. Illustration of study area using ArcView 3.2 to designate landcover types. The estate is located in the northern most reaches of Lower Austria (NiederÖsterreich) on the border of the Czech Republic.

CHAPTER 2

HABITAT USE AND SURVIVAL OF HEN PHEASANTS DURING WINTER IN LOWER AUSTRIA

INTRODUCTION

Pheasants are well studied in Great Britain and vast amounts of empirical data have been generated. As a result, it has been determined that winter survival is not a major factor influencing the population dynamics of the pheasants in Great Britain (Hill and Robertson 1988). In contrast, winter habitat use and mortality of female pheasants in Lower Austria are poorly understood. Pheasants in the UK spend most of the winter within 30 m of a woodland edge, whereas in North America wetlands are the key winter habitat (Robertson 1997). The more severe continental climate and larger predator community found in Austria suggests that there might be significant survival differences between British birds and those of continental Europe. The climate and land use in Lower Austria is similar to the plains region of the midwestern United States. Therefore, pheasant ecology in Austria might parallel that of pheasant populations in this particular region of the United States.

The pheasant is an adaptable species and will assume habitat use and movement patterns based on local conditions (Olsen 1977). It is important to note that pheasant population responses to localized conditions cannot be applied to all populations within its current range (Penrod and Hill 1985, Gatti *et al*. 1989).

A study conducted in southeastern North Dakota revealed that the pheasant population in the study area preferred semi-permanent wetlands containing cattail (*Typha* spp.) and bulrush (*Scirpus* spp.), which are resilient species that are capable of withstanding harsh weather (Homan *et al.* 2000). These wetland areas were chosen more often than their availability would suggest (Homan *et al.* 2000). Pheasant habitat selection in this study was determined by snow depth and the subsequent reduction in available cover. The pheasant selected idle upland areas first, then large wetlands with resilient vegetation and finally shelterbelts (Homan *et al.* 2000). Pheasant populations in similar studies from Iowa (Perkins *et al.* 1997), Wisconsin (Gates and Hale 1974), and South Dakota (Gabbert *et al.* 1999) maintained this selection sequence. Pheasants develop a stronger association with their breeding areas in the uplands than the lowland wintering areas (Gates and Hale 1974). Pheasants will often remain in breeding territory cover until climatic conditions and loss of cover will force a shift to wintering areas (Leptich 1992). Pheasants will reverse their movements along the continuum when weather permits. Use of upland grasslands increased as snow depth decreased in mild winters (Homan *et al.* 2000, Sather-Blair and Linder 1980).

Substantial snowfall (> 38cm) can force pheasants into emergency cover in woodland habitats (Gatti *et al.* 1989, Perkins *et al.* 1997, Gabbert *et al.* 1999). Mortality due to winter storms has reached an estimated 70 – 90% of the pheasant population in Illinois (Warner and David 1982). A search following a severe winter storm in Iowa resulted in the recovery of 27 frozen pheasants, which was 5.6% of the population prior to the storm (Warner and David 1978). Pheasant research in Iowa revealed an average survivorship of 64% (Perkins *et al.*

1997). Studies in North Dakota (Homan *et al.* 2000) and in South Dakota (Gabbert *et al.* 1999) demonstrated survival rates of 41% and 32%, respectively. These studies indicate that winter survival may play a significant role in pheasant populations. A number of scientists believe that survival during winter is a limiting factor for pheasant populations in the midwestern United States (Carroll 1990, Riley *et al.* 1994, Evard 1996). The effects that harsh weather may have on pheasant survivorship during winter could be negatively impacting annual population productivity (Gates and Hale 1974, Jarvis and Simpson 1978).

Interactions between severe winter storms and alterations to the agricultural landscape are thought to negatively impact pheasant survivorship (Klongan 1971, Farris *et al.* 1972). Increasing fragmentation of habitat types affects pheasant home range size and habitat use, which in turn may impact survivorship (Aebischer *et al.* 1993, Gatti *et al.* 1989). A study in Iowa determined that the best habitat for pheasant during prolonged snow cover was either perennial warm-season grasses or wetland vegetation (Perkins *et al.* 1997). Furthermore, the Iowa study noted that alternative cover types such as cool-season grasses were insufficient while snow covered the area (Perkins *et al.* 1997). Survival was affected by snow cover and temperature extremes indirectly, but mortality was most often directly associated (82%) with predation (Perkins *et al.* 1997). Many researchers have suggested that amount of snow cover impacts pheasant behavior (Gates and Hale 1974, Gatti *et al.* 1989, Perkins 1992). However, the interaction between snow cover, resulting pheasant populations and predation is poorly understood and requires further research (Perkins *et al.* 1997). It is possible that the escape value of certain cover types diminishes with excess snow cover (May 1978). Severe weather may concentrate predator and prey species in localized areas and these concentrations become exacerbated in areas where fragmentation of habitat has occurred (Perkins *et al.* 1997). A study of pheasants in Wisconsin revealed no strong relationship between habitat use and survivorship (Gatti *et al.* 1989). Yet the researchers admit that study shortcomings (which included broad characterization of habitat types and failure to document habitat selection of individuals that were depredated immediately after a behavioral change), may have affected results (Gatti *et al.* 1989). Clearly there is a need for further study into the interrelationship between inclement weather, habitat availability and quality and survivorship of pheasants during the winter months.

OBJECTIVES

There were several primary objectives for the research into the winter ecology of hen pheasant on Hardegg Estate:

- Determine relative use of habitat types in relation to their availability and determine hen mortality within each habitat type.
- Determine possible indirect and direct causes of mortality.

- Determine the primary pheasant predator species (i.e., does the red fox have as significant impact on pheasant populations as it does in other regions) on managed lands.
- Establish home ranges for wintering female pheasant and determine if home range size is related to habitat quality and/ or mortality.
- Determine the total over-winter mortality for the female pheasant population.

STUDY AREA

A mosaic of habitat types characterizes Hardegg Estate, the study area. It is a private estate in Lower Austria. The 2400 ha operation produces primarily cereal grains (1100 ha), and maize (300 ha) for feed in its swine operation. Additional crops include 70 ha of oilseed rape, 200 ha of sugar beets and 50 ha of vineyards. The remainder of the estate consists of 250 ha of woodland, 100 ha of wetland, 70 ha of long-term setaside and 200 ha of rotational setaside. The majority of the estate equipped with irrigation ditches. The estate is situated within an old lakebed that was drained for agricultural purposes. The average temperature from November through March is 3.2°C (37.8°F) and average precipitation for that period is 43.2mm (1.7in). For our habitat analysis we defined seven basic habitat types (Table 2.1).

METHODS

Capture - Initial trapping of hen pheasants commenced in October 1999. Hens were trapped in varying habitat types around the estate using 2' X 4' X 2' walk-in type funnel traps. Funnel traps were constructed with 1" X 1" wood strips and light gauge, 2" X 2" welded wire. The funnel was made from 1" chicken wire. Captured pheasant were fitted with 173 MHz necklace transmitters assembled at the Game Conservancy Trust laboratory in Fordingbridge, England. The condition of each bird was assessed at the time of capture by measuring tarsus length, visually inspecting for parasites and obtaining weight. A patagial tag was attached to the wing for absolute identification. The exact capture location was recorded for each bird prior to release. The pheasants were then given 1 day of post-capture acclimation before radio-tracking commenced.

Age distribution – The age distribution of the hen pheasant population was determined by taking the proximal (innermost) primary wing feather (1^{st} primary in the American system and 10^{th} primary using the European system) at time of capture. Proximal primary feathers were also collected from a random sample of males harvested during an organized shoot.

The feathers are then dried under low heat (50°C) for 24 hours. The shaft of each feather is measured at the level of the scar near the base of the barbs in the plane that coincides with the vane. Measurements were then compared to established norms for each age class (Woodburn 1999, Wishart 1969). This is the first primary feather molted during the post-juvenile molt. Therefore juvenile individuals are highly likely to have smaller shaft diameters than adult individuals. Research into variation in adult and juvenile proximal primaries found that established measurement standard used to separate the age classes was 92% accurate (Greenberg *et al.* 1972).

Radio - tracking - The pheasants were tracked using a Telonics handheld receiving unit for a period of 6 months or until death. Each bird was located every ± 2 days. Their exact locations were determined using homing and then the triangulation method of telemetry that required collection of readings from the three points of a triangle to establish strength of radio signal (Lee *et al.* 1985). Most locations were determined at < 30m from the pheasant. Precise habitat use was noted for each location including vegetative structure and topography. Pheasants were located primarily during daylight hours. Pheasants that had no movements for several days were flushed to assess survivorship.

Survival - Telemetry was also used as an aid in determining survival. Pheasants that did not survive were located and examined in an attempt to determine cause of death. Cause of death was categorized at least to either mammalian or avian predators or anthropogenic means. Where possible, cause of death was determined to predator species. Survival was estimated for the population using the Kaplan-Meier method (Kaplan and Meier 1958) and staggered - entry design

(Pollock *et al.* 1989). This method of measuring survival accounts for both entry and removal censoring.

Home range - Daily monitoring through telemetry commenced 1 day post - capture and continued through 2 April 2000, which we considered the start of Spring. Daily locations were noted to determine home range size and vegetation type was recorded to determine the proportion of specific vegetation types within a given home range. Using the animal movement extension version 2.0 for ArcView (Hooge and Eichenlaub 1997), the 95% probability kernel home ranges and the 100% minimum convex polygon (hereafter MCP) home ranges were calculated for each radio-collared pheasant that had > 15 radio locations.

Habitat Analysis - Proportions of the seven defined habitat types within the designated study area and each calculated MCP home range were determined by intersecting habitat type determinations with study area and home range delineations using the Geoprocessing Wizard in ArcView Version 3.2. Proportion of radio locations within a given MCP home range were manually recorded. Sample size was maximized by pooling data from across age classes (White and Garrot 1990). The 100% Minimum Convex Polygon method (Mohr 1947) of determining home range was employed due to its ubiquitous nature in the literature and more importantly because it only incorporates the area delimited by the outermost radiolocations recorded for a particular animal (Aebischer *et al.* 1993).

Statistical analysis was performed on the raw proportional data using BYCOMP.SAS (Aebischer *et al.* 1993 and Ott and Hovey 1997) compositional analysis code for SAS software. For each radio - collared hen, proportion of habitat types within the study area was compared to those within a given calculated MCP home range. The proportion of radio locations within a specific habitat type for a given hen was also compared to the proportion of habitat types within that hen's calculated MCP home range. Testing of comparisons at each level was performed through a series of MANOVA's using Wilk's λ analyses to test for significance. The program then ranks each habitat with the largest rank being the most preferred through paired comparisons among all habitat combinations using t-tests.

RESULTS

Fifty-six hens were captured, measured and radio collared for purposes of this study. Monitoring began on 18 November 1999 and continued through 2 April 2000. There were a total of approximately 120 days of monitoring. Monitoring resulted in the recording of 713 radiolocations. The proximal primary wing feather was collected from the 55 of the 56 hens involved in the project. The final hen involved in the study was released prior to proximal primary feather removal. The age distribution was evenly balanced between juvenile and adult hens (Figure 2.1). Age distribution among the male pheasant population was biased towards a juvenile dominated configuration (Figure 2.2).

Survival –Survival for the study area pheasant population during winter was determined to be 0.97 (± 3.02 SE) through the 136 days of the study (Figure 2.3).

Home range - The mean 95% probability kernel home range was 15.7 hectares with a range from 2.1ha to 175.6 ha. Juveniles maintained a mean of 14.1 ha and adults 16.6 ha 95% probability kernel home ranges. The mean 100% MCP home range was 7.8 hectares with a range of 0.68 ha to 31.4 ha. Juveniles maintained a mean 100% MCP home range of 7.9 ha and adults maintained a near identical 7.8 ha (Table 2.2).

Habitat Analysis – Comparisons between the habitat composition of the study area and MCP home ranges ($\lambda = 0.23$, 6, 25df, $P<0.0001$) revealed that habitat use was not random. Paired analyses among all habitats showed that coppice, wetland and setaside, respectively, were the most used habitats based upon availability whereas woodlands, cropfields, and gamecrops were least used (Table 2.3). Further analysis of MCP home ranges to recorded radiolocations ($\lambda = 0.14$, 6, 25df, $P< 0.0001$) revealed that within home ranges hen pheasant did not use habitats randomly. Paired comparisons among habitats revealed that woodlands, wetlands and coppice, respectively were the most used habitats based upon availability, whereas gamecrops, setasides, and other were least used (Table 2.4).

DISCUSSION

The initial results of the ongoing research at Hardegg Estate in Lower Austria suggest a healthy pheasant population. The even distribution of hen pheasant across age classes is indicative of a successful recruitment. Furthermore, the juvenile - dominated male age distribution suggests that males harvested the previous fall and winter were quickly replaced by young of the year. Spring counts by staff at The Game Conservancy Trust on Hardegg Estate estimated spring densities at 100 hens/ km^2, which are among the highest recorded for Europe (Robertson 1997). Exceptional winter habitat, feed hoppers and predator control likely augment survival numbers on the estate. With mortality exceeding 80% in some studies (Dumke and Pils 1973, Perkins *et al.* 1997) it is quite noteworthy that survivorship on Hardegg Estate was estimated at 97% for the winter of 1999. This high survival for hens is supported by the large percentage of adults among trapped hens. This is compared to the low percentage of adult males in this population where only males are harvested. Population levels entering recruitment play a significant role in maintaining or increasing levels for the following winter.

Mean MCP home range of 7.83 ha is comparable to research in west Texas where winter home ranges averaged 8.9 ± 1.8 ha (Whiteside and Guthery 1983). Whiteside and Guthery (1983) speculated home ranges were small due to restricted available cover. However, it is most likely that winter home ranges on our study site were restricted due to high quality cover and food availability. There was little need for pheasants to travel during the inclement weather of the winter months since maintaining quite restricted home ranges would fulfill all the basic survival requirements.

Research in southeastern North Dakota revealed that median 100% MCP home ranges were 10 and 9 ha during the winter of 1992 and 23 and 24 ha during the winter of 1994 for adult and juvenile hen pheasants respectively. Statistical analysis revealed that there was no age-class difference detected with regards to home range size (Homan *et al.* 2000). This finding agrees with our study showing no statistical difference between home ranges with respect to age classes. The work by Homan *et al.* (2000) and our findings from Hardegg Estate are in opposition to several studies indicating that juveniles are unsettled and possess significantly larger home ranges than adults (Gates and Hale 1974, Wooley and Rybarzck 1981, Gatti et al. 1989).

The scientists in the North Dakota study state that loss of habitat due to excessive snow cover during the winter of 1994 forced pheasants to seek more woodland shelter and thus extend the area of their home ranges among all age classes (Homan *et al.* 2000). Winter habitat throughout much of Hardegg Estate is available during periods of excessive snow accumulation. Reed beds on Hardegg Estate are available on slopes and within woodland interiors and are therefore shielded from snow accumulation and drift.

Second – order (as defined by Homan *et al.* 2000) compositional analysis revealed that coppice and wetlands were the most - preferred habitats within MCP home ranges based upon availability in the study area. Results from similar analysis of data from southeastern North Dakota showed wetlands were most preferred (Homan *et al.* 2000). Similarly, hen pheasants in west Texas used playa wetlands heavily during winter (Whiteside and Guthery 1983).

Several important trends were evident from third – order compositional analysis of MCP home ranges to radiolocations. Similar to research in southeastern North Dakota, hens preferred wetlands more frequently than availability would indicate within a given MCP home range based on radiolocations (Homan *et al.* 2000). Woodland and more specifically coppiced woodland were selected more than their availability within home ranges would indicate. These important trends may have significant implications for future habitat management.

Our research indicates that population management practices on Hardegg Estate augment pheasant population levels. Availability of feed hoppers near winter cover allows hen pheasants to maintain reduced home ranges and reduced exposure to predation while feeding. Predator control prevents populations of pheasant predators from experiencing exponential growth and potentially decimating pheasant populations. Availability of excellent winter cover reduces stress on pheasants during inclement weather. These winter management practices provide for a healthy pheasant population for the onset of the breeding season. Hen pheasants enter the spring in better health and are better able to cope with the rigors of reproduction.

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Table 2.1. The Hardegg Estate study area in Lower Austria was broken down into 7 defined habitat types for purposes of habitat analysis.

Type	Description	%
Woodland	Mature forest, primarily hardwoods, periodically thinned for timber and fuel	3.82
Coppice	Hardwood forest that has been cut and allowed to root sprout, also elderberry thickets are included in this habitat type	0.27
Setaside	Rotational and long-term setaside lands that are left in native plant species, these are partially subsidized by the EU	2.89
Gamecrop	Arable lands planted to mixtures of beneficial species which includes: cereals, forbs, sunflowers, hemp and Lucerne	0.94
Wetland	All lands adjacent to permanent or semi-permanent water including wetlands, irrigation ditches, and the Pulkau River	1.97
Cropfield	Arable lands primarily planted to cereal grains but also includes rape, maize, lucerne, sugar beet, and Austrian peas	70.41
Other	Primarily infrastructure which includes villages, all farm structures, storage facilities, wine cellars, roads, and silos	19.70

Table 2.2. 95% Kernel home range areas and 100% MCP home range areas for hen pheasants on Hardegg Estate during the winter of 1999 - 2000 calculated using ArcView Version 3.2.

	95% Kernel		100% MCP		
	Mean	SE	Mean	SE	n
Juvenile	14.06	5.58	7.87	2.32	11
Adult	16.62	8.45	7.81	2.01	20
Both	15.71	5.70	7.83	1.51	31

Table 2.3. Simplified rankings matrices of seven defined habitat types based upon comparison of proportional habitat use within each 100% MCP home range with the proportion of each habitat type within the Hardegg Estate study area. The higher ranking indicates greater use. Within the matrix, (+) indicates that the row habitat is used more than the column while a (-) indicates the opposite. A (+++ or - - -) indicates that $P < 0.05$ for use of the corresponding pair of habitats.

Habitat	1	2	3	4	5	6	7	Rank
Woodland	.	- - -	-	+	-	+	+++	3
Coppice	+++	.	+	+++	+	+++	+++	6
Setaside	+	-	.	+++	-	+++	+++	4
Gamecrop	-	- - -	- - -	.	- - -	-	+	1
Wetland	+	-	+	+++	.	+++	+++	5
Cropfield	-	- - -	- - -	+	- - -	.	+++	2
Other	- - -	- - -	- - -	-	- - -	- - -	.	0

Table 2.4. Simplified rankings matrices of seven defined habitat types based upon comparison of proportional habitat use at radiolocations with the proportion of each habitat type within the 100% MCP home ranges. The higher ranking indicates greater use. Within the matrix, (+) indicates that the row habitat is used more than the column while a (-) indicates the opposite. A (+++ or - - -) indicates that $P < 0.05$ for use of the corresponding pair of habitats.

Habitat	1	2	3	4	5	6	7	Rank
Woodland	.	+	+++	+++	+	+++	+++	6
Coppice	-	.	+	+	-	+++	+++	4
Setaside	- - -	-	.	-	- - -	+++	+++	2
Gamecrop	- - -	-	+	.	- - -	+++	+++	3
Wetland	-	+	+++	+++	.	+++	+++	5
Cropfield	- - -	- - -	- - -	- - -	- - -	.	-	0
Other	- - -	- - -	- - -	- - -	- - -	+	.	1

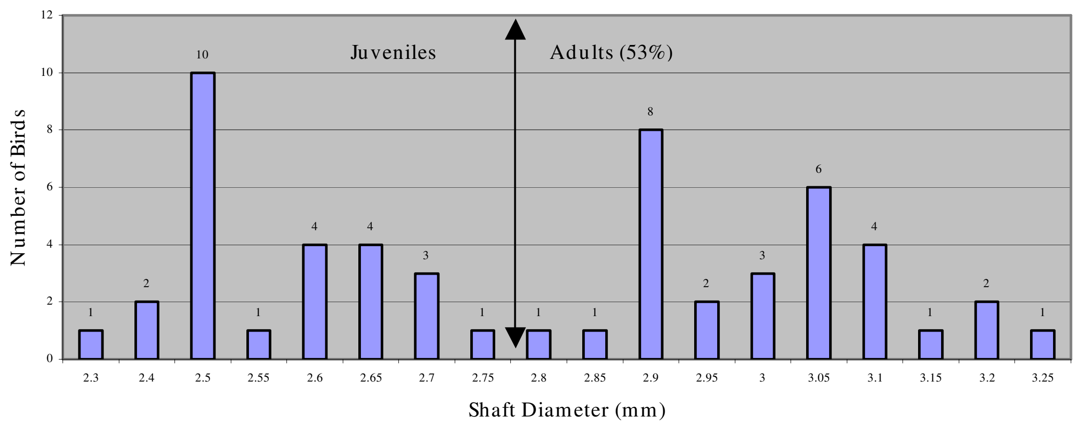

Figure 2.1. Age distribution of radio – collared hen pheasants on Hardegg Estate during the winter of 1999 (n = 55). The arrowed line indicates the separation between juvenile and adult hens based upon proximal primary shaft diameter.

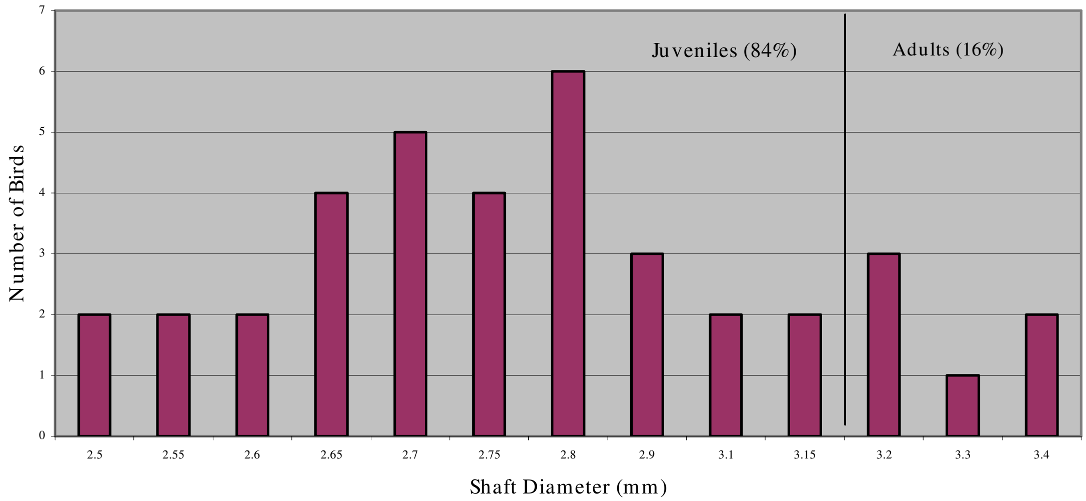

Figure 2.2. Age distribution of male pheasant collected during a shoot on Hardegg Estate during the winter of 1999 (n = 38). The vertical line indicates the separation between juvenile and adult males based upon proximal primary shaft diameter.

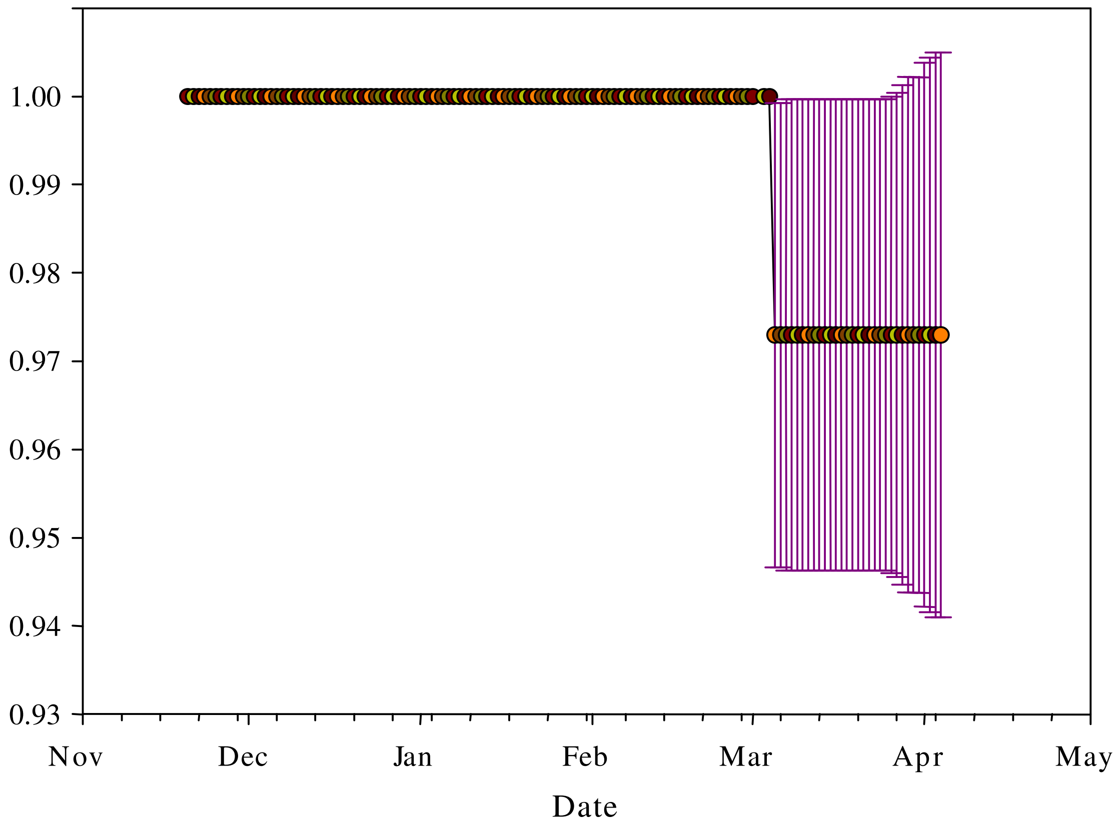

Figure 2.3. Survival of 55 hen pheasants was estimated using the Kaplan – Meier method and staggered entry design. Survival from November through April 1999 on Hardegg Estate was 97.3% (± 3.02 SE).

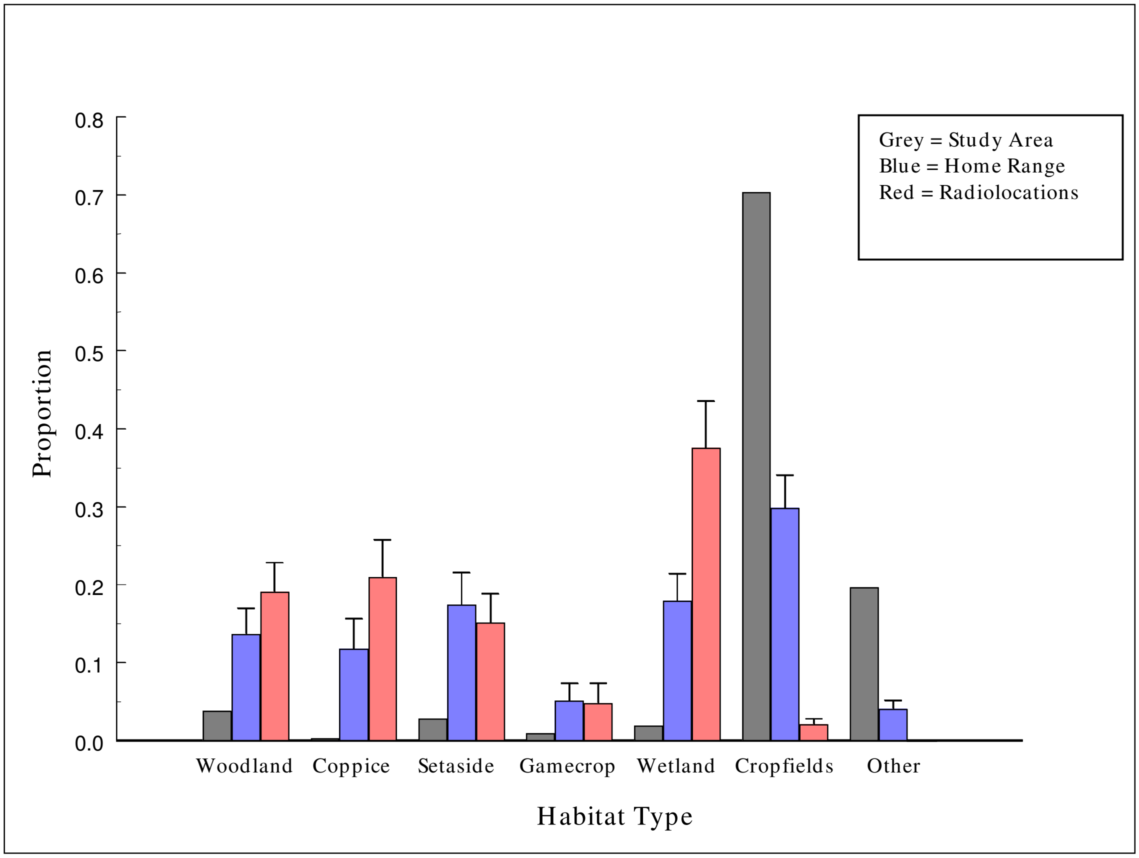

Figure 2.4. For habitat use analyses, the study area was broken down into seven habitat types. Proportions of each habitat within the study area appear without error bars. Proportional relative use of each habitat type at the 100%MCP home range and radiolocation levels was analyzed to determine its importance at both levels. Analysis was performed using BYCOMP.SAS.

CHAPTER 3

SURVIVAL, NESTING ECOLOGY, AND HABITAT USE OF HEN PHEASANTS IN LOWER AUSTRIA

INTRODUCTION

Population levels for a given species in a given location are determined in part by recruitment, which is in turn predicated on landscape and microhabitat variables that are not clearly understood with regard to the pheasant (Clark *et al.* 1999). The current knowledge base for pheasant recruitment behavior is limited primarily due to past research focusing solely on the microhabitat scale (Clark *et al.* 1999). More recent research has begun to address the importance of landscape scale variables (Morris 1995, Schmitz *et al.* 1999). Groombridge (1992) states, "that the destruction and fragmentation of natural habitats are the two most important factors in the current species extinction event."

Fragmentation often involves reduction of suitable pheasant nest sites and a concurrent amplification of the edge habitat available (Andren 1995). That reduction in suitable nest sites and increase in edge is often associated with increased predation rates on nests and nesting individuals (Andren 1995, Burger *et al.* 1994). Depredation of nests in an intensive agricultural setting can be considerable. This high nest loss is attributed to the limited quantity and drastically reduced quality of the available nesting cover. Most available cover in an intensive agricultural setting is linear and attenuated, such as fencerows, roadside edges and field margins (Gates and Hale 1975, Warner et al. 1987, Riley et al. 1994). It is important to note that most research involving the effects of fragmentation and habitat reduction draw no clear distinction between the two.

Therefore, the effects of the two variables are quite often confounded (Fahrig 1997).

Loss of habitat and fragmentation of remaining habitat and their negative effects on population levels are well documented for pheasants (Clark *et al.* 1999, Schmitz and Clark 1999, Warner 1984). Early research proclaimed that the amount of edge habitat in a given location determined the quality of the pheasant habitat or the greater the edge to total area ratio then the higher quality the habitat (Leopold 1933). However, more recent research indicates that previous efforts did not account for the negative effects of edge on survival and recruitment (Reese and Ratti 1988, Guthery 1997). A study conducted in northern Iowa, USA reported that during spring there is a negative association between increased edge habitat and survival. The patches of habitat with higher densities of edge were attractive to the hen pheasant whose predator avoidance instinct was apparently overcome by the need to reproduce (Schmitz and Clark 1999). Schmitz and Clark (1999) postulated that this would lead to high pheasant densities and predator activity in the small patches of suitable, available cover. Often these patches are the only available spring cover for pheasant in an agricultural setting (Clark *et al.* 1999).

LITERATURE REVIEW

Nest site selection behavior by hen pheasant has been thoroughly studied in the United States (Clark *et al.* 1999, Schmitz and Clark 1999, Whiteside and Guthery 1983). A study in northern Iowa revealed that pheasants in that region preferred nest sites in perennial grass blocks composed of cool-season grasses (Clark *et al.* 1999). The researchers noted however that vegetation type adjacent to the nest site did not predict selection or success during their study (Clark *et al.* 1999). Further research in eastern Colorado, USA revealed that winter wheat contained 75% of the successful nests throughout the 3-year study. The Colorado study also disclosed that nesting in perennial grass was lower than expected and nesting in weeds, roadsides and alfalfa was higher than expected (Snyder 1984). A review all of the North American literature regarding pheasant nesting from 1933 through 1990 was conducted to determine whether or not nesting cover is a limiting factor on pheasant populations (Robertson 1996). Robertson (1996) determined that pheasants select strip cover (defined as: roadsides, fence lines, ditches, railways) and hay (defined as: grass, alfalfa, clover, or a mix of these mowed at least once) over residual (defined as: ungrazed grass, old fields, conservation reserve, soil bank, short wetland vegetation, and other residual cover) and woody (defined as: scrub, high forest, orchards, tall wetland vegetation) cover, with cereal grains being least preferred for nesting. Further analysis of successfully hatched broods to availability of specific habitat type revealed that strip and woody cover maintained the highest productivity, hay and residual cover were intermediate and grain was rated the poorest. Finally, Robertson (1996) concluded, "If nesting cover is limiting, high density populations should contain higher proportions of birds nesting and hatching in preferred habitats. No difference in proportion of nests located or hatching in different habitats was identified between high- and low-density populations."

Hen pheasant home ranges during the breeding season tend to vary with activity. There are the pre-nesting range, the laying range and the renesting range (Hill and Robertson 1988). A study in Great Britain determined that the laying range average was 17.8 ± 3.6 ha whereas, the renesting range was generally smaller at 10.9 ± 4.0 ha. The pre-nesting range was approximately 9 ha larger than the average of all nesting ranges which was 16.0 ± 2.9 ha (Hill and Robertson 1988). Although pre-nesting and laying ranges overlap, there is no relationship between them with regard to size. Finally, 15 of the 24 pheasants in the British study nested on the edge or just outside of their laying range (Hill and Robertson 1988). A Maryland study of 11 radio-collared hens revealed an average home range of 235.9 ± 92.1 ha for the entire nesting period and 51.2 ha ± 41.2 ha for the post-nesting period (Smith *et al.* 1999). A study in west Texas disclosed an average spring home range for hen pheasant of 11.2 ± 2.6 ha (Whiteside and Guthery 1983). Further research in Great Britain concerning brood home ranges from hatching through 20 to 25 days of age revealed a range from 1.5 ha to 8.8 ha (Hill 1985). Finally, home ranges were determined for broods in a long-term study conducted in northern Iowa, USA. Brood home ranges were calculated for the first 28 days of life or until last chick in the brood died. For the two study areas the average home range for hens with broods was 76ha at Palo Alto and 66ha at Kossuth (Riley *et al.* 1998).

Pheasants nest in rather open areas especially early in the nesting season before the spring flush of vegetation. The cryptic coloration of the hen pheasant's plumage is certainly an aid in avoiding detection. However, mammalian predators rely primarily on their sense of smell for prey detection. There is some evidence that pheasants reduce their scent production during incubation by either diminution in scent produced or a general reduction in activity levels (Hill and Robertson 1988). A review of six published studies by Hill and Robertson (1988) concluded that nest success is highly variable. The six studies produced a range from 10.4% to 50.5% nest success. Losses were primarily attributed to predators and agricultural disturbances. In Europe, there are a host of species that depredate pheasant nests including *Corvus corone cornix* (hooded crow), *C. corone corone* (carrion crow), *Pica pica* (magpie), *Erinaceus europaeus* (Hedgehog), *Vulpes vulpes* (red fox), *Meles meles* (Eurasian badger), *Canis familiaris* (domestic dog) and *Felis catus* (domestic cat). A British study conducted by gamekeepers known as the Pheasant Nest Recording Scheme (hereafter PNRS) identified the predator when known nests were depredated. Calculated daily rates of nest loss showed that avian species were responsible for three times more losses during laying than incubation (Mayfield 1961, Hensler and Nichols 1981). Foxes (*Vulpes vulpes*) accounted for 24.5% of incubation losses in the PNRS study. An Iowa study of 245 radio-collared hens determined that 288 nests were attempted and 142 successfully hatched providing a 49.3% success rate (Clark *et al.* 1999).

There has been a direct relationship established between annual chick survival and the number of pheasants taken during the following shooting season (Hill and Robertson 1988). Chick survival is of the utmost concern because of the obvious effect it has on available shooting stocks and the fact that the drastic decline of the grey partridge (*Perdix perdix*) has been linked to poor chick survival (Potts 1970). Some research indicates that the highest chick mortality occurs within the first 2 weeks (Hill 1985a, Meyers *et al.* 1988). Research in Iowa showed an average chick survival over the 5 - year study of 46% and 37% on the Palo Alto and Kossuth sites, respectively. Chick survival was estimated from time of hatching to 28 days of age on the respective sites (Riley *et al.* 1998). A survey of eight Midwestern states determined that there was a significant decline in mean brood size from the 1950's and 1960's to the mid - 1990's. A 10 – 20% mean brood size reduction was observed during this time period (Riley and Riley 1999). The researchers attributed this decline in brood size to the concomitant reduction in grasslands, which in turn affects survival. Research in Great Britain by Hill (1985) tracked the survival of eight broods where survival was assessed from hatching through 20 –25 days of age and chick survival ranged from 18% to 88% among broods.

The well-documented decline of the grey partridge (*Perdix perdix*) in Europe was attributed to the reduction in insects, the primary partridge chick food source during the first 2 weeks of life (Potts 1970). It would, therefore, be reasonable to assume that pheasant population declines may be due to similar circumstances. Past research of pheasant chick food habits primarily involved crop analysis. This required the sacrifice of chicks and therefore hindered accurate analysis of survival – diet relationships (Hill 1985). A study performed in Great Britain used fecal analysis to determine diet of chicks. Incubating hens were trapped and fitted with radio collars and followed until hatching. Broods were located using telemetry and night roost sites were determined and marked. Fecal remains were collected the following morning and analyzed to determine insect consumption (Hill 1985). Mean brood home range was 4.8 ha ± 1.0 ha, which compares favorably with a study performed in Illinois (Warner 1979) where mean brood home range was determined to be between 5 and 10 ha. Hill (1985) discovered that chick survival was greater when insect biomass was greater and broods were able to maintain relatively small home ranges. Broods with ranges containing little insect biomass were forced to maintain larger home ranges and suffered greater mortality.

OBJECTIVES

There were several primary objectives for the research into the spring ecology of hen pheasant on Hardegg Estate:

- Determine relative use of habitat types in relation to their availability and determine hen mortality within each habitat type.
- Establish spring/ summer home ranges for female pheasant and determine if home range size is related to habitat quality and/ or mortality.

- Determine the total spring/ summer mortality and nesting success for the female pheasant population.
- Determine relative abundance of insect food for broods.

STUDY AREA

A mosaic of habitat types characterizes the study area, Hardegg Estate. It is a 2400 ha private estate in Lower Austria. It produces primarily cereal grains (1100 ha), and maize (300 ha) for feed in its swine operation. Additional crops include 70 ha of oilseed rape, 200 ha of sugar beets and 50 ha of vineyards. The remainder of the estate consists of 250 ha of woodland, 100 ha of wetland, 70 ha of long-term setaside and 200 ha of rotational setaside. The majority of the estate equipped with irrigation ditches. The estate is situated within an old lakebed that was drained for agricultural purposes.

METHODS

Capture - Trapping of hen pheasants commenced in March 2001. Hens were trapped in varying habitat types around the estate using 0.6m X 1.2m X 0.6m walk-in type funnel traps. Funnel traps were constructed with 2.5cm X 2.5cm wood strips and light gauge, 5cm X 5cm welded wire. The funnel was made from 2.5cm chicken wire. Captured pheasant were fitted with 173 MHz RI-2B adjustable elastic/ Dacron necklace transmitters with a six-month lifespan (manufactured by Holohil Systems, Limited in Ontario, Canada). At the time of capture we measured tarsus length (mm), obtaining weight (g), and a patagial tag was attached to the wing for absolute identification. The exact capture location was noted for each bird prior to release. The pheasants were then given 1 day of post-capture acclimation before telemetering commenced.

Age distribution – The age distribution of the hen pheasant population was determined by taking the proximal (innermost) primary wing feather (1^{st} primary in the American system and 10^{th} primary using the European system) at time of capture. The feathers are then dried under low heat (50°C) for 24 hours. The shaft of each feather is measured using a dial caliper at the level of the scar near the base of the barbs in the plane that coincides with the vane. Measurements are then compared to established norms for each age class (Woodburn 1999, Wishart 1969). This is the first primary feather molted during the post-juvenile molt. Therefore juvenile individuals are highly likely to have smaller shaft diameters than adult individuals. Research into variation in adult and juvenile proximal primaries found that established measurements used to separate age classes were 92% accurate (Greenberg *et al.* 1972).

Radio - tracking - Pheasants were tracked using a Telonics receiver and a 3-element Yagi antenna for a period of 6 months or until death. Each bird was located daily. Their exact locations were determined using a combination of the triangulation method of telemetry that requires taking readings from the three points of a triangle from <50m to establish strength of radio signal (Lee *et al.* 1985) and homing. Habitat use was noted for each location including vegetative structure and topography. Pheasants were located primarily during daylight hours.

Nest monitoring - Pheasants were monitored closely to determine initiation of incubation. Pheasants that reduced movements to a noticeably small area would be monitored multiple times within a given day to determine the location of the nest site as expeditiously as possible. Once incubation had been established, nest sites were checked twice daily until the hen was determined to be off the nest and feeding. Nests would then be checked for total number of eggs under incubation and "floated" to determine extent of incubation. Egg flotation in a water filled transparent container has been shown to be an effective means of determining how far in the incubation cycle a specific clutch of eggs has progressed. The angle and height at which a given egg floats within the water column designates the extent of incubation (Westerkov 1950, Carroll 1988). A nest would be visually inspected any time it was determined that the hen was not incubating. Depredated nests were thoroughly inspected in an attempt to determine predator species responsible.

Vegetation density at nest sites - Vegetation density measurements were taken in and around the nest site. A method was used adapted from Robel *et al.* (1970), which correlated the amount of vegetation present with indices to visual obstruction. Using a 1-m pole marked at each decimeter, readings were taken from each nautical direction to the nearest visible decimeter mark from a distance of 4 m and a height of 1 m. This measurement was performed at the nest site and at four random transects within twenty meters of the nest site.

An additional method of quantifying vegetation density was employed at each nest site. The method scales visibility of clutch from a side view where the researcher attempts to detect the clutch from a squatting position approximately 0.5 m from the nest. Clutch visibility is also assessed from a top-down perspective where the researcher assesses visibility directly above the nest site from an erect standing position. The method uses a one to four scale with four being the most densely vegetated site or rather clutch is totally obscured from view (R. A. H. Draycott pers. comm. 2001). The theory being that the side view represents possible detection by mammalian predators and the top-down view represents detections by avian predators.

Food availability relative to consumption - Locations taken after sunset at brood roost sites were necessary for fecal collection. The locations were marked with fluorescent flagging and researchers returned the following morning to collect fecal remains. Fecal matter collected was then frozen and forwarded to Steve Moreby, an entomologist at the Game Conservancy Trust in Fordingbridge, England for analysis. Using undigested portions of macroinvertebrates, Moreby was able to identify to family the macroinvertebrates consumed by broods (Moreby 1988).

In conjunction with the fecal collection, sweep netting was used to collect insects from the general area surrounding the roost site. Three 25 m, random transects were walked with alternating side-to-side sweeps totaling to 25 sweeps per transect. Insects collected were bagged and frozen for later analysis. Insects were then identified to family and frequency was recorded (Green 1984). The fecal analysis and the insects collected from the same area were compared to determine the specific consumption rates relative to availability of a particular insect family.

Survival - Telemetry was also used as an aid in determining survivorship. Pheasants and clutches or broods that did not survive were thoroughly examined in an attempt to determine cause of death. Cause of death was identified at least to either mammalian or avian predators or anthropogenic means. Where possible, cause of death or depredation was determined to species. Survival was estimated for the population using the Kaplan-Meier method (Kaplan and Meier 1958) and staggered entry design (Pollock *et al.* 1989). This method of measuring survival accounts for subjects that enter the radio-tagged population over time and those that are lost for reasons other than mortality.

Home range - Using the animal movement extension version 2.0 for ArcView (Hooge and Eichenlaub 1997), the 95% probability kernel home ranges and the 100% minimum convex polygon (hereafter MCP) home ranges were calculated for each of the radio-collared pheasant that had >15 radio locations.

Habitat Analysis - Proportions of seven defined habitat types within the designated study area and each calculated MCP home range were determined by intersecting habitat type determinations with study area and home range delineations using the Geoprocessing Wizard in ArcView Version 3.2. Sample size was maximized by pooling data from across age classes (White and Garrot 1990). The 100% Minimum Convex Polygon method (Mohr 1947) of determining home range was employed due to its ubiquitous nature in the literature and more importantly because it only incorporates the area delimited by the outermost radiolocations recorded for a particular animal (Aebischer *et al.* 1993).

Statistical analysis was performed on the raw proportional data using BYCOMP.SAS (Ott and Hovey 1997). For each radio collared hen, proportion of habitat types within the study area were compared to those within a given calculated MCP home range, and the proportion of radio locations within a specific habitat type for a given hen were compared to the proportion of habitat types within each hen's calculated MCP home range. This two-tiered approach allowed for testing of hypotheses at different scales of habitat use. Use of habitats at each level was performed using a multiple analysis of variance (MANOVA) and incorporating Wilk's λ analyses to test for significance. The program then ranked each habitat with the largest rank being the most preferred based upon paired t-tests for all habitat combinations of the log – ratio differences.

RESULTS

Capture – Thirty-six hens were captured, measured and radio - collared for this study. Monitoring began on 5 May 2001 and continued through 11 August 2001 for a total of approximately 100 days of monitoring. Monitoring resulted in a total of 1,173 radiolocations.

Age distribution – The proximal primary wing feather was collected from the 36 hens involved in the project plus one incidental capture for a total of 37. The age distribution was evenly balanced between juvenile and adult birds (Figure 3.1).

Nest monitoring – There was a success rate of 71% for nest attempts on Hardegg Estate during the study. Of the original 36 radio - collared hens, only 13 successfully laid a clutch of eggs with a single renest for a total of 14 known nesting attempts. Ten clutches were successfully incubated with 4 failures (Table 3.1). One of the nests was never discovered and the hen was finally located with a brood of <3 days old chicks. Average clutch size for all nest attempts was 9.5 (± 0.49 SE) eggs per clutch. However, it was impossible to determine whether clutches were first or second nest attempts. Sixty - nine percent of nest attempts on Hardegg Estate were within cropfields. The success rate for clutches in cropfields was 66% whereas nests in setasides experienced 100% clutch success

Vegetation at nest sites – Nine of the 13 nests studied were in agricultural fields with all but two of these being planted to winter wheat. The remaining nests were placed in naturally occurring grasses and forbs in fallowed areas (Table 3.2). There appeared to be no preference toward nest placement with regard to proximity to an edge with measurements ranging from 0.25 m to 100 m to the nearest edge. Average visual obstruction at nest sites was 6.40 dm (± 0.79 SE). Paired t-tests between nest site readings and random readings within 20 meters of the nest revealed that the mean difference = 0.04 (± 0.31 SE), 10 df, $P = 0.89$ (Table 3.3). Spearman Rho correlation calculations between vegetative visual obstruction (VVO) tests at nest sites based upon Robel *et al.* (1970) and a vegetation density measure developed by Draycott (*in press*) (Appendix A1) were performed. Draycott side view – VVO correlation calculations yielded r = -0.058, 10 df, $P = 0.8653$; for Draycott top view – VVO, r = -0.045, 10 df, $P = 0.8958$; and for Draycott top view – side view, r = 0.596, 10 df, $P = 0.0528$.

Food availability relative to consumption – Comparisons between fecal analysis and sweep netting results (Table 3.4) within a given brood home range may provide insight into insect biomass available in relation to consumption (Table 3.5). Fifty-seven percent of the insect Orders were found in both the fecal analysis and the sweep netting while 29% of the Orders were found in the fecal analysis but were absent from the sweep netting.

Survival – Hen survival for the study area pheasant population was 65.2% (±1.22 SE) through the 162 days of the study (Table 3.7). All hen losses to predation were noted and recorded with estimation as to potential predator responsible (Table 3.8). Although sample size was quite small, the red fox, *V. vulpes,* appeared to be the primary cause of spring and summer mortality. Fifty percent of confirmed deaths during the study were attributed to foxes (Table 3.6). A study of 354 nests under incubation in Great Britain indicates that 98 nests were lost with foxes accounting for 25% of nest losses (Hill and Robertson 1988). Research in Wisconsin revealed that 38% of pheasant predation was attributed to foxes and predation was elevated during the incubation period (Dumke and Pils 1973).

Home range - The mean 95% probability kernel home range was 50.3 ha (± 11.9 SE) with a range from 5.4 ha to 148.8 ha. The mean MCP home range was 50.3 ha (± 13.9 SE) with a range of 2.3 ha to 219.2 ha (Table 3.7).

Habitat Analysis – Comparisons between the habitat proportions of the study area and MCP home ranges ($\lambda = 0.072$, 6, 9 df, $P < 0.0001$) revealed that habitat use was not random. Paired analyses showed that wetlands and agricultural fields, respectively, were the most preferred habitats based upon relative use with woodlands being least preferred (Table 3.8). Further analysis of MCP home ranges to recorded radiolocations ($\lambda = 0.214$, 6, 8df, $P < 0.02$) revealed that use was not random. Within a given 100% MCP home range hen pheasant preferred woodlands and setasides, respectively, based on the relative use of these habitat types (Table 3.9).

DISCUSSION

Age structure was evenly distributed with juveniles comprising 49% of radio-collared individuals (Figure 3.1). An even age distribution is unusual for an r – selected species and serves to illustrate that survival is quite good on the Hardegg Estate. It appears that hens primarily nest in cereal fields and are subject to the management regimes for these types of crops. Site selection with regards to distance to nearest habitat edge was random. The nest success rate on Hardegg Estate during the study is consistent with similar studies of nest success. However, there must be consideration for the fact that our study included only one renest and therefore our success rate was essentially based upon first nest attempts while similar studies include all nest attempts by individuals in the study. The study of hen pheasant in a west Texas study revealed that 53 of 74 (72%) hens successfully hatched broods (Snyder 1984). A study in Iowa reveals similar nesting success with net success rates from 1990 – 1994 determined to be 70.5 ± 4.5% and 52.2 ± 7.1% at the Palo Alto and Kossuth study sites respectively (Clark *et al.* 1999).

Survival of hens during our study was lower than similar research in west Texas that maintained an 86% survival rate across the three years of the study. It is unlikely that pheasant densities in the west Texas study area reach the 100 hens/ km^2 recorded at our study site (Robertson 1997), which may contribute to increased mortality. However, spring-to-fall hen pheasant survival estimates, similar to the one for our study area, averaged 54% across fifteen North American studies (Petersen et al. 1988). Survival for March through August 2001 was estimated at 65% with little to no mortality during late winter for the North American studies, which is consistent with our finding during the winter of 1999. A loss of approximately 10 - 12% of the study population during April and another 10 – 12% in June were the most significant trends. Mortality appears to level off during the late summer months (Figure 3.2). These elevated mortality rates during April and June may correspond to the onset of spring dispersal and first nesting attempts. This would be consistent with research in Illinois where the greatest mortality corresponded with the peak of incubation (Warner et al. 2000). During the recruitment of 2001, the primary predator was the red fox (*V. vulpes*) while no record of mortality due to raptor species was recorded (Table 3.6).

Most nests during the Spring of 2001 on Hardegg Estate were established in cereal fields with areas of native grasses and forbs (primarily setasides) containing less than a quarter of the nests. Cropfields rank low in relative use at the radiolocation level because of their abundance at the landscape level. However, they appear to be critical nesting areas. This may be due to limited availability of more preferred nesting habitat types.

Hen pheasants appeared to establish their recruitment home ranges based upon male territories. This is consistent with previous research that indicates that hen pheasants choose a mate based upon the available food supply, nesting cover, previous experience of male, and mate guarding ability (Hill and Robertson 1988). Hen pheasants also appeared to nest relatively close to male territories. On Hardegg Estate, it is expected that utilization of cropfields and wetlands would rank high. Provision of linear wetland habitat along field edges allows males to establish territories at the boundary between quality cover and open areas to be used for mate attraction displays. Therefore, hens on Hardegg Estate primarily migrate to these areas within the landscape.

There was high overall consumption of available insect orders by pheasant chicks. Further analysis suggests that there was selective consumption among available insect orders by chicks during the spring of 2001 (Table 3.5).

Habitat utilization within home ranges on Hardegg Estate was greatest in woodland, setaside, and wetland. This is most likely due to the placement of feed hoppers along the edges of these habitat types. The managers on the estate believe that this will allow hens to the majority of their time in cover and would only be required to move to the edge of the available cover to feed. When setaside is available within a hen's home range then it will be utilized as brood habitat. However, this habitat type is not evenly distributed across the landscape and it is infrequently adjacent to preferred nesting habitat types.

Our preliminary research into the recruitment ecology of hen pheasant on Hardegg Estate indicates that current management practices significantly benefit local pheasant populations. Predator management on Hardegg Estate most likely plays a similar role to that of Mallard Island, North Dakota, USA. Research into pheasant nesting ecology on Mallard Island (Carroll and Sayler 1990) indicates that annual mammalian predator control contributes to increased recruitment success. Avian predators were not controlled on Mallard Island.

Habitat utilization analyses during the recruitment period revealed that nesting and brooding habitat dispersal on Hardegg Estate may contribute to decreased overall brood success. It appears that in areas where preferred brooding habitat is not directly adjacent to suitable nesting habitat then hens will utilize those available foraging areas where predation may play a larger role.

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Table 3.1. Data taken for each nest attempt by radio-collared hens including incubation estimates, where possible, using the flotation method described by Westerkov (1950).

Hen #	Clutch Size	Located	Floated	Estimate	Comments
1373[a]	-	05/ 26/ 01	-	-	depredated on 6/ 3/ 01 prior to nest data collection
1389	11	05/ 29/ 01	Day 1	06/ 24/ 01	nest depredated on ~ 6/ 19/ 01
1367	12	06/ 03/ 01	-	-	12 of 12 hatched on 6/ 5/ 01
1346	12	06/ 03/ 01	-	-	12 of 12 hatched on 6/ 4/ 01
1390	8	06/ 06/ 01	Day 16	07/ 03/ 01	6 of 8 hatched on 7/ 3/ 01
1371	9	06/ 06/ 01	-	-	5 of 9 hatched on 6/ 30/ 01
1386	9	06/ 06/ 01	-	-	4 of 9 hatched on 6/ 28/ 01
1372	10	06/ 07/ 01	Day 0	-	clutch abandoned after being mowed over on 6/ 7/ 01
1317	11	06/ 12/ 01	-	-	7 of 11 eggs hatched on 7/ 7/ 01
1347	8	06/ 20/ 01	-	-	4 of 8 hatched on 7/ 10/ 01
1373[b]	7	06/ 26/ 01	Day 3	07/ 22/ 01	7 of 7 hatched on 7/ 20/ 01
1316	9	06/ 26/ 01	Day 6 - 8	07/ 13/ 01	6 of 8 hatched on 7/ 14/ 01
1391	8	07/ 06/ 01	-	-	cereal harvested and nest destroyed
1321	-	-	-	-	brood discovered, no nest data
Mean	**9.5**				
SD	**1.68**				

[a] initial nest attempt

[b] second nest attempt

Table 3.2. Description of nest sites.

	% Composition at Nest Site				Distance to Nearest (m)		
Birds #	Forbs	Grasses	Woody	Site	edge	tree	road
1317	0	100	0	cereal field	40	160	165
1389	0	100	0	cereal field	46	50	47
1373[b]	0	100	0	cereal field	30	50	30
1373[a]	0	100	0	cereal field	29	35.5	30
1346	0	100	0	cereal field	100	110	112
1347	0	100	0	cereal field	50	60	50
1391	0	100	0	cereal field	1	40	40
1386	0	100	0	cereal field	2	15	18
1372	60	40	0	roadside/ field edge	0.25	20	0.25
1390	30	70	0	setaside	5	40	40
1371	100	0	0	setaside	1	20	18
1316	100	0	0	sugar beets	25	50	25
1367	20	60	20	woodland opening	1	1	50
				Mean	25.4	50.1	48.1
				SD	29.2	42.5	43.9

Table 3.3. Mean visual obstruction (Robel *et al* 1970) readings in decimeters used to determine vegetation density at the nest sites and random sites within 20m of nest sites.

Bird #	Nest	Random
1317	6.25	6.53
1367	4.75	6.59
1389	8.00	7.80
1373b	8.63	7.75
1373a	10.25	9.09
1346	7.75	8.59
1347	7.50	6.88
1390	3.75	5.19
1371	4.00	3.16
1316	1.38	1.25
1386	8.13	7.06
Mean	6.39	6.36
SD	2.63	2.35

Table 3.4. Counts of insects identified to order showing the comparison between fecal analysis and sweep netting results. Bird numbers followed by (†) indicate fecal collection results and the remaining columns under each specific date category indicate corresponding sweep-netting results.

Date	06/06/01		06/06/01		06/06/01		07/05/01				07/06/01				07/11/01				07/11/01			
Vegetation	winter wheat		fallow area		winter wheat		gamecrop				gamecrop/ setaside				gamecrop/ setaside				peas+/ setaside/ wheat			
								1st	2nd	3rd		1st	2nd	3rd		1st	2nd	3rd		1st	2nd	3rd
Insect Order	1321†	1321*	1367†	1367*	1346†	1346*	1371†	1371	1371	1371	1390†	1390	1390	1390	1390†	1390	1390	1390	1346†	1346	1346	1346
Coleoptera	5	7	68	4	29	5	13	8	27	32	10	48	76	61	43	52	49	29	28	68	40	18
Diptera	3	0	14	9	21	0	1	0	0	5	3	0	3	0	5	0	0	1	0	0	4	7
Hemiptera	3	1	10	12	3	4	1	42	24	102	5	30	27	39	14	20	22	18	1	2	20	20
Homoptera	0	0	0	6	0	1		0	0	2		5	13	9	0	4	5	3	0	0	3	1
Hymenoptera	2	0	7	0	1	0	1	0	0	2	7	2	4	3	30	0	0	4	8	0	0	4
Lepidoptera	1	0	15	0	2	9	0	4	7	7	1	13	0	0	3	2	2	1	1	0	0	0
Miscellaneous	1	0	11	29	6	0	1	1	9	10	0	29	42	41	8	1	2	17	0	1	3	0
Total	15	8	125	60	62	19	17	55	67	160	26	127	165	153	103	79	80	73	38	71	70	50

+ Austrian winter peas
*single transect swept

Table 3.5. The correlation between available insects biomass and consumption is represented using proportions. “YY” indicates that a particular Order represented in both the fecal collection and sweep net results. “YN” indicates an Order appeared in a sweep net sample but was absent from the corresponding fecal. “NY” indicates that a particular Order was represented in the fecal analysis but was absent from the corresponding sweep net results. “NN” indicates that a particular Order was absent from both the fecal and sweep net sampling for that particular brood and time.

Matrices Indicating Presence/ Absence of Important Insect Orders

			Proportion			
Bird #	Date		YY	YN	NY	NN
1321	06/ 06/ 01		0.29	0.00	0.57	0.14
1367	06/ 06/ 01		0.57	0.29	0.14	0.00
1346	06/ 06/ 01		0.43	0.43	0.14	0.00
1371	07/ 05/ 01		0.71	0.00	0.29	0.00
1390	07/ 06/ 01		0.71	0.00	0.29	0.00
1390	07/ 11/ 01		0.86	0.00	0.14	0.00
1346	07/ 11/ 01		0.43	0.14	0.43	0.00
		Mean	0.57	0.12	0.29	0.02
		SE	0.08	0.07	0.06	0.02

Table 3.6. Listing of each hen lost during the Spring 2001 study and an estimate as to the cause of death.

Hen #	Cause of death
1393	*Vulpes vulpes* - red fox
1323	*Martes foina* - stone marten
1348	*Vulpes vulpes* - red fox
1364	*Vulpes vulpes* - red fox
1350	Mammalian
1388	hit by vehicle
1325	Mammalian
1316	*Vulpes vulpes* - red fox
1367	*Vulpes vulpes* - red fox
1321	*Martes foina* - stone marten or *Felis catus* - domestic cat

Table 3.7. Mean home ranges (ha) for hen pheasant on Hardegg Estate during 2001 recruitment period displayed in both 95% probability kernel and 100% MCP. Results are divided into age classes to distinguish effects of age class on home range area.

	95% Kernel		100% MCP		
	Mean	SE	Mean	SE	n
Juvenile	63.98	25.20	64.83	32.15	6
Adult	42.02	11.98	41.54	12.10	10
Total	49.28	10.45	51.58	12.85	16

Table 3.8. Simplified rankings matrices of seven defined habitat types based upon comparison of proportional habitat use within each 100% MCP home range with the proportion of each habitat type within the study area. The higher ranking indicates greater use. Within the matrix, (+) indicates that the row habitat is used more than the column while a (-) indicates the opposite. A (+++ or - - -) indicates that $P < 0.05$ for use of the corresponding pair of habitats.

	Habitat							
Habitat	1	2	3	4	5	6	7	Rank
Woodland	.	- - -	- - -	- - -	- - -	- - -	-	0
Coppice	+++	.	-	+	-	-	+++	3
Setaside	+++	+	.	+	-	-	+++	4
Gamecrop	+++	-	-	.	-	-	+++	2
Wetland	+++	+	+	+	.	+	+++	6
Cropfield	+++	+	+	+	-	.	+++	5
Other	+	- - -	- - -	- - -	- - -	- - -	.	1

Table 3.9. Simplified rankings matrices of seven defined habitat types based upon comparison of proportional habitat use at radiolocations with the proportion of each habitat type within the 100% MCP home ranges. The higher ranking indicates greater use. Within the matrix, (+) indicates that the row habitat is used more than the column while a (-) indicates the opposite. A (+++ or - - -) indicates that $P < 0.05$ for use of the corresponding pair of habitats.

	Habitat							
Habitat	1	2	3	4	5	6	7	Rank
Woodland	.	+++	+	+++	+	+++	+++	6
Coppice	- - -	.	- - -	+	- - -	-	+	2
Setaside	-	+++	.	+++	+	+++	+++	5
Gamecrop	- - -	-	- - -	.	-	-	+	1
Wetland	-	+++	-	+	.	+	+++	4
Cropfield	- - -	+	- - -	+	-	.	+++	3
Other	- - -	-	- - -	-	- - -	- - -	.	0

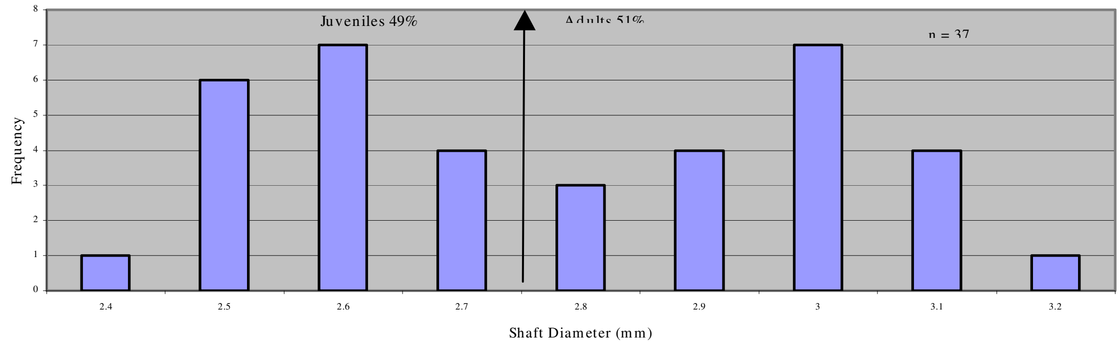

Figure 3.1. Age distribution of radio – collared hen pheasants on Hardegg Estate during the spring of 2001. The arrowed line indicates the separation between juvenile and adult hens based upon proximal primary shaft diameter (n = 37).

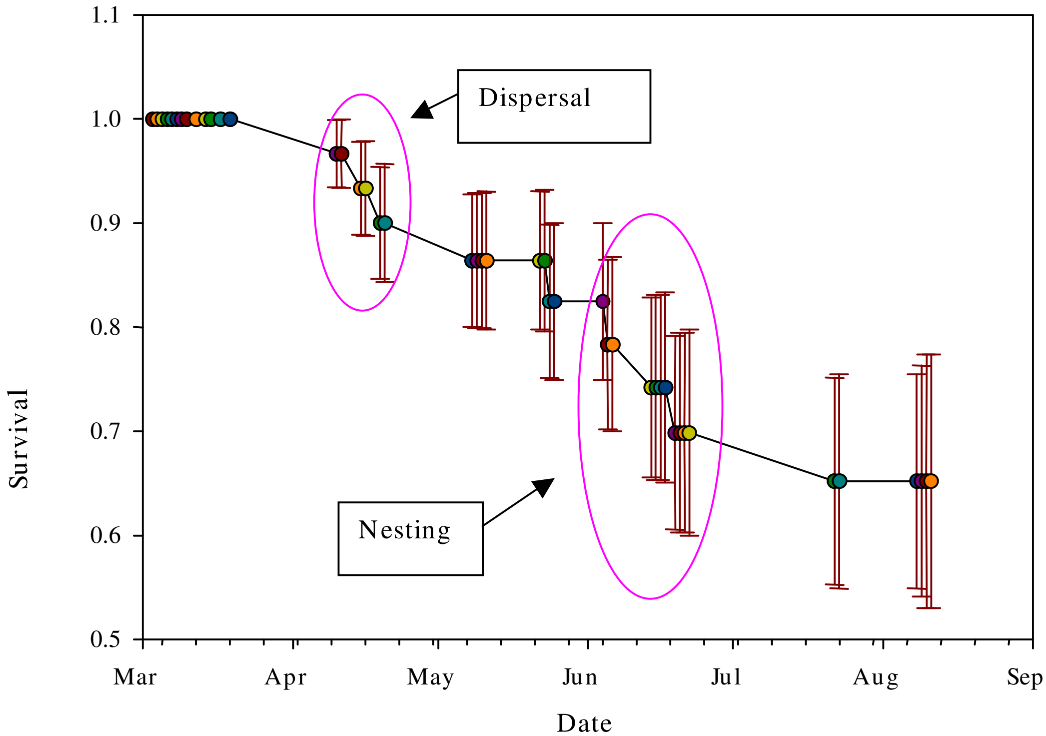

Figure 3.2. Kaplan – Meier survival estimates from November through April, 2001 was 65.2% (±1.22 SE) for radiotagged hen pheasants on Hardegg Estate (n = 36). Two critical periods are denoted with the first being spring dispersal and the second being the onset of the nesting period.

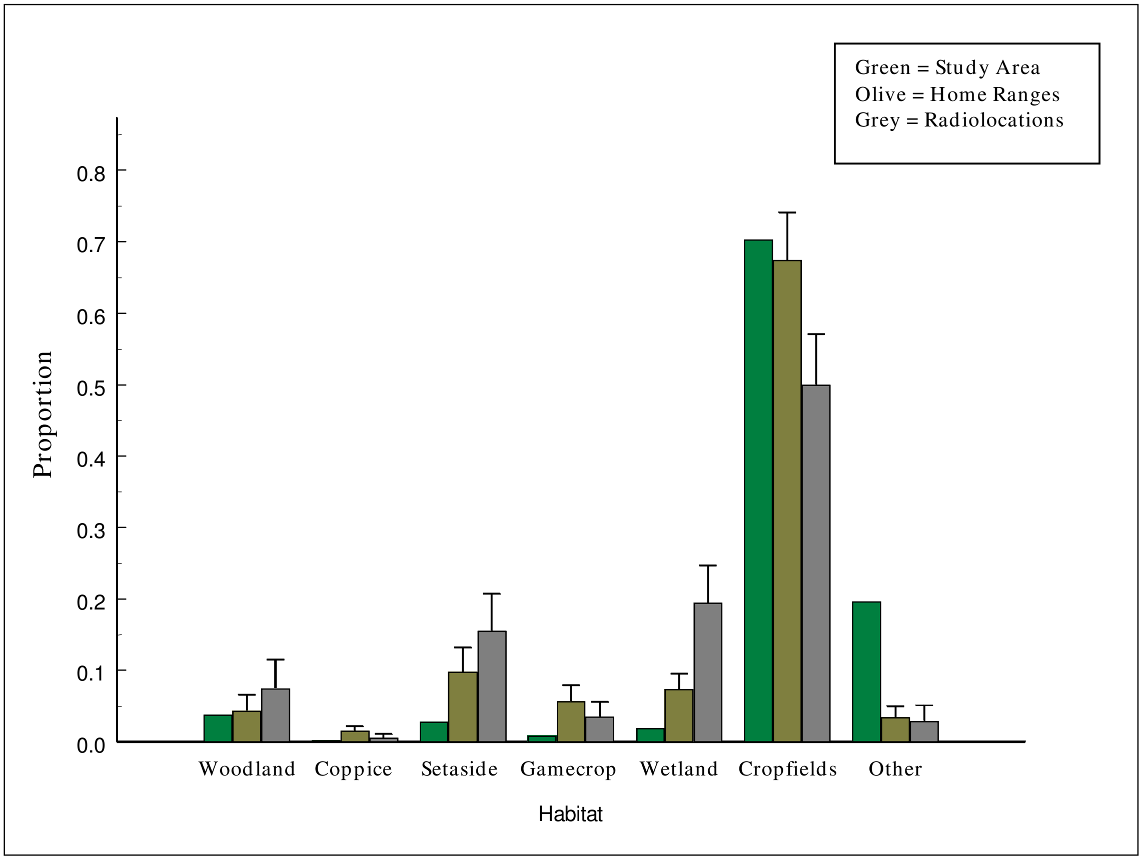

Figure 3.3. For habitat use analyses, the study area was broken down into seven habitat types. Proportions of each habitat within the study area appear without error bars. Proportional relative use of each habitat type at the 100%MCP home range and radiolocation levels was analyzed to determine its importance at both levels.

CHAPTER 4

MANGEMENT IMPLICATIONS FOR RING-NECKED PHEASANT IN LOWER AUSTRIA

MANAGEMENT IMPLICATIONS

This study suggests that population management measures taken by the staff on Hardegg Estate are exceptional for over – wintering pheasant. Winter survival estimates are near the highest recorded for pheasant populations excluding Pelee Island, where there is little to no predation (Robertson 1997). In contrast to prevailing belief in Europe that winter habitat management should focus solely on woodlands, our study confirms the importance of wetlands as preferred winter cover (Gatti *et al.* 1989, Gates and Hale 1974, Olsen 1977). Furthermore, our work supports research in Illinois that woody vegetation is an important component of winter habitat requirements for pheasant (Warner and David 1982). Coppice and properly managed woodlands proved to be highly preferred. Interestingly, coppice comprised only 12 ha of habitat across the study area. This may indicate that use of other habitat types is due in part to a limitation of available coppice. Hardegg Estate is continuing the development of wetlands and increasing the available coppice, which seem to be positively impacting the pheasant population.

Other research has indicated that hen pheasant may be forced to expand their home range during winter to include adequate food patches (Gatti *et al.* 1989). Provision of feed hoppers near preferred winter habitat on Hardegg Estate most likely reduces the need for home range expansion. This, in turn, may reduce vulnerability to potential predators and explains our exceptional survival rate (97%). However, a mild winter in 1999 probably contributed to elevated survival. Research in Iowa points to extended snow cover and minimum temperatures negatively affecting survival (Perkins et al. 1997). Predator management must also be considered as a contributing factor. Perkins *et al.* (1997) implicitly state that weather affects survival indirectly while predation is almost always the direct affect. Our research contradicts findings that juvenile hen pheasant maintain larger winter home ranges than adults (Gates and Hale 1974, Wooley and Rybarzck 1981, Penrod and Hill 1985, Gatti *et al.* 1989). Comparison of 100% MCP home ranges between age classes reveals that home range size was nearly identical. Additional research into habitat use, home ranges and survival during more typical weather for the region may prove useful in a comparison of disparate winters and their subsequent affect on the local pheasant population.

Breeding season research on Hardegg Estate revealed that spring survival was consistent with that of similar research in Colorado, Iowa and Wisconsin, USA (Snyder 1985, Schmitz and Clark 1999, Dumke and Pils 1973). Peak predation periods appeared to coincide temporally with the onset of first and second nest attempts. Further research is necessary to more accurately predict the timing of nest attempts for the pheasant population on Hardegg Estate. The role of predation is poorly understood in this region as well. Anecdotal accounts regarding numerous potential predators should be verified empirically.Our preliminary work indicates that mammalian predators had significant impact on survival. Nest monitoring with video cameras and radio - tagging of broods would potentially provide a more accurate assessment of the role predation plays during the spring and summer months. Roadside surveys to determine mean brood size may also aid in assessing spring pheasant population health from year to year (Riley and Riley 1999).

The general consensus among scientists is that the provision of quality nesting cover is the most effective means of enhancing pheasant population levels (Robertson 1996). Compositional analyses of habitat use on Hardegg Estate ranked cropfields as moderately important during the breeding season due to their relative abundance. However, nearly 3/ 4 of nest attempts on Hardegg Estate were within cropfields during 2001. The success rate for clutches in cropfields was significantly lower than nests in setasides, which experienced no depredation. This may be evidence that limitations on preferred nesting cover are affecting pheasant population levels. However, further research into clutch success is necessary due to the limited sample size during the 2001 research.

Continued research on Hardegg Estate is essential toward gaining an understanding of pheasant population ecology in Eastern Europe. The ecology of pheasant in this region is grossly understudied. Current management practices on Hardegg Estate that are empirically proven to contribute to the success of pheasant populations might be applied throughout the region where pheasant populations are experiencing declines.

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APPENDIX

A1. Nest scoring indices developed by R. A. H. Draycott as a method for determining vegetation density at the nest site level. Nests are scored on a continuum from 0 to 4 with 4 being that the nest is completely obscured from view. Nests are scored using a side view and top – down visual obstruction rating.

Tag #	Side	Top Down	Ht.(dm)	Hatched
1372	3	4	-	n
1389	3	3	10	n
1373a	2	3	9	n
1391	2	1	5	n
1317	3	3	7	y
1367	3	4	3.5	y
1373b	2	3	8	y
1346	3	3	9	y
1347	1	2	8.5	y
1390	3	3	11	y
1371	3	4	3.5	y
1316	0	0	2	y
1386	3	2	8	y
Mean	**2.38**	**2.69**	**7.04**	
SD	**0.96**	**1.18**	**2.87**	
Hatch x	2.33	2.67	6.72	
No Hatch x	2.5	2.75	8	

Table A.2. Data collected at time of capture for winter 1999 research.

Number	Date	Location	Weight (g)	Tarsus (mm)	Feather	Shaft (mm)	Patagial Tag	Radio Freq.
1	11/ 16/ 99	C8a	1000	71.5	YES	2.9	312	0.039
2	11/ 16/ 99	C8a	1000	80.7	YES	2.9	313	0.812
3	11/ 18/ 99	C8a	1060	90.5	YES	3.05	301	0.554
4	11/ 19/ 99	B8b	1010	80.2	YES	3.05	302	0.257
5	11/ 19/ 99	C8a	990	82.2	YES	2.55	304	0.633
6	11/ 22/ 99	D1c	900	72	YES	2.85	305	0.435
7	11/ 22/ 99	B8b	1015	77.7	YES	2.9	306	0.614
8	11/ 22/ 99	C9d	1100	79.7	YES	3	307	0.138
9	11/ 24/ 99	D1c	1020	87.3	YES	2.9	308	0.792
10	11/ 24/ 99	D1c	1000	84.1	YES	2.5	309	0.277
11	11/ 29/ 99	B8b	960	78.2	YES	2.7	310	0.336
12	11/ 29/ 99	C6e	980	81.5	YES	2.6	311	0.911
13	11/ 30/ 99	D1c	940	85.6	YES	3.05	314	0.831
14	11/ 30/ 99	D1c	860	78.5	YES	2.7	315	0.95
15	12/ 01/ 99	D1c	980	81	YES	2.9	316	0.534
16	12/ 01/ 99	C9d	920	79.5	YES	2.5	319	0.416
17	12/ 01/ 99	B8b	980	82.3	YES	2.5	320	0.198
18	12/ 02/ 99	A8f	1120	82.5	YES	2.5	321	0.871
19	12/ 02/ 99	C9d	940	80.7	YES	2.5	322	0.891
20	12/ 02/ 99	C9d	850	75.6	YES	2.75	325	0.675
21	12/ 05/ 99	C8a	880	79.3	YES	2.9	326	0.455
22	12/ 05/ 99	B8b	820	80.1	YES	2.5	327	0.158
23	12/ 06/ 99	C8a	970	84.3	YES	2.4	317	0.567
24	12/ 07/ 99	B8b	1060	85.8	YES	2.7	328	0.218
25	-	C6e	960	79.2	YES	2.65	329	0.376
26	12/ 08/ 99	C6e	1020	81.2	YES	2.8	330	0.594
27	12/ 10/ 99	D2g	1000	74	YES	2.9	332	0.495

Number	Date	Location	Weight (g)	Tarsus (mm)	Feather	Shaft (mm)	Patagial Tag	Radio Freq.
28	12/ 10/ 99	D2g	1025	77.5	YES	2.95	333	0.752
29	12/ 10/ 99	D3h	1000	75.9	YES	3.05	334	0.93
30	12/ 14/ 99	D3i	900	77.3	YES	3	335	0.871
31	12/ 17/ 99	D2g	880	76.1	YES	2.4	336	0.099
32	12/ 20/ 99	D3i	1000	71.1	YES	2.65	338	0.97
33	12/ 20/ 99	D3i	1080	80.5	YES	2.95	339	0.475
34	12/ 20/ 99	D3i	1020	73.5	YES	3.05	337	0.297
35	12/ 20/ 99	D3h	1080	78	YES	3.1	341	0.851
36	12/ 21/ 99	D3i	950	65.2	YES	3.05	342	0.118
37	12/ 21/ 99	D3h	850	78.1	YES	2.65	343	0.614
38	12/ 21/ 99	D3i	1080	83.6	YES	3.2	344	0.178
39	12/ 22/ 99	D3h	800	77.5	NO	-	346	0.534
40	01/ 25/ 00	B5j	900	78.2	YES	2.5	347	0.752
41	01/ 26/ 00	C4k	910	77.3	YES	2.3	348	0.772
42	01/ 26/ 00	B5j	900	77.8	YES	2.65	349	0.317
43	01/ 26/ 00	B5j	980	81.1	YES	2.5	350	0.396
44	01/ 27/ 00	B5j	940	82	YES	2.9	351	0.831
45	01/ 29/ 00	D4l	970	81.3	YES	2.6	352	0.693
46	02/ 19/ 00	V	900	81	YES	2.5	353	0.475
47	03/ 01/ 00	W	1090	86	YES	3.1	354	0.95
48	03/ 01/ 00	W	930	80.8	YES	3.15	355	0.059
49	03/ 01/ 00	W	980	84.1	YES	3.1	356	0.198
50	03/ 02/ 00	W	910	82.3	YES	3.1	357	0.851
51	03/ 02/ 00	W	1070	83.8	YES	3.2	358	0.277
52	03/ 02/ 00	W	960	83.2	YES	2.5	359	0.633
53	03/ 02/ 00	W	1030	79.1	YES	3	360	0.574
54	03/ 03/ 00	W	965	85.5	YES	2.6	361	0.713
55	03/ 04/ 00	W	910	83.6	YES	2.6	362	458
56	03/ 04/ 00	W	1030	84.1	YES	3.25	363	0.891

Table A.3. Data collected at time of capture for spring 2001 research.

	Date	Location	Frequency	Tag	Weight (g)	Tarsus (mm)	Shaft (mm)
1	3/ 3/ 2001	4	0.321	1325	940	62	2.8
2	3/ 3/ 2001	3	0.659	1350	925	58.2	2.8
3	3/ 3/ 2001	4	0.234	1324	1060	65	2.9
4	4/ 3/ 2001	2	0.601	1323	925	56	2.5
5	4/ 3/ 2001	2	0.309	1349	925	59	2.5
6	4/ 3/ 2001	3	0.360	1375	950	63.5	3.0
7	4/ 3/ 2001	3	0.484	1348	950	60	2.6
8	4/ 3/ 2001	4	0.594	1347	1020	60	3.1
9	5/ 3/ 2001	3	0.202	1400	1000	61	2.6
10	6/ 3/ 2001	1	0.531	1373	1040	60.5	3.0
11	6/ 3/ 2001	3	0.107	1346	900	59	2.6
12	6/ 3/ 2001	4	0.681	1345	900	61.5	2.7
13	6/ 3/ 2001	2	0.469	1371	940	59	3.0
14	7/ 3/ 2001	1	0.212	1397	980	63	2.7
15	7/ 3/ 2001	3	0.512	1393	920	59	2.5
16	7/ 3/ 2001	3	0.242	1398	820	62	2.5
17	7/ 3/ 2001	7	0.429	1391	1050	65	2.7
18	7/ 3/ 2001	7	0.613	1341	900	62	2.7
19	7/ 3/ 2001	3	0.145	1372	920	58.5	2.9
20	7/ 3/ 2001	3	0.261	1317	940	59	3.1
21	8/ 3/ 2001	7	0.372	1344	1060	61	3.0
22	8/ 3/ 2001	5	0.671	1364	840	57	2.5
23	9/ 3/ 2001	2	0.408	1396	950	60	3.0
24	9/ 3/ 2001	5	0.183	1365	960	59	2.9
25	9/ 3/ 2001	5	0.451	1321	860	61	2.6
26	10/ 3/ 2001	1	0.460	1399	950	63	2.6
27	10/ 3/ 2001	2	0.331	1342	1120	61	3.0

28	10/ 3/ 2001	5	0.393	1390	920	60	2.6
29	10/ 3/ 2001	7	0.300	1316	880	57	2.4
30	10/ 3/ 2001	7	0.519	1322	1180	62	3.1
31	10/ 3/ 2001	7	0.132	1395	860	61	2.5
32	12/ 3/ 2001	1	0.172	1388	1000	63	2.9
33	15/ 3/ 2001	2	0.282	1311	1040	60	3.1
34	16/ 3/ 2001	1	0.601	1367	1040	63.5	3.2
35	17/ 3/ 2001	8	0.354	1389	960	63	2.8
36	3/ 19/ 2001	1	0.440	1386	1000	58.5	3.0

Table A.4. List of avifauna benefiting from pheasant habitat management on Hardegg estate as observed by Dr. Hans-Martin Berg and Karl Pock in June 1998 and with additions by B. C. Anderson in 1999 - 2000.

Common	Latin
Starling	*Starnus vulgaris*
Kestrel	*Falco tinnunculus*
Turtle Dove	*Streptopelia turtur*
Wryneck	*Jynx torquilla*
Chiffcaff	*Philloscopus collipitus*
White Wagtail	*Motacilla alba*
Syrian Woodpecker	*Dentrocopos syriacus*
Whitethroat	*Sylvia communis*
Tree Sparrow	*Passer montanus*
Serin	*Serinus serinus*
Yellowhammer	*Emeriza citrinella*
Corn Bunting	*Miliarea calandra*
Housesparrow	*Passer domesticus*
Lesser Whitethroat	*Sylvia curruca*
Red-backed Shrike	*Lanius collurio*
Stonechat	*Saxicola torquata*
Barred Warbler	*Sylvia nisoria*
Goldfinch	*Cardvelis carduelis*
Collared Dove	*Streptopelia decaocto*
Montagues' Harrier	*Circus pygargus*
Penduline Tit	*Remis pendulinus*
Grasshopper Warbler	*Locustella naevia*
Grey Heron	*Ardea cinerea*
Black Bird	*Turdus merula*
Northern Hobby	*Falco subbuteo*
Tree Pipit	*Anthus trivialis*

Blue Tit	*Parus caeruleus*
Chaffinch	*Fringilla coelebs*
Great Spotted Woodpecker	*Dendrocopos major*
European Jay	*Garrulus glandarius*
Willow Warbler	*Phylloscopus trochilus*
Garden Warbler	*Sylvia borin*
Icterine Warbler	*Hippolais icterina*
Spotted Flycatcher	*Musicapa striata*
European Greenfinch	*Carduelis chloris*
Green Woodpecker	*Picus viridis*
Hawfinch	*Coccothraustes coccothraustes*
Great Tit	*Parus major*
Cuckoo	*Cuculus canorus*
Buzzard	*Buteo buteo*
Middle Spotted Woodpecker	*Picoides medius*
Blackcap	*Sylvia atricapilla*
Nightingale	*Luscinia megarhynchos*
Golden Oriole	*Oriolus oriolus*
Wood Pigeon	*Columba palumbus*
European Robin	*Erithacus rubecula*
Song Thrush	*Turdus philomelos*
Black-crowned Night Heron	*Nycticorax nycticorax*
Reed Bunting	*Emberiza schoenicus*
Marsh Harrier	*Circus aeruginosus*
Yellow Wagtail	*Motacilla flava*
River Warbler	*Locustella fluviatilis*
Black Stork	*Ciconia nigra*
Mallard	*Anas platyrhynchos*
Marsh Warbler	*Acrocephalus palustris*
Moorhen	*Galinula chloropus*
Reed Warbler	*Acrocephalus scirpaceus*

White Stork	*Ciconia ciconia*
Little Bittern	*Ixobrychus minutus*
Pochard	*Anas ferina*
Teal	*Anas crecca*
Tufted Duck	*Anas fuligula*
Garganey	*Anas querquedula*
Kingfisher	*Alcedo atthis*
Grey Partridge	*Perdix perdix*
Quail	*Coturnix cortunix*
Goshawk	*Accipiter gentiles*
Lapwing	*Vanellus vanellus*
Black-headed Gull	*Larus ridibundus*
Skylark	*Alauda arvensis*
Barn Swallow	*Hirundo rustica*
House Martin	*Delichon urbica*
Whinchat	*Saxicola rubetra*
Carrion Crow	*Corvus corone corone*
Magpie	*Pica pica*
Hooded Crow	*Corvus corone cornix*
Little Egret	*Egretta garzetta*
Honey Buzzard	*Pernis apivorus*
Eagle Owl	*Bubo bubo*
Coot	*Fulica atra*
Little Ringed Plover	*Charadrius dubious*
Green Sandpiper	*Tringa ochropus*
Stock Dove	*Coulmba oenas*
Great Grey Shrike	*Lanius excubitor*
Black Redstart	*Phoenicurus ochruros*
Mistle Thrush	*Turdus viscivorus*
Linnet	*Carduelis cannabina*

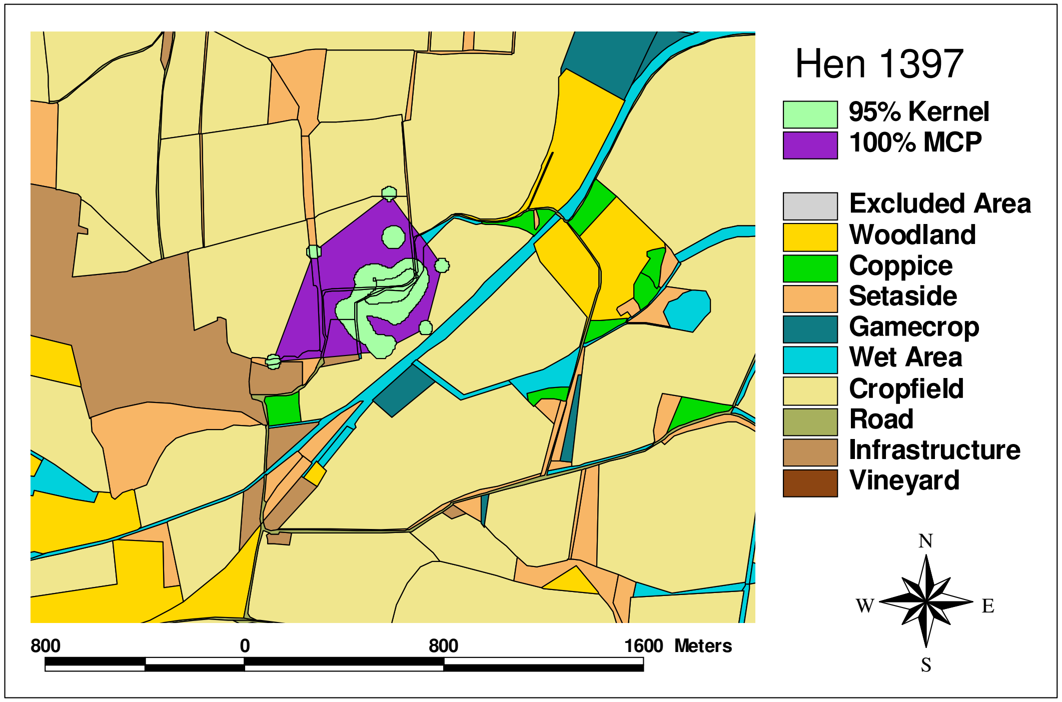

Figure A.1. This figure represents the 95% probability kernel home range and the 100% Minimum Convex Polygon (MCP) home range for hen #1397. The95% kernel method of home range calculation estimates habitat usage by establishing a buffer around known radiolocations. The 100% MCP home range calculation incorporates all recorded radiolocations by connecting the outermost locations.

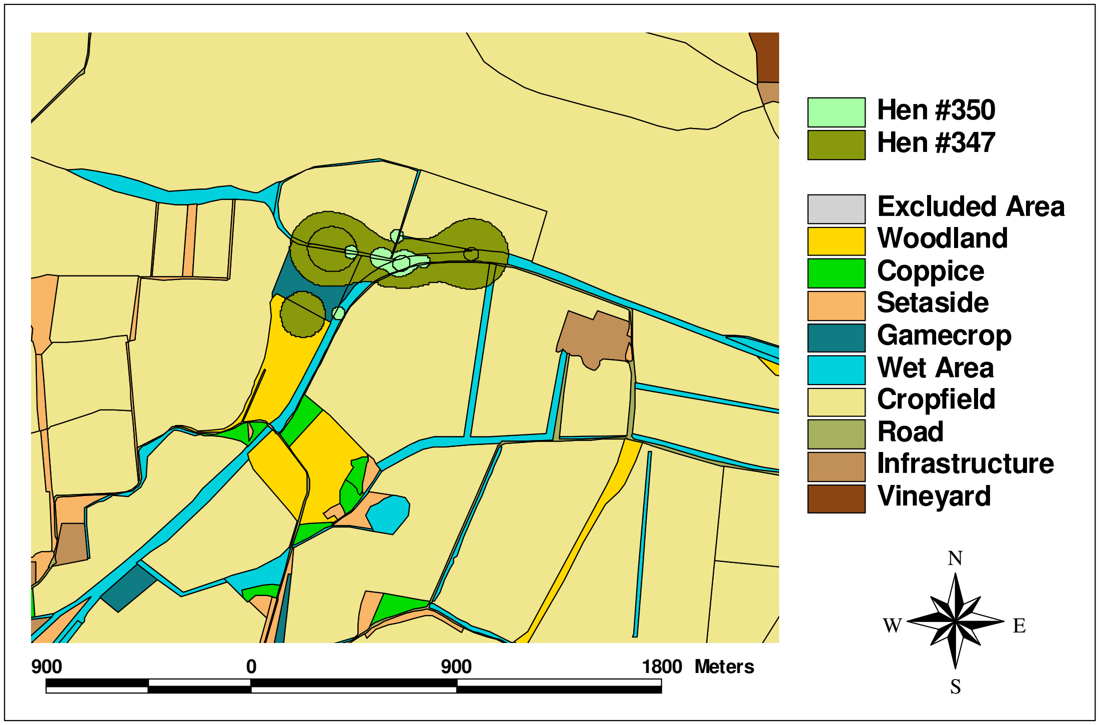

Figure A.2. This figure illustrates the disparate home range sizes of hen pheasants occupying sympatric habitats during the winter of 1999 – 2000 on Hardegg Estate.

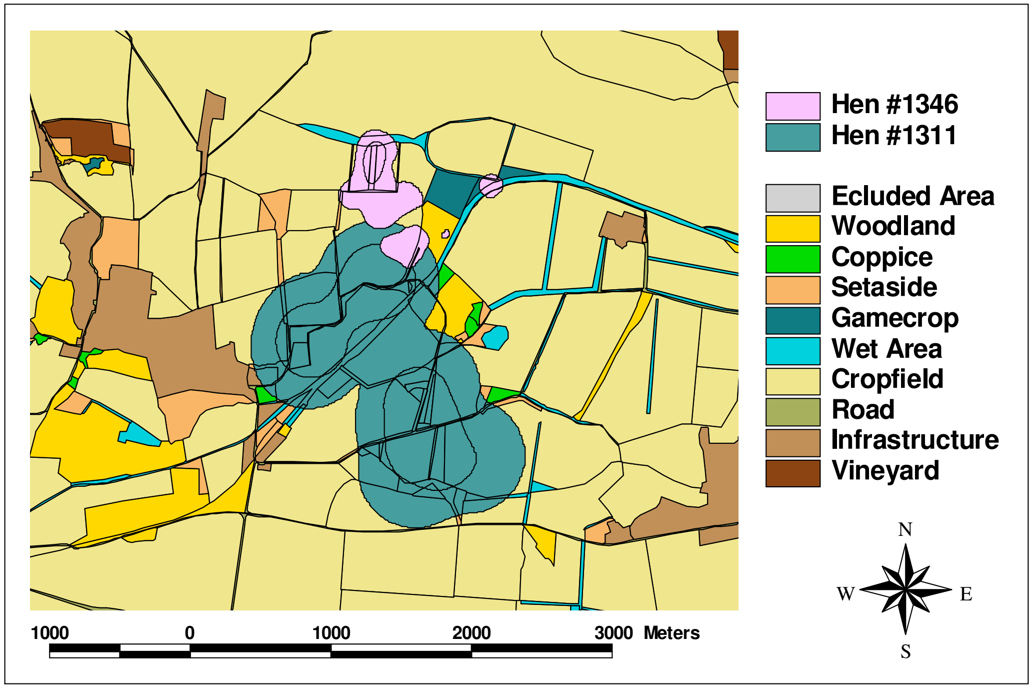

Figure A.3. This figure illustrates the disparate home range sizes of hen pheasants occupying sympatric habitats during the spring - summer of 2001 on Hardegg Estate.

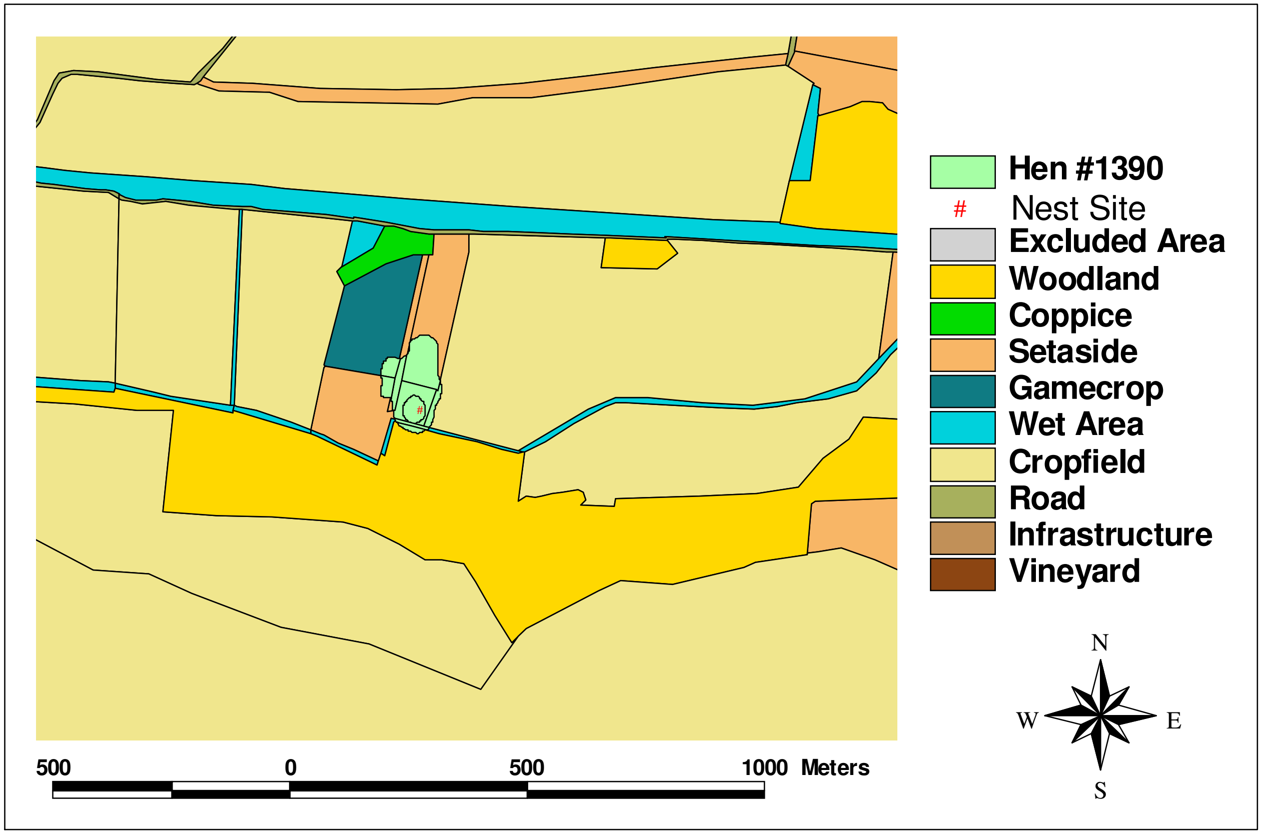

Figure A.4. Hen pheasants nesting in regions on the Hardegg Estate during 2001 that provided good nesting and brooding cover maintained minimal home ranges throughout recruitment.

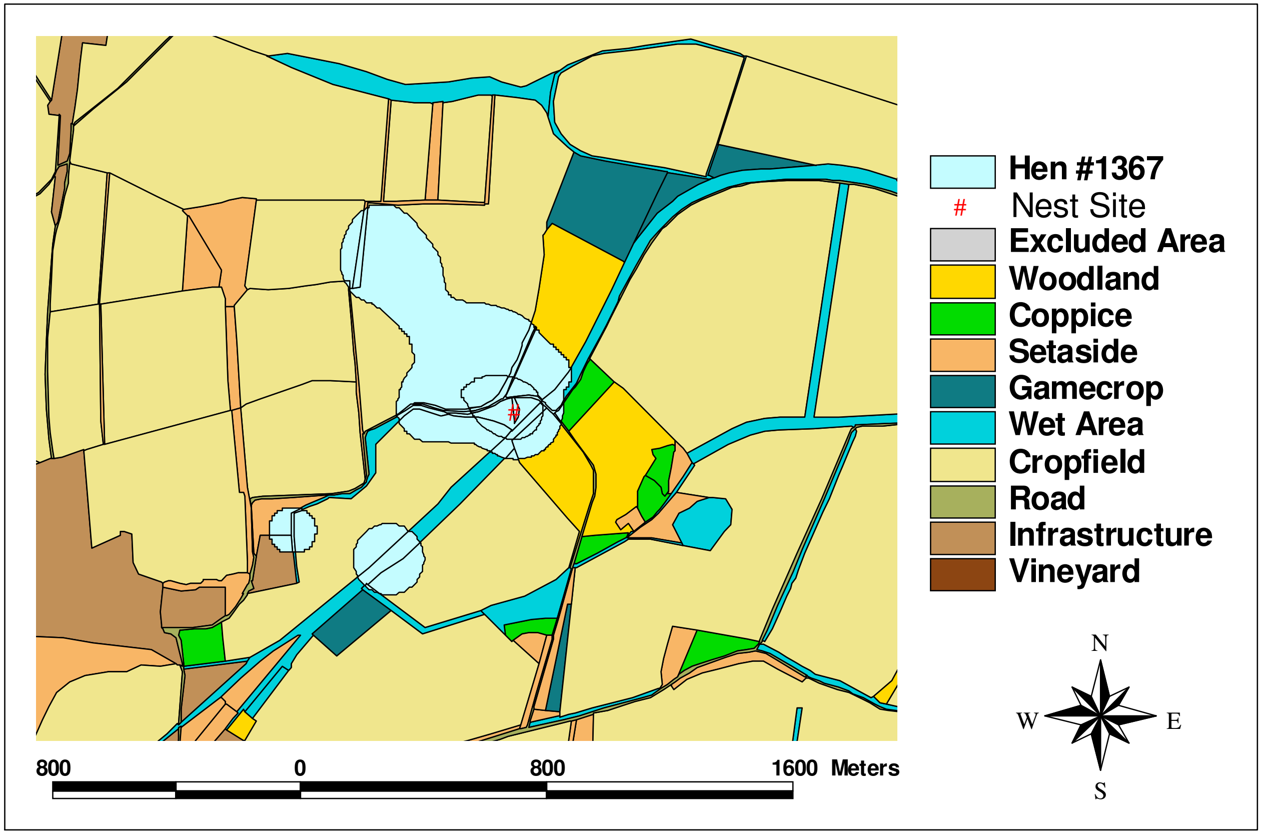

Figure A.5. Hen pheasants nesting in regions on the Hardegg Estate during 2001 that failed to provide good nesting and brooding cover adjacent to one another maintained enlarged home ranges throughout recruitment.