EVALUATING THE SURROGATOR® TO INCREASE RING-NECKED PHEASANT ABUNDANCE AND ENHANCE HUNTING

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CHAPTER I

LITERATURE REVIEW

The ring-necked pheasant (*Phasianus colchicus*) is a widespread, popular gamebird. A native of Asia, the species has been widely introduced around the world, and occurs on every continent except Antarctica (Johnsgard 1999). In 1881, Judge O. N. Denny first introduced ring-necked pheasants to the United States in Linn County, Oregon (Shaw 1908). It has since become so ubiquitous in American culture that few people realize that it is not a natural part of the native ecosystem (Temple 1992). There are many different pheasant subspecies in North America. Hybrids are common due to many different introductions since the initial introduction (Giesel et al. 1997). In addition to these subspecies, there are many strains that have been bred in captivity for the purpose of releasing for sport hunting (Robertson et. al 1993).

Similar to many other avian species, there has been a marked decline in many populations of gamebirds nationally, including ring-necked pheasants (Murphy 2003). Rodgers (1999) speculated that the declines in pheasant populations were caused by a number of factors including changing agricultural and management practices, agricultural chemical use, and unfavorable weather conditions. Changing agricultural and land management practices that have been implicated for decreasing pheasant populations include a shift to row-crop monocultures (Taylor et al. 1978), urbanization (Applegate et al. 2003), and tillage of winter wheat stubble (Taylor et al. 1978, Rodgers 2002) by replacing preferred habitats with ones less suitable for pheasants. Agriculture chemicals such as herbicides (Rodgers 2002) and insecticides (Genelly and Rudd 1956, Bennet and Prince 1981, Grove et al. 2001) have negatively impacted pheasant populations through inhibiting reproduction. Unusual weather patterns such as hard winters (Gabbert et al. 1999, Grove 2001) and drought (Martinson and Grondahl 1966) have also been linked to pheasant declines. These declines are rarely directly related to weather conditions such as freezing, but rather, they stem from indirect effects related to weather conditions such as loss of cover and declines in insect abundances. While weather patterns such as these are usually short term, they can be disastrous for vulnerable populations, especially for those populations already in decline from other factors (Grove et al. 2001).

The North American Breeding Bird Survey (BBS) has shown a gradual decline in national pheasant numbers over the past decade (Sauer et al. 2011). These declines have been seen in almost every BBS surveying region. My study was conducted in Kansas where pheasant numbers in recent years have been at record numbers (Sauer et al. 2011), although there was a large decline previously. Using rural mail carrier roadside surveys, Applegate and Williams (1998) showed a decline in the pheasant population statewide from a mean sighting rate of 5.57 ± 1.87 (SD) pheasant per route from the period 1963–1972 to a mean sighting rate of 2.62 ± 1.01 per route form 1983–1992. These declines were shown to be especially severe in the western part of the state, possibly due to the changing agricultural practices such as the use of herbicide and tillage of winter wheat stubble that diminished suitable habitat (Rodgers 1999).

With the decline in pheasant populations, many efforts such as predator control, release of pen-reared adult pheasants, and habitat management have been implemented in an attempt to stabilize and increase pheasant numbers. Predator control, while possibly effective, is often impractical for most landowners due to a number of factors such as expense and federal regulations (Riley and Schulz 2001). The release of farm-raised adult birds is often used where wild birds are scarce, but low survival and reproductive rates mean that they are unlikely to contribute to a sustainable population (Anderson 1964, Hill and Robertson 1988, Leif 1994, Musil and Connelly 2009). Various manipulations of habitat including providing more cover (Jaimenez and Conover 2001) and prescribed burning (Van Dyke et al. 2007) have been shown to be effective, but can be expensive. There also must be an existing population of pheasant for habitat management to be effective.

Recently, a method known as the Surrogator® (Wildlife Management Technologies, Wichita, KS) (hereafter, surrogator) has been used to supplement wild ring-necked pheasant populations. The surrogator is a device used to introduce gamebirds into a new environment. The device is placed into an area that the landowner has targeted for introduction and then is stocked with day-old pheasants. The surrogator requires infrequent maintenance from the operator as it provides the birds with food, water, heat and shelter until the birds are released after 4 weeks. The purpose of the surrogator is to immediately expose farm-hatched pheasant chicks to the wild, which possibly allows the chicks to acclimate to the environment, while still protecting the chicks during this vulnerable stage of their life. Releasing chicks from the surrogator is possibly preferable to releasing adult birds because the chicks will have received little exposure to humans and will have been exposed to the environment in which they will be released.

The differences between adult farm-raised and adult wild birds are well documented. In studies comparing flight characteristics (Robertson et al. 1993) and survival and reproduction (Hill and Robertson 1988, Brittas et al. 1992, Leif 1994) of pen-reared adult pheasants, researchers have suggested that pen-reared adult pheasants are inferior to wild pheasants. For example, pen-reared pheasants do not fly as fast nor fly with the same agility as wild birds. Pen-reared birds have lower survival rates even when compared to wild birds that have been translocated (Musil and Connelly 2009), suggesting that experience in the wild is critical for survival. When pen-reared birds manage to survive long enough to breed, they typically have much lower reproductive success and generally are not able to maintain a sustainable population. In Leif's (1994) study, pen-reared pheasant hens had a survival rate of 7.8%, while wild hens had a survival rate of 54.6% over a period of 181 days. In the same study, the wild hens recruited 34 broods per 100 hens, while pen-reared hens only recruited 3 broods per 100 hens.

The most hazardous time in a pheasant's life is in its early stages of development. Out of all age groups, young birds are most prone to mortality, especially during the first 2 weeks after hatching. Common sources of mortality are predators (especially mammals) and exposure (Riley et al. 1998). One of the possible advantages of the surrogator is that the brood-rearing process and its hazards are avoided, and the survival rates for chicks in the surrogator are predicted to be much higher than wild birds during the first 4 weeks after hatching.

For the surrogator to be considered a success for introducing gamebirds to the environment, released birds must both stay on the property and survive, at least until the hunting season. Upon release, pheasant chicks will disperse into the surrounding fields. While studies involving released birds at 4 weeks of age have not been conducted, previous studies have shown that pen-reared adult male pheasants do not typically disperse far from the release site, usually around 0.5 km (Krauss et al. 1987). After release, chicks are vulnerable to both predation and the elements. For surrogator-reared chicks, selection of appropriate cover will likely be the key to their survival. Because wild pheasant chicks typically remain with the hen for the first 10–11 weeks of life (Johnsgard 1999), surrogator-reared chicks may be at a disadvantage in terms of selecting appropriate habitats for concealment from predators and protection from weather events. For example, surrogator-reared chicks should be able to thermoregulate by the time of release (Gdowska et al. 1993), but these birds will still need to seek out microclimates that will reduce the need for thermoregulation, as it is a metabolically expensive process (Wolf and Walsberg 1996).

Another factor that determines habitat selection is the risk of predation and the need to minimize danger (Thomson et al. 2006). Therefore, an understanding of dispersal and habitat use patterns of surrogator-reared pheasant chicks is critical to evaluating the effectiveness of the surrogator, but these factors have not been previously studied for surrogator-reared birds.

It is desirable to release the pheasant chicks into a quality habitat to increase their probability of survival, and one indicator of high quality habitat is the availability of food. Insects, which are high in protein, are an important food source for chicks (Doxon and Carroll 2007). According to Doxon and Carroll (2010), human-imprinted pheasant chicks preferred insects of the orders Homoptera, Hemiptera, and Coleoptera in Conservation Reserve Program (CRP) fields in northwestern Kansas. While the Doxon and Carroll (2010) study reported a preference for certain types of prey by pheasant chicks, Whitmore et al. (1986) reported that pheasant chicks in Nebraska would, in general, consume the most available insects with no preference for any of them. As insects are such an important food for chicks, it is possible that invertebrates can be used as an index to compare the suitability of habitat for pheasant on given fields.

It has been shown repeatedly that predation poses the greatest risk to pheasants at all stages of life (Shipley and Scott 2003, Bliss et al 2006). Riley et al. (1998) reported an overall survival rate of wild pheasant chicks from hatching to 28 days to be 42% and attributed 85% of chick mortality to predation, with mammals accounting for most of the predation. Other researchers have reported a variety of avian predators as a source of high rates of mortality, with red-tailed hawks (*Buteo jamaicensis*) and great horned owls (*Bubo virginianus*) cited most often (Petersen et al. 1988). It has also been shown that both mammalian and avian predators will be found in higher density where prey is concentrated (Godbois et al. 2004, Turner et al. 2008). Godbois et al. (2004) found that bobcats (*Lynx rufus*) concentrated on areas where supplemental feed for quail was distributed. The supplemental feed also attracted rodents, a primary food source for bobcats. It was found that bobcats stayed much closer to areas with feed than would otherwise be expected, likely due to the increased number of rodents attracted to the feed. Turner et al. (2008) examined the response of red-tailed hawks to supplemental feeding for quail. They found that the hawks would concentrate in areas with supplemental feeding, which was also likely due to the availability of rodents. While these studies focused on rodents, and while bobcats have not been implicated as major predators of pheasant, red-tailed hawks have been implicated as major predators (Riley and Schultz 2001), and it is logical to suspect that other predators will respond similarly to large concentrations of their preferred prey species. Since the Surrogator concentrates large numbers of pheasant chicks in a small area, an evaluation of predator response to the presence and use of a surrogator is warranted.

The goal of the surrogator is to improve the quality of hunting on the property where birds have been released. Enhancement of hunting opportunities is the primary reason for the development and use of the surrogator. In the United States, the ring-necked pheasant is the second most popular gamebird, only behind the wild turkey (*Meleagris gallopavo*) in terms of hunter numbers and the number of hunt-days spent in the field by those hunters. In 2006, 1.6 million hunters cumulatively spent 12 million days in the field hunting pheasants (U.S. Department of the Interior 2006). In other parts of the world such as Europe, ring-necked pheasants are also one of the most popular gamebirds (Draycott et al. 2008, Santilli and Bagliacca 2008). With so many hunters spending so much time pursuing this bird, its economic impact is significant; as an example, the estimated expenditures related to pheasant hunting in the United States was $219 million in 2008 (Switzer 2009). Further, Erickson and Wiebe (1973) found that the number of out-of-state hunters visiting South Dakota was directly correlated to the number of pheasants harvested in the state the previous year. Hence, for the most economic impact, it is desirable to keep pheasant numbers both high and stable. To this end, it is important to assess the impact of the surrogator on the influencing the quality of hunts.

OBJECTIVES

Pre and Post Release Survival

The effectiveness of the surrogator to influence pheasant populations depends upon high pre-release survival within the Surrogator and high survival post-release. Survival is closely related to movements and habitat use by pheasants. These factors have all been studied in adult pheasants and wild-born chicks, but not for surrogator-reared chicks. Predator and invertebrate concentrations also contribute to survival and relate to habitat selection by the birds. Proper habitat selection by the chicks will balance between the need to forage and finding cover to shelter from predators. These factors will be examined in my study, as they are integral to an evaluation of the surrogator. The objectives of this component of the study are:

1. Determine mortality rates and causes of mortality within the surrogator for pre-release ring-necked pheasant chicks.
2. Determine the dispersal, habitat use, and mortality of pheasant chicks post-release.
3. Monitor mammalian and avian predator populations on the study areas.
4. Assess habitat suitability among treatment and control fields.

The Effect of Surrogator Birds on Hunting

The surrogator is advertised as a product to enhance hunting on a given property. Therefore, it is important to determine the effects of released pheasants upon hunt quality. This is effectively accomplished by collecting data from band-return rates to determine how many birds were harvested of those birds that were released. Also, hunters are the target audience for the surrogator and as such, are an important consideration when considering the effect of surrogator birds on hunting. However, there are relatively few studies of hunter characteristics or the hunter in the field. Further understanding of this aspect of game management is valuable information, which could prove useful to managers. The objectives of this component of the study are:

1. Collect data on the effect of surrogator-reared pheasants on hunts by examining band return rates.
2. Conduct surveys of hunters to determine basic demographics and attitudes of hunters.
3. Collect data on hunters' and hunting dogs' activities while in the field.

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CHAPTER II

EVALUATING SURVIVAL AND HABITAT USE OF PHEASANT CHICKS RELEASED FROM THE SURROGATOR®

Abstract: The ring-necked pheasant (*Phasianus colchicus*) is a popular and economically important gamebird that has experienced population declines throughout most of its range. The Surrogator® is a device developed to increase the abundance of pheasants and other gamebirds for hunting. My objectives were to monitor chick survival inside the surrogators, monitor chick survival, dispersal, and habitat use after release, survey invertebrates as a measure of habitat suitability, and monitor the effect of surrogator-reared birds on predator abundance. To accomplish these objectives, I monitored mortality while pheasants were in the Surrogator®, habitat use and mortality following release, invertebrate biomass, and predator abundances. In 2009 and 2010, the 4-week survival rates in the surrogator were 85% ± 5 (SE) and 79% ± 8, respectively. Released chicks had an overall survival rate of 0.08 ± 0.06 (n = 58) over 12 weeks, with most mortalities occurring in first few weeks after release. Results for habitat use based on radiotelemetry in 2010 showed a slight preference for denser vegetation than random sites. Movement distances between tracking periods and home range sizes were highly variable among fields.

The average distance traveled between tracked locations was 100.5 m ± 22.6 (n = 120 measured distances) for surrogator pheasants, and the average home range size of groups of released birds was 13.2 ha ± 9.3 (n = 12). Invertebrate abundances were similar between fields, and did not seem to have an effect on released birds. Likewise, there was no noticeable effect of released birds on predator abundances. The Surrogator® may not be an effective method of re-establishing populations of pheasants, however, it could be used as an effective method for supplementing existing huntable populations of pheasants.

Key Words: Kansas, leg bands, *Phasianus colchicus*, predation, radio-telemetry, restocking

INTRODUCTION

The ring-necked pheasant (*Phasianus colchicus*) is a widespread, popular gamebird. In the United States, it is second only to the wild turkey (*Meleagris gallopavo*) in terms of popularity (U.S. Department of the Interior 2006). Because of this, the species is of economic importance in areas where it is abundant (Erickson and Wiebe 1973, Switzer 2009). However, pheasant populations in the United States have had a gradual downward trend in recent decades (Sauer et al. 2011).

In response to these low populations, a variety of techniques have been employed to supplement and increase pheasant populations (Sokos et al. 2008). These techniques include releasing farm-reared adult birds and translocating wild birds from different areas. Both of these techniques, however, have significant drawbacks. Farm-reared adults typically have very poor survival and reproduction as compared to wild birds (Hill and

Robertson 1988, Brittas et al. 1992). In addition, their flight abilities and agility may be less than wild birds (Robertson et al. 1993), possibly making them less desirable for hunting. Translocated wild birds are an improvement over farm-reared birds, but the process of translocation is comparatively expensive and is not recommended for hunting purposes (Musil and Connelly 2009). These shortcomings justify investigations into new techniques that could possibly combine the advantages of both methods. The Surrogator® (hereafter, surrogator) is a relatively new approach to introducing gamebirds into the wild, and one of the species it is primarily marketed for is the ring-necked pheasant. The surrogator is a brooder that can be placed into a suitable habitat where the bird species is intended to be released. With minimal maintenance from the operator, chicks are maintained in the surrogator until they can be released into the environment. The company that produces the surrogator, Wildlife Management Technologies, claims that surrogator-reared birds are superior to other release methods as they will be more able to survive in the wild and have other characteristics similar to wild birds. To verify this claim a number of factors must be examined.

The survival rate of wild pheasant chicks from hatching to 28 days old, the age surrogator birds are released, is generally low (Hill 1985*a*, Riley 1998). Since the chicks are maintained inside the Surrogator during this time period it is expected that their survival rate would be much higher. The condition and survival rate of chicks during their time inside surrogators is an important factor to consider for the effectiveness of the technique as a whole. A low in-surrogator survival rate necessarily leads to a low number of birds released. A poor body condition, as demonstrated by a smaller than average size or poor feathering, upon release likely means that a given bird’s chance of survival is lower than a bird in good condition. Swarbrick (1985) reported that chicks that had a poor body condition often died of exposure in release pens. Since the surrogator reared-chicks will be released into the wild, where there are other hazards in addition to exposure, it is likely that a chick in poor condition is in even more danger.

Determining the suitability of a habitat for pheasant chicks is a difficult, but important step in the evaluation of the effectiveness of surrogators. A possible way to judge the suitability of the habitat that chicks are released in is to survey the amount of invertebrates available. Invertebrates are a heavily used food source early in the lives of pheasants (Ferrel et al. 1949), and are important as they are high in protein (Doxon and Carroll 2007).

Upon release into a chosen environment, the survival of pheasants, and hence the success of the technique as a whole, will depend in large part on the habitat they select. Habitat influences important factors such as vulnerability to predators (Thomson et al. 2006) and the availability of microclimates (Wolf and Walsberg 1996). In a review of studies conducted on farmland birds in the United Kingdom, Wittingham and Evans (2004) examined how different habitats presented trade offs between safety and foraging efficiency in a variety of species. They found that, in general, shorter, more open vegetation improved foraging efficiency, but that taller, denser vegetation was better for cover from predators. Thompson et al. (2006) found that greater sage grouse (*Centrocercus urophasianus*) hens with broods will select for denser more protective cover with fewer invertebrates as compared to random sites, and it is not unreasonable that pheasant hens would act similarly. Since surrogator-reared chicks do not follow a hen, it is possible that they would select habitats differently. These factors make an evaluation of the habitat selected by the released pheasant chicks important.

In addition to where the chicks disperse, the distance they disperse is another factor in determining the usefulness of the surrogator. Dispersal distance can be an important factor as Hill (1985*a*) found that pheasant hens with broods that moved greater distances had much higher chick mortality rates than hens with broods that did not move far. Moreover, those hens with broods had comparatively small home range sizes. In Hill's (1985*a*) study, the brood with the lowest survival rate (18%) had a home range of 8.8 ha, whereas the brood with the highest survival rate (88%) had a home range of 2.9 ha. It is also desirable for released birds to remain close to the area of release to be available to hunters, if that is the goal of the manager.

Sub-adult and adult pen-reared birds historically have had very high mortality rates upon release into the wild (Hessler et al. 1970, Brittas et al. 1992, Musil and Connelly 2009). A main claim of the surrogator is that surrogator-reared birds will have higher survival than pen-reared birds. This claim makes post-release mortality rates one of the most important factors examined to assess the usefulness of the surrogator as compared to other techniques.

The main source of mortality in pheasant of all ages is predation (Shipley and Scott 2003, Bliss et al. 2006). Additionally, predators have been shown to focus on areas where prey is concentrated (Godbois et al. 2004, Turner et al. 2008). While these studies considered bobcat (Godbois et al. 2004) and red-tailed hawks (Turner et al. 2008) preying on rodents that had been concentrated by gamebird feed, it is logical to assume that those results can be applied more generally to other species. It is also of note that red-tailed hawks are considered a major predator of pheasant (Riley and Schultz 2001). Given this, surrogator-released pheasants are especially at risk, as they are typically concentrated in a small area for at least 4 weeks. At the time of release, they will have been inside the surrogator for several weeks and will further be concentrated around the device for a time after release before dispersing. Examining the effect of surrogator releases on predator abundances in the release area and the effect of these predators on the released chicks is a critical component of whether the surrogator is a viable technique.

The goal of this project was to evaluate the effectiveness of the surrogator to introduce gamebirds into the environment and then to assess the ability of those birds to survive in the environment post release. Should the device be shown to be effective, it could be used to bolster populations of game birds in areas that receive heavy hunting pressure and re-establish populations in historical ranges. The surrogator could also potentially be used where there is a high year-to-year variation in population size of gamebirds so that the population may be more stable. These possibilities provide justification for studies evaluating the effectiveness of the surrogator.

The ring-necked pheasant provides an ideal species for evaluating this technique. Ring-necked pheasants are well studied and are commonly stocked and hunted in many areas (U.S. Department of the Interior 2006, Draycott et al. 2008, Santilli and Bagliacca 2008), therefore, there is an excellent repository of information that can be referenced and compared for this study. All of these factors together make the pheasant a suitable test species.

The objectives of this study were:

1. Determine mortality rates and causes of mortality within the surrogator for pre-release ring-necked pheasant chicks.
2. Determine the dispersal, habitat use, and mortality of the pheasant chicks post-release.
3. Conduct surveys to monitor mammalian and avian predator populations on the study areas.
4. Conduct invertebrate surveys to assess food availability among treatment and control fields.

STUDY AREA

This study was conducted in Kiowa County in south-central Kansas. In winter, the average temperature is 1.2° C and in summer the average temperature is 25.6° C (United States Department of Agriculture 1986). The average annual rainfall for the area is 57.3 cm with most of the precipitation occurring from April to September.

The northern third of the county, where the study was conducted, consists of sand hills (Latta 1948). The highest elevation in the county is 743 m and the lowest elevation is 592 m (Latta 1948). Cropland, woodland, and grassland are mixed throughout the county and trees can be found in windbreaks and along streams. Most of the land in the study area is composed of either cropland or rangeland. The principal crops are wheat and sorghum (United States Department of Agriculture 1986), but large tracts of land have also been enrolled in the Conservation Reserve Program (CRP). Currently, about

26,551 ha of land in the county have been enrolled in CRP (United States Department of Agriculture 2010).

The study was conducted on 4 fields, 2 experimental fields (with surrogators) and 2 control fields (without surrogators). The mean size of the fields was 103 ha with fields ranging in size from 32 to 161 ha. Fields occur as close as 20 m to as far as 3.2 km from one another. All fields were enrolled in CRP and planted with CP2 (native grasses) plantings. The predominant vegetation groups in the experimental and control fields were grasses such as big bluestem (*Andropogon geradii*), little bluestem (*Schizachyrium scoparium*), and indiangrass (*Sorghastrum nutans*), followed by forbs such as blackeyed susan (*Rudbeckia hirta*) and ragweed (*Ambrosia* sp.). There was a scattering of Chickasaw plum (*Prunus angustifolia*) on some fields. In 2009, food plot strips were planted on the fields; however, these were not replanted in 2010. The fields had prescribed burns performed on them previously, but not for at least 3 years prior to initiation of the study (J. Johnson, Wildlife Management Technologies, personal communication).

METHODS

Description of the Surrogator

I used 2 different models of surrogator over the course of the study. The Traditional surrogator was used in 2009, and the XL surrogator was used in 2010. The Traditional model was made of a metal frame with plastic components and had a more simplistic design, while the XL model had a metal body and could be disassembled into sections for ease of transport and cleaning. Other differences between the models were either to make operation more efficient or cosmetic. Both models consisted of an enclosed space that could be divided into 2 areas, a resting area and a brooding area. The brooding area had solid walls, a gravity fed feeder trough, an overhead propane-powered heater connected to a propane tank, and a watering pipe with 4 nipples connected to a 56.8 L reservoir. The chicks were confined to the brooding area by a drop down divider during the first week inside the unit. After the first week, the divider was raised and the chicks were allowed into the resting end of the unit.

Set Up and Use of the Surrogator

Surrogators were placed in the research fields on top of vinyl-covered, plywood boards, which aided in cleaning surrogators and inhibited plants from growing into the unit. Shade canopies were also placed over the units to provide protection from direct sun. When the units were set up, 70 1-day-old pheasant chicks were placed in the surrogators and maintained in surrogators until 4 weeks of age. This time period was referred to as a "rearing cycle" or "cycle". In 2009, there were 4 rearing cycles with each cycle occurring in May, June, July, and August. During 2010, the first rearing cycle began in June and 2 additional release cycles occurred in July and August. Food, water, and temperature settings were monitored on a weekly basis and replenished or adjusted as needed. I used a game bird feed supplied by Birds of Brilliance (Gamebird Starter, Birds of Brilliance, Milford, KS). The macronutrient composition for the feed was crude protein 27.5%, crude fat 4.2%, crude fiber 2.8%, and calcium 1.5%. A chick starter (Chick-aid, Wildlife Management Technologies, Wichita, KS) was provided for the chicks when they were first introduced to the surrogator. Chick starters are commonly used in the poultry industry to provide hydration and beneficial bacteria to enhance the chick's digestive system.

Chick Survival in the Surrogators

In-surrogator survival of pheasant chicks was monitored during the weekly maintenance checks. All dead chicks were counted and removed and cause of death was recorded if known. Factors such as body condition and the situation of the body, such as if the body was located in the piping of the heating unit, were taken into account to determine a cause of death. Abnormalities in the chicks such as poor feather development or injuries were also noted.

Banding and Radio-telemetry

Prior to release, all birds were banded with metal leg bands (#6 band size, National Band and Tag Company, Newport, KY). The leg bands were individually numbered to distinguish individual birds, and a phone number was imprinted on the band so that I could be contacted for birds collected off property. At the time of release, the chicks were too small for the adult-sized bands, which resulted in many of the bands slipping off soon after release. To solve this problem, I glued cotton to the inside of the bands before attachment, which allowed the bands to be retained until the bird's leg grew enough to prevent the bands from slipping off.

To determine dispersal patterns, habitat use, and mortality for post-release birds, I attached 2.05-g radio-transmitters (Holohil Systems, Ltd., Carp, Ontario) to 20 birds from the June release, 30 birds from the July release, and 10 birds from the September release in 2010. I attached each transmitter by using a suturing technique (Burkepile et al. 2002). The Oklahoma State University Institutional Animal Care and Use Committee approved the suturing technique (IACUC #AG-09-9).

I monitored each radio-marked bird 3 times a week, at different times of the day, until the transmitter detached or ceased functioning, or the fate of the chick was known. I did not include an acclimation period before beginning tracking. I used a homing technique to approach within 20 m of each chick (White and Garrott 1990). When I had approached close to the chick, I circled around the suspected location to ensure its accuracy. I then recorded my final location in relation to the chick on a notepad and with a global positioning system (GPS) unit. I later returned to the location after the chick had left and recorded the actual location. If the location of the radio signal did not change for 2 consecutive tracking days, I attempted to locate the transmitter to determine the fate of the chick. When a chick's signal could not be located, I intensively searched for it over a wide area. If the chick was not located that day, the searches were continued intensively for several tracking periods after the initial disappearance. Searches became more sporadic as time progressed and were stopped when the last bird from the same release died or disappeared.

Vegetation Sampling

I measured a variety of habitat variables to assess habitat use by released pheasant chicks. I used a Daubenmire (1959) frame to estimate canopy cover of functional plant groups (i.e., grasses, forbs, shrubs, and litter) by placing the frame in each of the cardinal directions immediately at the telemetry location and recording percent cover for each functional group. I used the line intercept method to measure canopy cover of shrubs

(Canfield 1941). I performed the line intercept technique in each of the cardinal directions along a meter tape stretched 4 m from the telemetry location. A Robel pole was used to estimate visual obstruction of vegetation and is useful for determining how vulnerable a chick may be to mammalian predators (Robel et al. 1970). I recorded visual obscurity from the 4 cardinal directions, at a 1 m height and at a distance of 4 m for each telemetry location. The angle of obstruction is used to estimate how vulnerable a chick is to avian predators. For angle of obstruction, I tilted a pole in 8 directions at the telemetry location and recorded the angle when the pole first made contact with an obstruction for each direction (Kopp et al. 1998). These measurements give the angles from which an avian predator will be able to detect the chick (Kopp et al. 1998).

Each telemetry location measured was paired with a separate, unused location. To determine this location, I randomly selected a cardinal direction and a distance between 1 m and 100 m from the telemetry location.

Invertebrate Sampling

To assess invertebrate food abundance, I conducted monthly invertebrate surveys by sweep netting in the study fields from May to September each year. Sweep netting has been found to be an effective and efficient method of sampling invertebrates, giving similar or superior results to other methods, such as suction sampling, in less time (Randel et al. 2006). I conducted sweep net surveys by sweeping a 38-cm-diameter net 50 times through the vegetation. These surveys were conducted in random locations in the fields at a rate of 1 sample per 16 ha. All invertebrates were placed in Ziploc bags and frozen for later identification. After the insects were sorted, I identified them to order

(Eaton and Kaufman 2007), counted the representatives of each order, oven-dried them at 70°C for 24 hours to a constant mass, and weighed the dried specimens (Whitmore et al. 1986).

Predator Abundance

I conducted surveys to determine if the presence of surrogators and surrogator-reared birds influenced predator abundance. I monitored mammalian predator abundance using scent post stations once before a release and once after a release from May to October. Scent post stations are a commonly used, cost-efficient, and non-invasive method for monitoring mammalian predator populations such as striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*) and red foxes (*Vulpes vulpes*) (Linhart and Knowlton 1975). The scent stations consisted of a circular area 1 m in diameter cleared of brush and raked smooth. I poured water on the area to further smooth the soil and increase the probability that the sandy soil would retain a print with good definition. A fatty acid scent disk (Pocatello Supply Depot, Pocatello, ID), used to attract predators, was placed in the middle of the cleared area. I setup stations in the early evening and re-checked the station the following morning for predator tracks. I identified the tracks by species and recorded them.

To monitor avian predator abundance, I conducted point-count surveys twice a week from mid-May to the early November in 2009 and 2010. I used a GPS to locate point-count stations every 0.4 km along roads bordering treatment and control fields. At each station, I attempted to locate raptors by sight for a 3-min duration at each stop (Sauer et al. 1994). When a raptor was observed it was identified and recorded.

Data Analysis

For much of my data, descriptive statistics such as means and standard errors were used for analysis. To compare variables (e.g., habitat variables) between treatment and control fields, I used confidence intervals. If 95% confidence intervals overlapped between the 2 variables, the variables being compared were not considered notably different (Cohen 1994).

Home ranges were established by 100% minimum convex polygons (Martin et al. 2009). These were done by collectively taking all the GPS points from a release in a given time frame (i.e., 10 days post-release) and drawing lines connecting the outermost points (Mohr 1947). To determine the dispersal patterns, these polygons were overlaid onto each other to exhibit the expansion of the chicks outward from the surrogator. The home ranges were determined for releases as a whole. Home ranges were created using Hawth's Tools (Beyer 2004) in ArcGIS 9.2 (Environmental Systems Research Institute, Redlands, CA).

I used the Kaplan-Meier staggered entry procedure to estimate survival probabilities for radio-marked chicks (Kaplan and Meier 1958, Pollock et al. 1989). Survival was estimated to 12 weeks post release, which was the estimated battery life of my radio-transmitters. Any chicks that disappeared during the study were censored. I estimated survival by month as well as overall for the entire study period.

RESULTS

In-Surrogator Survival

The in-surrogator survival rate was 85% ± 5 (SE) (n = 14) in 2009 and 79% ± 8 (n = 6) in 2010. In-surrogator survival differed between release dates. In-surrogator survival was high for earlier releases, ranging from 95 to 96% for the June, July, and August releases in 2009 and 88% for June and August releases in 2010, but was low for the last releases in September (63% in 2009 and 62% in 2010). There was one unit with a survival rate of 14% that could be attributed to operator-error, which was not included in the survival calculations. Because chick carcasses usually deteriorated to the point where cause of death could not be determined, I was only able to determine cause of death for a few of the chicks. In those cases, accidents, such as a leg becoming caught in the grate flooring or a chick being caught in the piping of the heating unit, were a leading cause of death. Another factor contributing to in-surrogator mortality was aggression between chicks. While the conditions of the bodies when we found them were usually such that an exact cause of death could not often be attributed, birds were observed with significant injuries attributed to aggression while they were in the surrogator.

Habitat Use

In 2010, I radio-marked 58 ring-necked pheasant chicks. Of the 58 radio-marked birds, 11.4% lost their transmitters possibly due to suturing thread failure and 6.8% disappeared soon after release. The mean survival rate of surrogator chicks for the 12-week monitoring period was 0.08 $\pm$ 0.06 (Fig. 1). All three releases had similar trends of high mortality rates 2–3 weeks after release, but the rate declined thereafter. The mortality rates for the June and July releases stabilized around 7–8 weeks post-release, but none of the birds from the September release survived beyond week 5 (Fig. 1). Overall, 76% of the radio-marked chicks were confirmed to have died during the study.

Predation was the most common cause of death, accounting for 89% of the mortality. Mammals accounted for 51% of predation mortality, followed by 28% from unknown predators, and 21% from avian predators. The remaining 5 deaths could not be attributed to a particular cause and were recorded as unknown.

I obtained 434 telemetry locations on the pheasants after their release. They were located at or inside the surrogator unit 43% of the time, in CRP fields 40% of the time, and in cornfields surrounding the CRP fields 17% of the time.

I conducted vegetation sampling at 148 of the locations over the course of the tracking period. All of the vegetation variables, except for visual obstruction, did not differ from random locations (Table 2). For visual obstruction, the height of the obstruction was 10.9 cm ± 1.12 higher at used locations than at random sites. There were other variables whose confidence intervals did not overlap, but the actual differences were small enough as to likely be insignificant.

The mean maximum home range for pheasant chicks was 13.2 ha ± 9.3 ($n = 12$). Within the fields, the size of the home ranges varied greatly. For example, the maximum home range on field 2 was 2.4 ha after 40 days, while the maximum home range on field 3 was 50.2 ha after 90 days, which was the largest home range during the study. The average distance travelled by pheasant chicks was 84.9 m ± 12.6, 158.6 m ± 35.5, and 42.2 m ± 11.3 during June, August, and September releases. The average distance travelled within the fields were similar; the average distance travelled in field 2 was 90.2 m ± 23.4, while the average distance travelled in field 3 was 110.7 m ± 21.8 between tracking periods. Field 3 pheasants consistently dispersed much farther than field 2 pheasants, with home ranges on field 3 being 93.6% larger at 40 days post-release than those on field 2. Field 3 birds also dispersed more quickly, often dispersing over a greater area in the first 10 days than the field 2 birds had dispersed by 40 days.

Invertebrate Surveys

I collected 9 invertebrate taxa from treatment and control fields during each year. Of these, Orthoptera was most abundant, consisting 86.9% and 88.9% of the total biomass collected for 2009 and 2010, respectively. The remainder of the biomass consisted largely of Hemiptera, Coleoptera, and Lepidoptera, though none of these groups constituted more than 5% of the total biomass individually. All other taxa collected did not individually make up more than 1% of the total biomass. The total insect biomass generally followed an upward trend throughout the summer, with a few fluctuations (Fig. 2). The most productive field for invertebrates was field 6 in both years. Field 6 was a treatment field in 2009 and became a control field in 2010. All fields were largely consistent in amount of biomass between years (Tables 2 and 3). The month with the highest biomass was July in both years, largely due to the abundance of Orthopterans. The month with the least biomass was June in 2009 and May in 2010. I did not conduct invertebrate surveys in May 2009.

Predator Surveys

There were no major differences in avian predator abundances between treatment and control fields in 2009 or 2010 (Figs. 3 and 4). Overall, point-count surveys averaged 0.13 ± 0.01 raptors observed/stop for treatment fields versus 0.10 ± 0.01 raptors observed/stop for control fields in 2009. In 2010, raptor abundances averaged 0.15 ± 0.06

raptors observed/stop on treatment fields and 0.11 ± 0.04 raptors observed/stop on control fields. I observed the highest number of raptors in October during both years with 48% and 26% of the total observations occurring during that month for each year, respectively. Data were not collected in September 2009 and in only part of the month of November during both years. The most common raptors observed in 2009 were northern harriers (*Circus cyraneus*), which accounted for the majority of the observations on treatment fields (Table 5). In 2010, the most common raptors observed were red-tailed hawks (*Buteo jamaicensis*), which made up the majority of observations on treatment fields and a large percentage of those on control fields (Table 6). The numbers of avian predators observed did not appear to differ among release periods (Figs. 3 and 4).

Data were not collected in 2009 for mammalian surveys. Scent stations showed little difference between treatment and control fields in mammalian predator activity in 2010. Stations on treatment fields had a visitation rate of 0.19 ± 0.07 (n = 8), while stations on control fields had a visitation rate of 0.19 ± 0.06 (n = 8). Within treatment fields, the pre-release visitation rate was 0.11 ± 0.05 (n = 3) and the post-release visitation rate was 0.18 ± 0.06 (n = 5). Visitations to the scent stations were highly variable with no visitations occurring in September and 7 visitations occurring in August. The most common mammalian predators at the scent station were long-tailed weasels (*Mustela frenata*) comprising 47% (n = 8) of the total (Table 4). Other predators detected included raccoons (*Procyon lotor*), red fox (*Vulpes vulpes*), opossum (*Didelphis virginianus*), and coyote (*Canis latrans*).

DISCUSSION

In-Surrogator Survival

Overall, in-surrogator survival was high. The overall survival rate for 2009 was higher than in 2010. This is likely attributable to using different models of surrogator between years. The 2010 model functioned similarly to the original surrogator, but changes were made by the company, such as being able to be separated into 2 pieces for easier cleaning and transport, to make the machine more operator-friendly. However, there were problems with the 2010 model such as several chicks' heads becoming trapped in the piping of the heating unit and feed flow issues. In an effort to curb feed waste from chicks scratching in the food trough, the mouth of the trough was narrowed. However, this had the unintended consequence of causing the feed delivery system to become obstructed, which prevented the feed from falling into the bottom of the trough. Overall, the birds released in 2010 seemed to have poorer feather development and a poorer overall body condition upon release than was observed in 2009. I hypothesize this was due to feed flow issues rather than an issue with the chicks themselves.

Another factor, noted often in 2010, that likely contributed to the poorer condition and higher mortality was increased aggression between chicks. Often if a chick was wounded or had some other factor (such as small size) that indicated it as weaker, it was harassed and pecked repeatedly. Due to the limited human exposure allowed by surrogator maintenance, this is hard to show quantitatively; as the birds were left largely alone inside the device. However, during banding, injuries to the backs and heads of birds were recorded and poor feathering was noted that might have possibly been due to feather pecking. Other studies have found that the body condition of pheasant chicks decline as feather pecking and aggression increased with higher densities of pheasant chicks (Cain et al. 1984, Kjaer 2004). Since the surrogator has a high stocking density, it may be assumed that aggression will also be high (Kjaer 2004). Cain et al. (1984) also found that insufficient protein in the diet can increase feather pecking and cannibalism. While the feed I used met the minimum requirements for pheasant chicks, the issues with feed flow may have contributed to increased feather pecking and cannibalism. Despite these issues, in-surrogator survival was much higher over the period from hatching to 28 days old than was reported by Riley et al. (1998) for wild broods over the same length of time in Iowa. That study reported mean survival rates of 46% and 37% for two different areas. This leads to the conclusion that for at least the first 4 weeks of life, surrogator-reared birds have a survival advantage over wild birds.

Post-Release Mortality and Habitat Use

Pheasant chicks had a high mortality rate following release, especially during the first 2 weeks post-release. This initial high mortality rate is similar to other studies involving released birds where post release mortality ranged from approximately 40%–85% in the first 2 weeks after release (Hessler et al. 1970, Brittas et al. 1992, Musil and Connelly 2009). It is also similar to a smaller scale study of surrogator-reared pheasant conducted in Nebraska, where the estimated survival rate over 14 weeks was 12%, with most of the mortalities taking place in the first 2 weeks after release (J. J. Lusk, Nebraska Game and Parks Commission, unpublished report). This sharp decline in survival was observed in all 3 releases, but was most pronounced in July and September releases. After the first 2weeks, the June release continued to have better survival over the 12-week tracking period than the latter 2 releases. This is comparable to wild pheasants, in that later hatching chicks have a lower survival rate than chicks hatching earlier during the breeding season (Riley et al. 1998, Clark and Bogenschutz 1999).

The dismal performance of the September release could be attributable to several causes. It was noted that chicks were in poor condition relative to the other releases (R. L. Hamm, personal observation), possibly making them more vulnerable to sources of mortality (Swarbrick 1985). It is also possible that the later release date meant fewer available food sources. While there was only a slight decrease in available invertebrates (Fig. 5), it is possible that seeds and other plant foods were less available. Their late release also coincided with an increase in the number of avian predators observed on the treatment fields (Fig. 7), possibly making predation more likely. It is also possible that the smaller sample size than the prior releases made it more likely that all transmittered birds would be lost compared to the earlier, larger releases.

The 12-week post-release survival rate is below the 25% chick survival threshold for a self-sustaining population modeled by Hill (1985*b*). From the chick survival rate alone, this means that, at least in 2010, it would be unlikely that the surrogator chicks would establish a self-sustaining population. In addition, in an unpublished study conducted in Nebraska, estimated annual survival for pheasant released from a surrogator was >1% (J. J. Lusk, Nebraska Game and Parks Commission, unpublished report). Further, Brittas et al. (2009) reported that pen-reared hens that had been raised entirely in a brooder had lower reproductive rates than pen-reared hens that had been fostered with domestic chickens, and that neither of these compared to the reproductive rate for wild hens in the same area. Since hens raised in a surrogator would be most comparable to those raised by the brooder, it is likely that their reproductive rate will be very low. Taken together, these studies suggest that the surrogator may be an ineffective method for re-establishing pheasant populations.

The most common cause of mortality for surrogator-released pheasants was predation. The overall predation rate for my study is similar to predation rates reported for wild pheasant chicks (71%; Musil and Connelly 2009) and released, captive-reared pheasants (99%; Bliss et al. 2006). In my study, about half of the depredations were attributed to mammals, followed by avian predations and unknown predations. In other studies of pheasants, mammals were also reported as major predators. Brittas et al. (1992) attributed 45% of pheasant deaths to mammals, 22.5% to raptors, and 5.5% to unknown predators during a study in Sweden. Similarly, Riley et al. (1998) and Bliss et al. (2009) attributed the majority of pheasant mortalities in their studies to mammalian predators, with rates of 85% and 71.4%, respectively. Interestingly, neither of these studies mentions avian predators. Although Musil and Connelly (2009) were unable to attribute 54% of mortalities to any cause, they did report 26% of pheasant mortalities were caused by mammalian predators and 12% by avian predators. Given my methodology, it was not possible to determine the exact circumstances of death. Due to the fact that I only located the chicks 3 times a week and did not always find a dead bird until it had been located a second time in the same location, it is possible that some recorded depredations were not depredations, but were birds that died from another cause and were later scavenged. For this reason, my predation rates should be considered a maximum predation rate and the actual predation rate may be lower.

A large number of bird locations were recorded at the surrogator. The pheasant chicks generally stayed close to the surrogator for a time after release, usually 7– 10 days.

During this time, I frequently observed the birds feeding and taking shelter in the unit. They then left when there was little to no food remaining in the feeding trough. Since more birds were alive immediately after release, this accounts for the comparatively high number of times that pheasant were observed at the surrogator for the relatively short amount of time they stayed there, as opposed to in the CRP or in cornfields. A possible issue with leaving surrogators in place after post-release is that the birds were concentrated, which possibly made them more vulnerable to predation. An example from this study was an incident where at least 15 birds were killed near the surrogator over a short time period, likely a single night. The most likely predator for this incident was the long-tailed weasel. I reached this conclusion due to the large numbers of birds killed, evidence of head trauma or where only the head was missing, and the abundance of weasel tracks found in the scent stations (Martin et al. 2006).

In my study, pheasants that occurred in CRP fields did not use habitat that differed greatly from the random sites. This is not surprising as these fields were similar in composition. Riley et al. (1998) found a strong preference for grassland habitats over row crops or woodland habitats by hens and broods. In studies that did not have CRP land, the crops that were preferred, such as hay and oats (Warner 1979) and cereal crops (Hill 1985*a*), are structurally comparable to grass. The birds did, however, use areas that had a higher visual obstruction height than was recorded in the random sites. This higher visual obstruction was likely used as cover to avoid predation (Wittingham and Evans 2004). This is comparable to the results found by Thompson et al. (2006) where greater sage grouse hens selected areas with better cover from predators over areas with greater amounts of invertebrates, suggesting that the chicks selected habitat similarly to wild birds.

Many chicks spent at least some time in surrounding cornfields rather than research fields. Some of the chicks that were tracked for the longest lengths of times were located in corn on a consistent basis. Pheasants from every release cycle spent time in corn. Possible reasons for the birds using cornfields include excellent overhead cover from avian predators and relatively open ground that allows easier movement. Hanson and Progulske (1973) and Warner (1979) found that pheasant hens with broods would readily use corn, but that its use was less than its availability suggesting that corn was not a preferred habitat. However, Warner (1984) found that the use of corn increased in the absence of oats and hay, and the author speculated it was due to superior cover provided by the corn rather than availability of food (Warner 1984).

There were large differences in home range sizes between fields. The maximum home range reported for field 2 was much smaller than was found by Riley et al. (1998) who reported home ranges of 15–179 ha over a 4 week period. However, they were similar to those found in Hill (1985*a*) of 1.5–8.8 ha, albeit Hill's home ranges were for only the first 12 days post-hatch. The maximum home range for field 3 was inside the home ranges reported by Riley (1998). It is likely that if accurate locations in the cornfields could have been determined, home range sizes for both fields 2 and 3 would have been similar to the larger home ranges reported by Riley et al. (1998).

The average movement distances in my study were lower than those reported by Whiteside and Guthery (1983) and Riley et al. (1998) who reported average distances of

188 m and 155 m, respectively, in spring and summer. However, the distances in my study were greater than the average distance (75 m) reported by Hill (1985*a*). It is surprising that the numbers are comparable, as these studies recorded daily movements and locations rather than the thrice-weekly recordings in my study. This would suggest that the surrogator-released pheasants generally stayed in the same area or dispersed much more slowly than is typical for wild pheasants. It is possible that this was due to more suitable habitat that was available in my study area compared to these studies, which were conducted areas that were primarily composed of agricultural fields and not CRP land, as was the case for my study.

There are several possible issues with my methodology for determining home ranges and dispersal distances. First, all chicks from a given release on a field were considered cumulatively for home ranges. This allowed a larger number of points to be gathered, but presented a problem because a bird that travelled an unusually long distance had a large effect on the size of the cumulative home range. This was a particular problem on field 3 where there were several birds that separated themselves from all the others and went a comparatively long distance from the surrogator before settling into a relatively small area or dying. Secondly, the chick home ranges only include locations from the study fields because I was denied access to surrounding cornfields. This explains why I was not able to track past 40 days on field 2. By day 40, all the birds had either died, the transmitters had failed, or the birds were in a cornfield and were not observed outside of the cornfield again before their transmitters batteries died. The maximum dispersal range for field 3 also had issues, as there were birds that spent a large amount of time in surrounding cornfields as well.

After dispersing from the surrogator, chicks appeared to be mostly solitary, and when chicks were observed together, they were rarely observed in groups of more than 2–3 individuals. This is in contrast to wild chicks, which would still be with the hen and surviving brood members at 4 weeks of age (Johnsgard 1999). That the chicks were more solitary is important, as it could have exposed them to more danger than if they had been in a group, where group vigilance and the dilution effect would have provided more security for the chicks (Ale and Brown 2007). Also, the chicks likely covered a wider area as individuals and small groups than they would have in larger groups. In a study conducted in England, Hill (1985*a*) found that pheasant hens with broods that covered wider areas were prone to higher mortality rates than those that covered smaller areas. The large area covered by the group as whole, combined with the solitary nature of the chicks, suggest a high vulnerability to predation.

Invertebrate Surveys

A wide variety of invertebrates were found on the treatment and control fields. Doxon and Carroll (2010) found that the orders Hemiptera and Coleoptera were the most commonly consumed orders for pheasant chicks in a study conducted in Kansas on a variety of CRP fields. Both of these orders were commonly found on my fields and in quantities that suggest an abundant food source for chicks. Doxon and Carroll (2010) used 4–10 day old chicks, which were younger than the surrogator chicks at the age of release. I hypothesize that the older birds would be more able to utilize available insect sources due to more advanced development, such as being able to more effectively hunt and engulf larger prey as well as being able to more effectively move through the environment searching for prey. A factor cited in the Doxon and Carroll (2010) is the difficulty their chicks had moving through the CRP grasses. This would be much less of a concern for older birds such as occurred in my study. Taking this into account, all the fields included in my study should have had more than adequate levels of invertebrates for the chicks.

The biomass of all invertebrate orders increased over the summer. This also suggests that there was more available food at the time of release for the 2 later cycles. However, this did not correlate with a higher pheasant survival, as the 2 later releases had lower survival rates (Fig. 1) and fewer pheasants from later releases were harvested than from earlier releases (R. L. Hamm, unpublished report). This could be due to the fact that at the time the chicks were being released they are becoming less reliant on animal foods, and were eating more plant matter such that the availability of insects was not a limiting factor to their survival (Ferrel et al. 1949, Johnsgard 1999).

Predator Surveys

The scent station surveys did not reveal a difference in relative abundances of mammalian predators for treatment fields compared to control fields. This is surprising, as other studies have shown that predators will converge on concentrated prey to take advantage of an abundant food source (Godbois et al. 2004). It is possible that this is due to the nature of the fields and specific habitats used by the chicks. A high visual obstruction measurement would make it more difficult for the chicks to be spotted by mammalian predators. Another possibility is that, while there were a variety of mammalian predators on my study sites, a primary predator species was largely missing. The red fox has been implicated as a primary predator in many pheasant studies (Hessler et al.1970, Riley et al. 1998). While red fox were present in the study area, tracks were only found once in the scent station survey, which could be indicative of a low abundance in the area. If there were more foxes in the area, the results may have shown more of a predator response. It should be noted that while foxes are often cited as a major predator, so are weasels (Riley et al. 1998), which were commonly found in scent stations.

Avian predators did show a difference in abundances between treatment and control fields. In both years, northern harriers (*Circus cyaneus*) and red-tailed hawks were more abundant over fields 1 and 3, respectively. Since these trends were observed both years, it is unlikely to be due to surrogator birds being released on these fields. Red-tailed hawks are a major predator of pheasants (Hessler et al. 1970, Petersen 1979), and it is possible that since the 2010 pheasants were released on a field where the hawks were observed more often, pheasants were subsequently depredated more often than they would have been on other fields. Swainson's hawks (*Buteo swainsoni*) were observed much more often on control fields as opposed to treatment fields in 2010, but this was likely a mated pair near a nest, as all the sightings were close to the same locations along a wood lot.

A possible weakness of the study is that I did not conduct any surveys for owls. Great horned owls (*Bubo virginianus*) have been cited as another significant avian predator for pheasants (Petersen 1979) and they were occasionally observed in the area around twilight. Along with great horned owls, barred owls (*Strix varia*) were occasionally observed in the area; while these have not been documented as a predator of pheasants, they might be large enough to opportunistically depredate one.

MANAGEMENT IMPLICATIONS

The surrogator may not be a useful tool for the re-establishment of pheasant populations. My study shows that few birds survived past the first few weeks post-release. Given that predation and other sources of mortality continued after the tracking period was over, it is likely even fewer birds survived to the hunting season and fewer still likely survived the winter. Combining this low survival with the low reproductive rates associated with released birds, it is unlikely that pheasants released from the surrogator will establish a sustainable, self-supporting population. However, the surrogator could possibly be used to supplement an area with a low population due to hunting pressure, but where releasing adult birds is undesirable.

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Table 1. Comparative properties of habitat at used and random points (n = 148 paired sites) for ring-necked pheasants released from surrogators, Kiowa County, Kansas, June–October 2010.

Variable	Used		Random		Effect size	
	$\bar{x}_1$	SE	$\bar{x}_2$	SE	$\bar{x}_1 - \bar{x}_2$	SE
Daubenmire coverage (%)						
Bare ground	1.8	3.07	1.8	0.98	0.0	0.24
Litter	3.2	3.05	7.3	1.33	-4.1[a]	0.34
Grass	73.6	10.52	72.0	3.19	1.6	0.91
Forb	20.4	9.08	18.14	2.1	2.3[a]	0.72
Woody	0.8	1.62	0.87	0.6	-0.1	0.14
Line intercept						
Woody Canopy coverage (%)	3.7	4.84	1.1	0.82	2.6[a]	0.44
Robel obstruction (cm)	56.2	10.29	45.2	2.48	10.9[a]	1.12
Angle of obstruction (^{o})	89.6	0.23	87.8	1.11	1.8[a]	0.20

[a] 95% CIs do not overlap 0.0.

Table 2. Invertebrate taxa and dry mass (g) collected from treatment and control fields, Kiowa County, Kansas, summer 2009.

	June		July		August		September	
Taxa	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Araneae	0.012	0.015	0.03	0.011	0.021	0.02	0.007	0.006
Hemiptera	0.109	0.069	0.1	0.049	0.177	0.027	0.077	0.029
Coleoptera	0.229	0.042	0.07	0.091	0.055	0.027	0.05	0.029
Orthoptera	2.183	0.192	6.918	1.293	3.268	0.288	1.311	0.423
Hymenoptera	0.003	0	0.01	0.005	0.03	0.005	0.004	0
Lepidoptera	0.398	0.002	0.02	0.064	0.044	0.008	0.102	0.144
Diptera	0.013	0.006	0.023	0.006	0.017	0.005	0.01	0.002
Odonata	0.003	0	0.003	0	0	0	0	0
Mantodea	0	0	0.016	0.031	0	0	0	0
Neuroptera	0	0	0	0	0.003	0	0	0
Total	2.951	0.325	7.19	1.549	3.614	0.443	1.56	0.635

Table 3. Invertebrate taxa dry mass (g) found by month on treatment and control fields, Kiowa County, Kansas, summer 2010.

	May		June		July		August		September	
Taxa	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Contr
Araneae	0.007	0.006	0.019	0.042	0.024	0.037	0.046	0.053	0.051	0.065
Hemiptera	0.009	0.002	0.058	0.158	0.042	0.07	0.185	0.129	0.119	0.155
Coleoptera	0.008	0.001	0.015	0.027	0	0.035	0.066	0.004	0.023	0.036
Orthoptera	0	0.01	0.245	0.836	0.994	4.687	1.194	3.884	0.718	4.101
Hymenoptera	0	0	0	0	0.045	0.008	0.032	0.007	0	0.088
Lepidoptera	0	0.006	0.065	0.009	0.01	0.01	0.05	0.013	0.057	0.02
Diptera	0.055	0.031	0.001	0.02	0.013	0.014	0.007	0.002	0.008	0.006
Odonata	0	0.004	0	0.001	0	0	0.004	0.004	0	0.001
Mantodea	0	0	0	0.002	0.002	0	0	0	0	0
Total	0.079	0.06	0.403	1.094	1.131	4.862	1.583	4.096	0.975	4.473

Table 4. Occurrence and composition of mammalian predator species observed on treatment and control fields, Kiowa County, Kansas, summer 2009.

	Occurrence (%)		Species composition (%)	
Species	Treatment (*n* = 42)	Control (*n* = 42)	Treatment (*n* = 8)	Control (*n* = 8)
Long- tailed weasel	11.9	7.1	55.6	37.5
Opposum	4.8	2.4	22.2	12.5
Raccoon	0.0	2.4	0.0	12.5
Coyote	2.4	2.4	11.1	12.5
Red fox	0.0	2.4	0.0	12.5
Bobcat	2.4	2.4	11.1	12.5

Table 5. Occurrence and composition of raptor species observed on treatment and control fields, Kiowa County, Kansas, summer 2009.

	Occurrence (%)		Species Composition (%)	
Species	Treatment (n = 246)	Control (n = 124)	Treatment (n = 31)	Control (n = 14)
Red-tailed hawk	2.0	5.7	22.9	83.3
Northern harrier	3.2	2.4	48.6	16.7
Swainson's hawk	1.6	0.0	11.4	0.0
Ferruginous hawk	0.4	0.0	2.9	0.0
Unknown	3.6	0.0	14.3	0.0

Table 6. Occurrence and composition of raptor species observed on treatment and control fields, Kiowa County, Kansas, summer 2010.

	Occurrence (%)		Species Composition (%)	
Species	Treatment (n = 343)	Control (n = 392)	Treatment (n = 61)	Control (n = 44)
Red-tailed hawk	8.0	2.5	62.8	31.8
Northern harrier	4.0	3.5	27.5	31.8
Swainson's hawk	0.9	0.3	5.9	31.8
Unknown	0.9	2.8	3.9	4.6

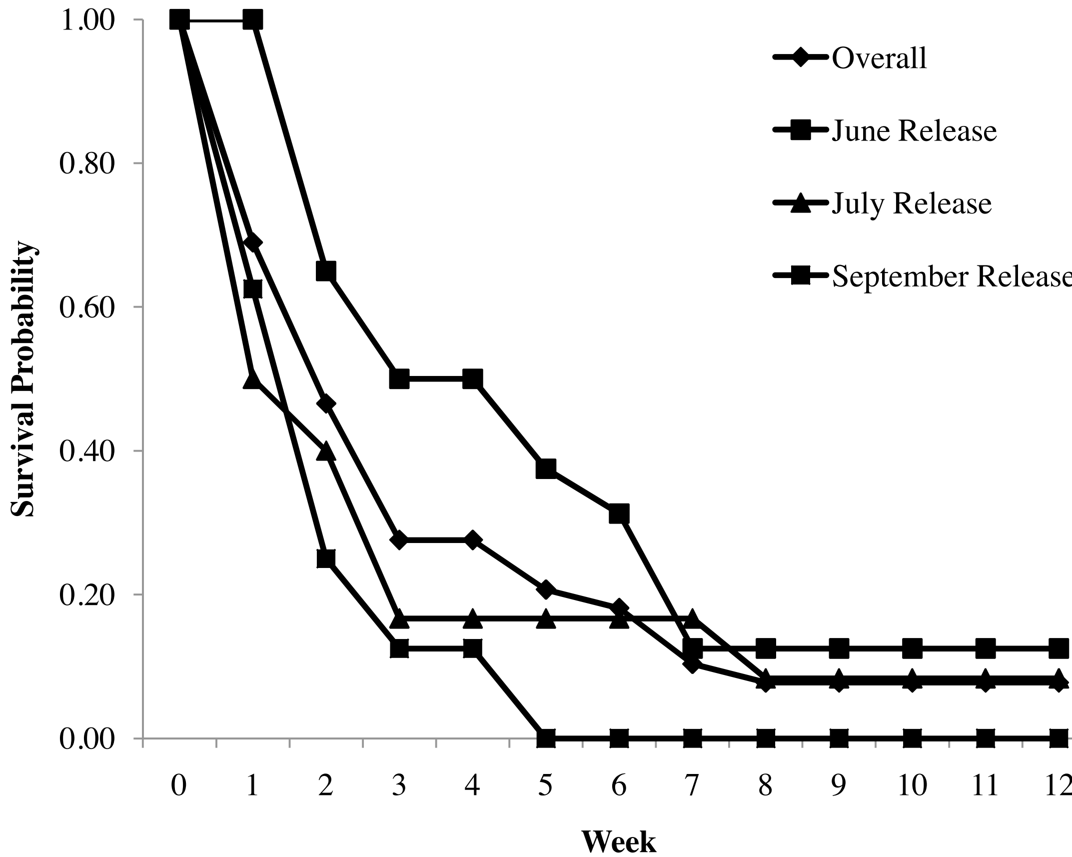

Figure 1.Weekly post-release Kaplan-Meier survival probabilities of ring-necked pheasant chicks released from Surrogators by release date (n = 20 for June, n = 30 for July, and n = 8 for September) and overall survival (n = 58), Kiowa County, Kansas, summer 2010.

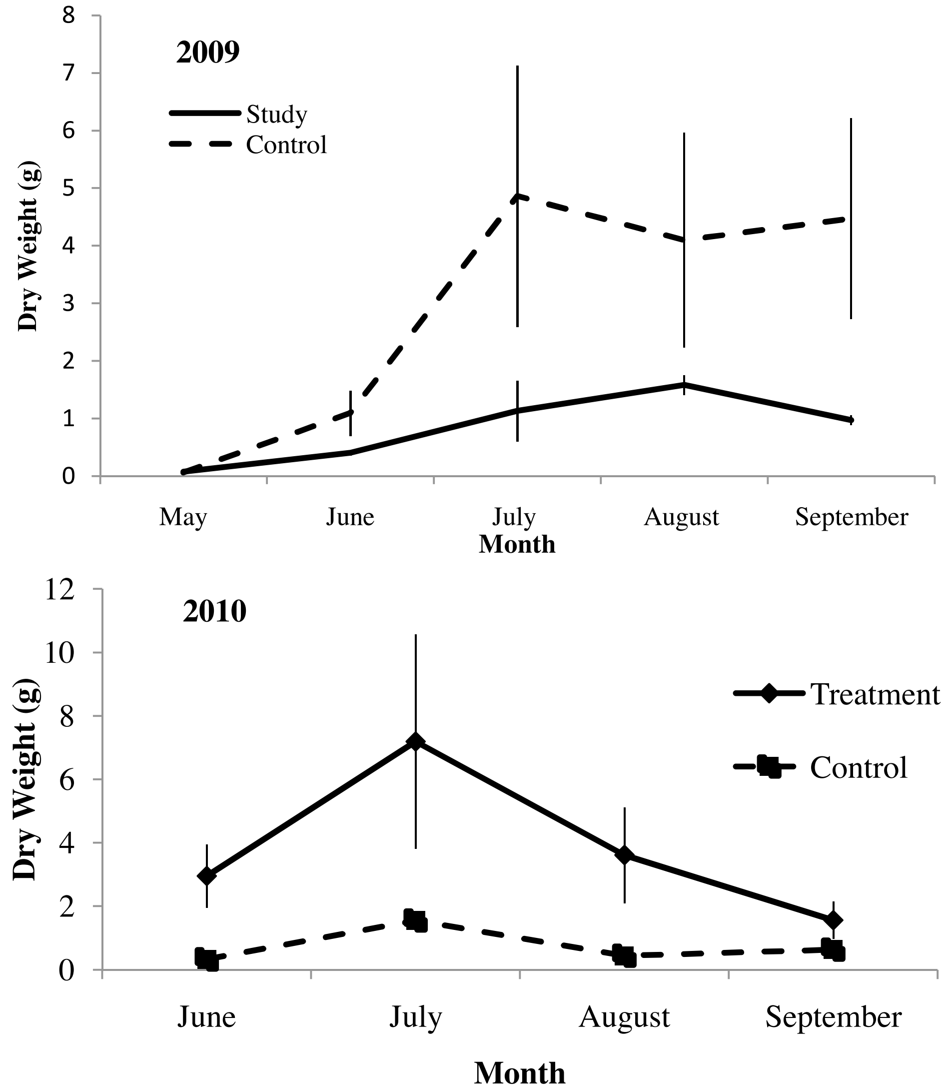

Figure 2. Invertebrate dry mass totals (g) for treatment and control fields by month, Kiowa County, Kansas, summers 2009 and 2010.

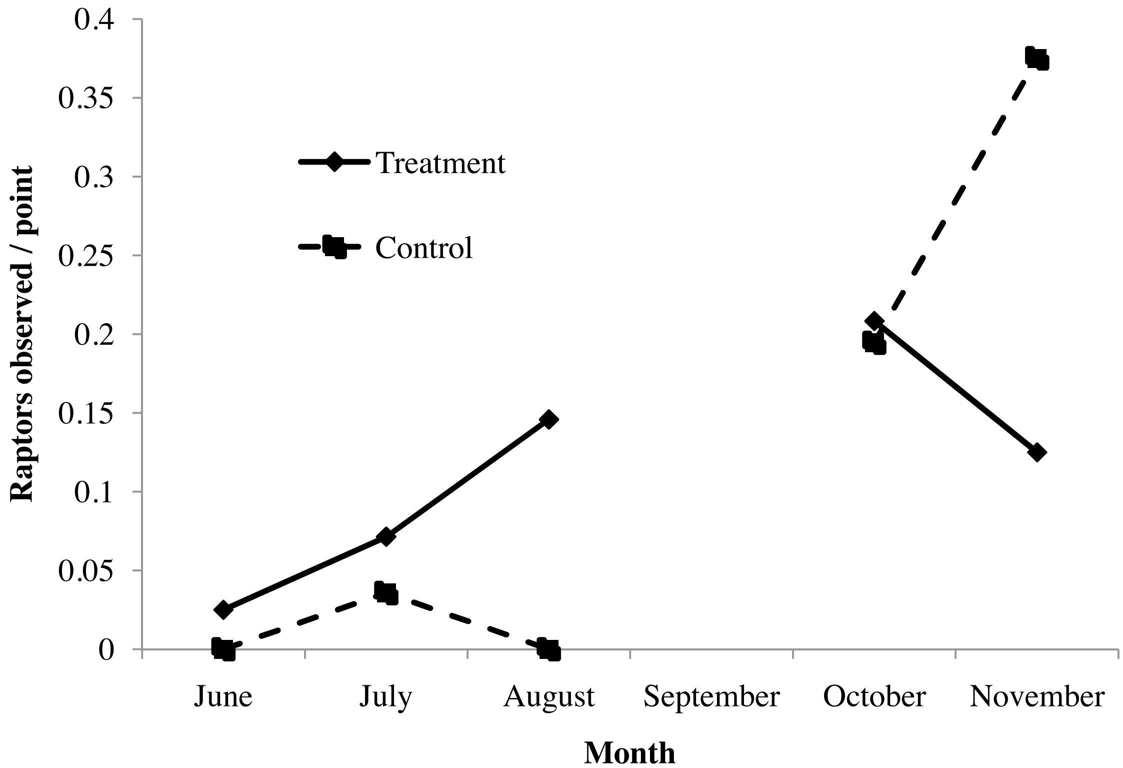

Figure 3. Avian predator trends from June–November 2009 (surveys were not conducted in September) as observed over treatment (n = 246 points) and control (n = 124 points) Conservation Reserve Program fields Kiowa County, Kansas.

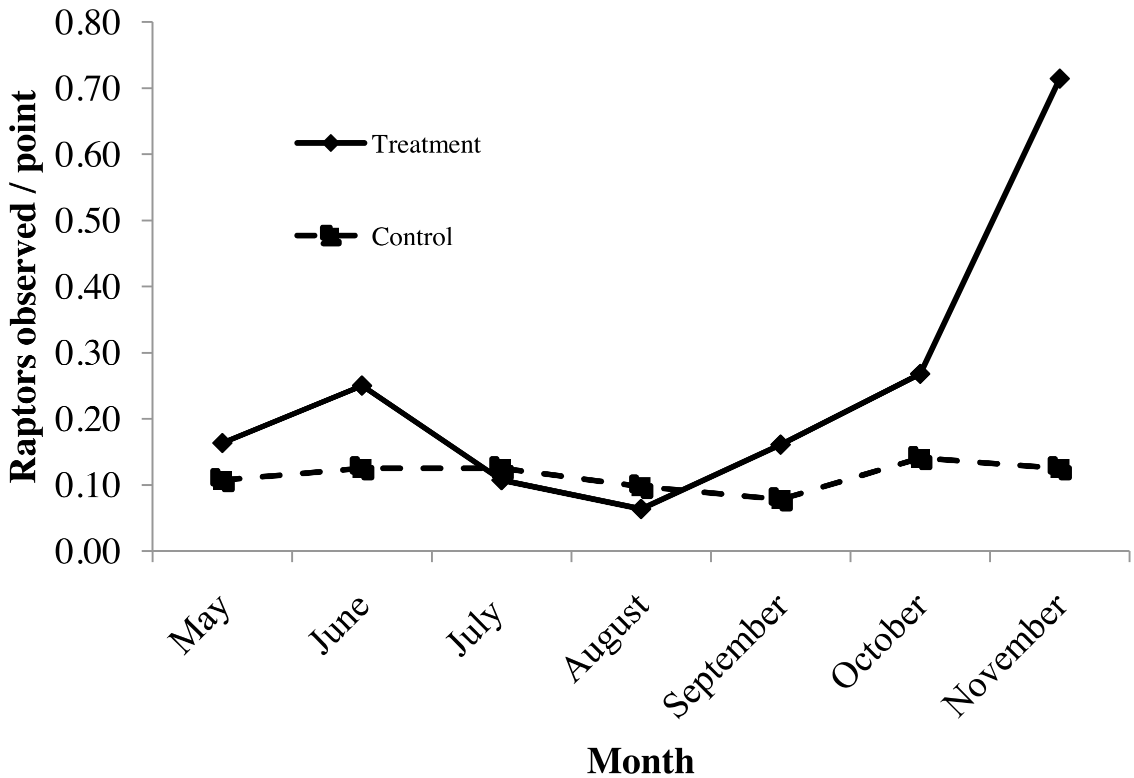

Figure 4. Avian predator trends from May–November 2010 as observed over treatment (*n* = 343 points) and control (*n* = 392 points) Conservation Reserve Program fields Kiowa County, Kansas.

CHAPTER III

EFFECT OF SURROGATOR®-REARED RING-NECKED PHEASANTS ON HUNTING QUALITY

Abstract: Releasing gamebirds for hunting is a commonly used management technique. However, current methods have significant drawbacks, such as low returns and high cost, which make them undesirable in some situations. The Surrogator® is a device used to release gamebirds into a new environment for the purpose of establishing huntable populations. My objectives were to determine the effect of surrogator-reared ring-necked pheasants (*Phasianus colchicus*) on the quality of hunting and assess hunter attitudes toward surrogator-reared pheasants. I accomplished this by surveying demographics of 97 individual hunters in addition to surveying their hunting experience with the surrogator birds. Further, I collected data on the hunters' activities in the field such as how long they spent walking and how long they spent stopped and their velocities while hunting. I also collected bands from harvested pheasants to determine the return-rate for pheasants released from the Surrogator. The hunters were primarily male, middle age, and experienced upland bird hunters. They generally had a positive attitude about the released pheasants. Return rates for pheasants were 2% (n = 11) and 16% (n = 52) in the 2009–2010 and 2010–2011 hunting seasons, respectively. In this study, surrogator pheasants increased the total take and improved hunt quality.

Keywords: Hunters, leg bands, *Phasianus colchicus*, return rate

INTRODUCTION

The ring-necked pheasant (*Phasianus colchicus*) is a widespread game bird, second only to the wild turkey in terms of popularity in the United States (U.S. Department of the Interior 2006). In other countries such as Italy (Santilli and Bagliacca 2008), New Zealand (Johnsgard 1999), and Great Britain (Hill and Robertson 1988), it is one of the most popular gamebirds. Due to this popularity and the accompanying economic benefits, it is desirable for many sportsmen and state game agencies that pheasant populations are maintained at high, huntable populations (Erickson and Wiebe 1973).

One way of maintaining a large number of huntable birds is to release adult birds in selected areas. Currently, there are a variety of captive-rearing methods used to enhance and supplement pheasant populations. Most of these methods can be classified into 2 categories: release of sub-adult or adult farm-reared birds (Hill and Robertson 1988) and translocation of wild adult birds (Bagliacca et al. 2008, Musil and Connelly 2009). Both of these methods have drawbacks. Farm-reared birds generally have poor survival post release (Brittas et al. 1992, Leif 1994), and additionally are inferior in terms of flight characteristics, agility, and reproduction (Hill and Robertson 1988, Robertson et al. 1993). Translocated wild birds are an improvement over farmed birds, but are difficult to obtain and are expensive (Musil and Connelly 2009). Recently, a captive-rearing device known as the Surrogator® (hereafter, surrogator) has been marketed to enhance gamebird hunting opportunities as well as provide birds that possess characteristics similar to wild birds.

The main purpose of the surrogator is to establish or supplement populations of released gamebirds species for hunting. The device is a brooder that can be placed into a selected habitat that the owner wants to introduce gamebirds to. Chicks are placed into the surrogator at 1 day of age and are supplied shelter, heat, food, and water until they are old enough to be released into the environment with minimal maintenance from the owner. Pheasant are released at 4 weeks of age.

Hunters are the driving force behind the development of the surrogator and primary demographic that it is marketed towards. The most effective way to gather information on this group is by surveying the hunters themselves. Further, the hunters must consider the surrogator-reared birds to be superior to other artificial options for the device to be considered effective.

The objectives of this study were to:

1. Conduct surveys of ring-necked pheasant hunters in south-central Kansas to collect demographic data and evaluate their attitudes toward hunting surrogator-reared pheasants.
2. Determine the activity budgets of hunters during pheasant hunts.
3. Determine the rate of return for surrogator-reared pheasants.

STUDY AREA

This study was conducted in Kiowa County in south-central Kansas. In winter, the average temperature is 1.2° C and in summer the average temperature is 25.6° C. The average annual rainfall for the area is 57.3 cm with most of the precipitation occurring from April to September (United States Department of Agriculture 1986).

The northern third of the county, where this study was conducted, consists of sand hills (Latta 1948). The highest elevation in the county is 743 m and the lowest elevation is 592 m (Latta 1948). Cropland, woodland, and grassland are mixed throughout the county and trees can be found in windbreaks and along streams. Most of the land in the study area is composed of either cropland or rangeland. The principal crops of the county are wheat and sorghum (United States Department of Agriculture 1986), but large tracts of land have also been enrolled in the Conservation Reserve Program (CRP). Currently, approximately 26,551 ha of land in the county have been enrolled in CRP (United States Department of Agriculture 2010).

The study was conducted on 4 fields, 2 experimental fields (with surrogators) and 2 control fields (without surrogators). The mean size of the fields was 103 ha with fields ranging in size from 64 to 161 ha. Fields occur as close as 20 m to as far as 3.2 km from one another. All fields were enrolled in CRP and planted with CP2 (native grasses) plantings. The predominant vegetation groups in the experimental and control fields were grasses such as big bluestem (*Andropogon geradii*), little bluestem (*Schizachyrium scoparium*), and indiangrass (*Sorghastrum nutans*), followed by forbs that included species such as blackeyed susan (*Rudbeckia hirta*) and ragweed (*Ambrosia* sp.). There was a scattering of Chickasaw plum (*Prunus angustifolia*) on some fields. In 2009, food plot strips were planted on the fields; however, these were not replanted in 2010. The fields had control burns performed on them previously, but not for at least 3 years for all fields in 2009 (J. Johnson, Wildlife Management Technologies, personal communication).

METHODS

Hunter Surveys

During the hunting season, which occurred from 13 November–31 January, I monitored pheasant hunts on study fields. I did not actively participate in the hunts nor did I attempt to influence the hunters in any way. I surveyed hunters to determine demographic characteristics (e.g., age, hunting experience) and perceptions of hunting surrogator birds (Appendix 1). This survey is similar to the survey conducted by Richardson (2006) during his study of northern bobwhite (*Colinus virginianus*) hunters. The hunters were also asked to rate the wildness of the pheasants on a scale of 1–10, with 1 being “tame” and 10 being “completely wild”. This survey was approved by the Oklahoma State University’s Institutional Review Board (IRB #AG0943).

Hunter and Dog Activity

When hunters were hunting study or control fields, I monitored them closely. I either followed immediately behind a hunter or as part of the drive line, whichever was deemed safer at the time. During each hunt, I recorded the amount of time the hunters engaged in a variety of behaviors (e.g., walking, stopping, in-between passes [during a hunt, in-between passes occurred when the line of hunters had completed one pass through the field and was resetting for another pass], approaching dog on point, retrieving bird from dog, and searching for a lost dog) to determine time-activity budgets. Time-activity budgets began when the hunters began the first hunting drive and ended at edge of the field following the last drive. I attempted to monitor hunting dog activities, but the habitat was too tall and dense to allow me to follow the dogs.

To measure hunter and dog velocity, I attached a GPS unit (Garmin Foretrex 201, Garmin International Inc., Olathe, KS) to either my vest or coat and to the vest or coat of a hunter in the group as well as to the collars of 2 dogs used in the hunt. These GPS units recorded a location every 7 seconds. Mecozzi (2007) tested the accuracy and effectiveness of this model and found that, while largely accurate, the Foretrex 201 may register a range of velocities when the GPS is not moving and will occasionally show deviations from a path when there was no actual deviation. I attached 2 units to the collars of each hunting dog in order to ensure that there was no signal loss. I also attached plastic zip ties to each unit to prevent structural failures in the wristband that could result in the loss of the GPS unit (Mecozzi and Guthery 2008). Velocity was measured by determining the distance between to points in meters using the distance formula, and then dividing by 7 to obtain m/second (Mecozzi 2007).

Band Returns

During the hunts, I recorded any banded surrogator pheasants that were harvested by hunters on the study fields. All surrogator-reared pheasants were banded prior to their release during the summer. In all, 643 birds were banded in 2009 and 352 were banded in 2010. All leg bands were individually numbered and had a telephone number for reporting recovered bands. Hunters who reported recovered bands were asked questions about the location where the bird was harvested and the characteristics of the bird (i.e., flight ability, behavior prior to being harvested, and overall body condition). The number of banded birds harvested was compared to the number of birds released to determine the band recovery rate.

RESULTS

Hunter Surveys

During the 2009 hunting season, 34 different hunters were surveyed. The average age of hunters was 40.8 ± 3.2 (SE) years old with 22 ± 3.0 years of pheasant or quail hunting experience. These hunters reported that they went pheasant or quail hunting 7 ± 2.7 days a year. During the 2010 hunting season, 63 different hunters were surveyed. The average age of hunters was 44.6 ± 1.7 years old with 23.1 ± 2.1 years of pheasant or quail hunting experience. These hunters reported they went pheasant or quail hunting 6.8 ± 1.5 days a year. During both years, the hunters were overwhelmingly male, with only 1 female being surveyed in 2010 and none in 2009. The average rating of the pheasants was 9.11 ± 0.25(n = 33 hunters) in 2009 and 9.13 ± 0.28 (n = 23 hunters) in 2010.

Hunting Pressure Distribution

In 2009, 77 hunters spent 14.9 hrs hunting on surrogator fields and 42 hunters spent 3.8 hrs on control fields. In 2010, 89 hunters spent a total of 45.3 hrs hunting on surrogator fields and 83 hunters spent a total of 8.6 hrs hunting on control fields. In 2009, the average time spent hunting on surrogator fields was 2.1 ± 0.33 hrs and the average party size was 7.7 ± 1.5 hunters. The average time spent hunting control fields in 2009 was 0.95 ± 0.21 hrs and the average party size was 10.5 ± 1.0 hunters. In 2010, the average amount of time spent hunting on surrogator and control fields was 1.8 ± 0.22 hrs and 1.2 ± 0.19 hrs, respectively, and the average hunting party size for surrogator and control fields was 7.1 ± 0.8 hunters and 5.9 ± 0.8 hunters, respectively. Most hunting was conducted on study fields both years, and mostly later in the season (Fig. 1).

Hunter and Dog Activity

I monitored 10 hunts on surrogator fields and 4 hunts on control fields in 2009 and 11 hunts on surrogator fields and 7 hunts on control fields in 2010. On both surrogator and control fields, hunters spent the majority of their time walking followed by time spent in between passes (Table 1). Other measured variables did not compose a large percentage of time individually (Table 1). Hunter velocity on control fields in 2009 averaged 0.58 m/s and dog velocity on control fields averaged 1.96 m/s. Unfortunately, velocity could be determined for 1 hunter and 1 dog on treatment fields in 2009; the mean hunter velocity was 0.76 m/s and the mean dog velocity was 2.28 m/s. In 2010, the mean hunter velocity for treatment fields was 1.02 m/s ± 0.27 (n = 10) and for control fields averaged 0.67 m/s ± 0.15 (n = 4). For dogs, the mean velocity was 3.32 m/s ± 0.83 (n = 10) for treatment fields and 2.88 m/s ± 0.80 (n = 6) for control in 2010.

Band Returns

The return rate of surrogator pheasants to the bag in 2009 was 2% (11 returned/ 695 released), while the return rate in 2010 was 16% (52 returned / 323 released) (Tables 2 and 3). In 2009, 7 banded pheasants were harvested on the field where they were released and 2 were harvested offsite, while in 2010, 34 pheasants were harvested on their release field and 18 were harvested offsite. There was 1 pheasant banded in 2009 that was harvested during the 2010–2011 hunting season.

DISCUSSION

Hunter Surveys

The average hunter in my sample was male, middle aged and experienced at hunting upland gamebirds. This is similar to the quail hunters surveyed by Mecozzi and Guthery (2008) and Richardson (2006) and pheasant hunters surveyed by Shay (1994). While the hunters in my study were not randomly selected, the similarity of their characteristics with those of hunters from other studies suggests that they are representative of the average upland gamebird hunters.

The wildness rating assigned to the birds by the hunters who harvested a banded bird is high and seems to suggest that hunters could not distinguish between surrogator and wild pheasants. It is possible that the large amount of experience reported by the hunters surveyed lends credence to the wildness ratings. Few hunters chose to add further comments to the surveys, but those that did tended to comment that the hunt had been a great experience and that all birds encountered flew well and acted wild.

Although the hunters rated surrogator birds as being wild, there are several factors that may have also influenced their perceptions of the birds. The first is that it was not possible to assess whether the hunters had hunted wild or farm-reared birds, which may have influenced their perceptions of the birds they harvested. The second is that while I only accepted ratings from hunters who had harvested a banded bird, the hunter saw and likely harvested many birds that were unbanded that same day, making comparisons difficult. The third factor was that the hunters in our study were either friends or paying clients of the hunting guide, which may have influenced their perceptions of the birds.

Hunter and Dog Activity

The hunters' activity budgets differed between treatment and control fields, although different hunting methods make it difficult to make a true comparison. The main differences were in the amount of time walking and the amount of time in between passes, which were likely due to the layout of the fields. Treatment fields were easier to access as they generally had more road frontage and had mowed paths that could be driven on. The guide preferred to hunt going into the wind, if feasible, and when it was possible he would have trucks waiting to drive hunters around the fields so that each pass was made facing into the wind, resulting in more time in between passes which gave hunters time to rest. The control fields did not have these paths and driving on the fields was not allowed. This meant that either each pass started almost immediately or that there were no individual passes, rather the perimeter of the field was hunted in one long pass. This method of hunting could also account for the difference in hunter and dog velocities on study and control fields. Since there was little to no rest on control fields, it is likely the hunters and dogs tired and their velocities decreased as the hunt progressed. The hunter velocities on control fields were comparable to those found by Richardson (2006) and Mecozzi (2007) on control fields, however, the average velocity on treatment fields in 2010 were on average higher. This is possibly due, again, to the rest periods afforded in between passes to hunters on treatment fields as the hunters in Richardson's (2006) and Mecozzi's (2007) studies often hunted for much longer periods than hunters in my study.

Band Returns

The band return rates are the most significant test for the effectiveness of the surrogator. The band returns for the study were higher in 2010 than in 2009. The banding technique used in 2009 often resulted in constriction of the legs of the chicks as they grew which likely crippled the birds and possibly contributed to the bird's death prior to the hunting season, lowering the return rate. The return rate for 2010 was higher than the 6.4% found by Ginn (1947) for pheasant released in Indiana, 10.8 % found by MacNamara and Kozicky (1949) for pheasant released by the state in New Jersey, and 14.4% found by Roby (1951) for pheasant released in Montana. All of the releases in these studies were conducted with farm-reared adults well before the season opened. However, Diefenbach et al. (2000) reported a return rate of 54.6% for farm-reared adult pheasant released a few days before the season in Pennsylvania. Since adult pen-reared birds do not survive well in the wild (Brittas et al. 1992), it is likely many birds in the older studies had died before the season opened; a possibility acknowledged by Ginn (1947) and illustrated by MacNamara and Kozicky (1949) in an analysis of return rate versus release date. This could account for the large range in return rates among the studies, but it could possibly make the earlier studies more comparable to surrogator-reared birds, as the surrogator-reared birds are released well before the hunting season as well. It is notable that the return rate for this study was also much higher than the return rate for a previous study involving surrogator-reared pheasants in Nebraska which reported a band return rate of 3.5% (J. J. Lusk, Nebraska Game and Parks Commission, unpublished report). Differences in methodology make comparisons with this study difficult. The Nebraska study occurred on public land, sometimes in areas containing poor pheasant habitat, whereas almost all hunts in this study were on private land directed by a guide that were excellent pheasant habitat. Also the total number of pheasant harvested in the Nebraska study (*n* = 53) is just above the number of banded pheasant harvested in 2010, suggesting that the hunting pressure was much different.

Overall, the band-return rate was relatively high in 2010 (Table 3). However, there are a couple of issues that must be considered. The first is that not all of the pheasants released were roosters. It is difficult to sex day-old chicks, though the hatchery claimed an accuracy rate of 85–90%. This is consistent with the accuracy rate reported by Wohler and Gates (1970) in a study describing the methods used to sex day-old chicks. One pheasant that was tracked during the radiotelemetry phase of the study was visually confirmed to be a female. Since hens cannot be legally harvested they would not have been included in our return rate. This means that the reported return rate for this study should be considered a minimum rate.

A second issue is that about half of the banded pheasants harvested were reported off-site, and it is unlikely all birds harvested were reported. Banded birds historically have a low return rates due to large numbers of bands never being recovered, but there is also a problem with some bands being recovered and never being reported (Nichols et al. 1991). While I advertized information about the study around the town of Greensburg with flyers, announced the study at a local Ducks Unlimited event prior to opening day of pheasant season, and talked to groups of hunters encountered in the field, it would be impossible to reach all the hunters that came into the area. Diefenbach et al. (2000) found a band-reporting rate of 71% for non-reward bands during a study conducted in Pennsylvania on the effectiveness of reward bands with farm-raised pheasant. This contrasts with the reporting rates of 32 – 38% for non-reward bands in studies with mallards (*Anas platyrhynchos*) (Nichols et al. 1991, Nichols et al. 1995). Since not many birds were harvested overall and half of the birds harvested were on site where they absolutely would have been recorded, this is not likely to be a large factor for this study. However, if reporting rates were similar to those reported by Nichols et al. (1991) the actual return rate might have been appreciably higher.

Many of the birds harvested in 2010 were from the first release (Table 3). It is possible that the early June release date more closely mirrored natural reproduction timing for pheasants. This is important, as previous studies have shown that earlier hatches are associated with increased chick survival (Riley et al. 1998). It is also possible that there were environmental conditions that made it more difficult for young birds to establish themselves and survive during the later releases. The low return from the September release on field 3 is not surprising due to the high in-surrogator mortality rate for that release.

MANAGEMENT IMPLICATIONS

Overall, the hunters surveyed had a positive view of the Surrogator. It is possible that the surrogator birds have behavioral characteristics (e.g., wariness and flight capabilities) that make them preferable to farm-reared adults. However, the return rate for surrogator pheasants does not differ much from released adult birds in previous studies (Ginn 1947, MacNamara and Kozicky 1949, Roby 1951) and surrogator birds might actually have a lower return rate depending on when the adult birds are released (Diefenbach et al. 2000). While the surrogator-reared pheasants certainly provided additional birds for hunters to harvest, managers will need to judge whether the band returns justify the cost and effort associated with using surrogators to supplement hunting opportunities.

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Table 1. Activity budget for hunters on Conservation Reserve Program fields in Kiowa County, Kansas, during 2009 (Nov–Dec) and 2010 (Nov–Jan) hunting seasons.

	Treatment fields (*n* = 21 hunts)			Control fields (*n* = 8 hunts)		
Variable	Time (%)	SE	Range (%)	Time (%)	SE	Range (%)
Walking	61.8	10.4	60.0 – 100.0	77.2	4.2	60.0 – 87.5
Stopped	5.1	1.7	0.0 – 10.0	7.22	0.5	0.0 – 10.4
In-between passes	25.8	9.9	0.0 – 35.6	8.1	1.0	0.0 – 33.7
Approaching point	2.2	1.7	0.0 – 16.7	2.8	0.3	0.0 – 6.3
Retrieving bird	5.1	2.2	0.0 – 13.3	4.6	1.6	0.0 – 8.3

Table 2. Band returns for harvested ring-necked pheasant on surrogator fields in winter 2009–2010, Kiowa County, Kansas.

Category	Field 1	Field 6
Total number of pheasants released	449	378
Harvest from June release	2	2
Harvest from July release	0	5
Harvest from August release	0	2
Total number of banded birds harvested	2	9
Band return rate (%)	0.4%	2.4%
Banded birds harvested onsite	2	7
Banded birds harvested offsite	0	2

Table 3. Band returns for harvested ring-necked pheasant on treatment fields in winter 2010–2011, Kiowa County, Kansas.

Category	Field 2	Field 3
Total number of pheasants released	174	149
Harvest from June release	14	14
Harvest from August release	5	7
Harvest from September release	10	2
Total number of banded birds harvested	29	23
Band return rate (%)	17	15
Banded birds harvested onsite	17	17
Banded birds harvested offsite	12	6

.

APPPENDICES

An Evaluation of Leg Banding and Attachment of Radio-Transmitters on Juvenile Ring-Necked Pheasants

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ABSTRACT

In studies with wild animals, it is often necessary to permanently mark and/or track animals over a period of time. Leg banding and radiotelemetry are techniques often used to meet these requirements. While commonly used on adult birds, banding and telemetry of juvenile upland gamebird chicks is rare, and sometimes recommended against. However, valuable information, such as habitat use, mortality rates, and return-to-bag rates can be gained from the use of these techniques with chicks; and development of safe techniques to gather this information was necessary for our study on ring-necked pheasant (*Phasianus colchicus*) chicks. We compared 4 methods of leg banding (plain aluminum bands, plastic wrap-around bands, combination of plain aluminum and plastic wrap around bands, and cotton-filled aluminum bands) and 2 methods of attaching radio-transmitters (gluing and suturing). We found that plain aluminum leg bands did not stay attached to the birds due to the bands being too large to remain on the legs, and the plastic wrap around bands commonly caused constriction of the legs, thus crippling birds. Cotton filled leg-bands were shown to be an effective method of banding gamebird chicks. Glued transmitters had short attachment times, often < 2 days. Suturing had much longer attachment times and is recommended as a method for attaching radio-transmitters to 4-week-old pheasant chicks.

KEY WORDS: Gluing, leg bands, radio-telemetry, suturing.

INTRODUCTION

There are numerous methods to mark birds for both identification and radiotracking in scientific studies. Leg banding birds for future identification is a common practice. Banding was first developed to study migration routes and species ranges, but has been adapted for use in behavioral studies, ecological studies, and studies of population dynamics (Gauthier-Clerc and Le Maho 2001). Radiotransmitters have been used to determine the location of animals for a variety of purposes, such as determining habitat use, and survival rates. For both leg bands and radiotransmitters, proper attachment to the bird is critical for survival of the species and success of the project. Various methods for banding birds involving bands composed of different materials and of different forms (Blums et al. 1999, Dwyer and Mannan 2009) and for attaching radio-transmitters (Perry et al. 1981) have been developed; however, almost all of these techniques have been developed for use with adult birds. Methods of banding and attaching radio-transmitters to chicks and sub-adults are either non-existent or have drawbacks that can hamper studies. This justifies studies that investigate new techniques of banding and attaching radio-transmitters that would improve on the methods currently used.

During the summers of 2009 and 2010, we conducted a study to evaluate the survival and habitat use of 4-week-old ring-necked pheasants (*Phasianus colchicus*) which were released from a device called a Surrogator® (hereafter, surrogator). The surrogator is a device used to introduce gamebird chicks into a chosen habitat to establish or supplement a population for hunting. The objectives of this study required that we suitably mark birds so that they were readily recognizable and to track a proportion of the released birds to gather post-release data.

Leg banding is a commonly used technique as it is a inexpensive, effective way to mark birds for studies. It is also considered a largely safe method for marking birds with few associated problems, except when improperly applied (Reed and Oring 1993, Gratto-Trevor 1994, Splittgerber and Clark 2005). Due to the nature of our study, we determined that leg bands would be an appropriate marker for our birds since they would be readily visible to hunters if any of the birds were harvested during the hunting season. In the past, it has been accepted that leg bands typically used for adults are inappropriate for precocial upland bird chicks due to differences in size between chicks and adults (Carver et al. 1999). Since the birds in our study were to be marked and released at 4 weeks of age, this was a concern. Acknowledging this, we sought methods to band birds that were suitable to meet both research objectives and cause minimal harm to the birds.

Data gathered from radiotracking can include mortality rates, movements, home range size, and habitat use. One of the problems with radio-tracking birds is how to attach the radiotransmitter to the bird without harming the bird or affecting its survival or behavior (Fuller et al. 2005). Radiotransmitters have been attached to birds by gluing to the back (Johnson et al. 1991), using harnesses (Nicholls and Warner 1968) and necklaces (Marcstrom 1989), suturing (Martin and Bider 1978, Burkepile et al. 2002), using subcutaneous prongs and sutures (Mauser and Jarvis 1991), and subcutaneous implantation (Gregg et al. 2007). Some of these techniques had significant issues that made them unsuitable to the nature of our study. Necklaces and harnesses require either adult birds to be used or they must be replaced as young birds grow. Implantation is a very invasive technique and must be conducted in a sterile environment and typically requires the supervision of a veterinarian. Suturing with prongs is less invasive than full implantation, but still requires the subcutaneous implantation of an anchor or prong. This left gluing and suturing as acceptable techniques for our study as they are minimally invasive and have been used with success in the past (Bowman et al. 2002, Burkepile 2002, Spears et al. 2002).

The purpose of this paper is to examine different techniques used to mark and attach radiotransmitters to 4-week-old pheasant chicks. We evaluated four banding techniques: # 6 aluminum butt-end leg bands, a colored plastic wrap-around band, #6 aluminum butt-end leg bands with a colored plastic wrap-around leg band used to prevent the band from slipping off, and cotton filled #6 aluminum butt-end leg bands. We investigated 2 techniques for attaching radiotransmitters: gluing transmitters to the back of the chicks and suturing transmitters to the chicks.

STUDY AREA

This study was conducted in Kiowa County located in south-central Kansas. In summer the average temperature is 25.6° C and in winter it is 1.2° C. The average rainfall for the area is 57.28 cm with most precipitation occurring from April to September (United States Department of Agriculture 1986). The northern third of the county, where this study was conducted, consists of sand hills (Latta 1948). The highest elevation in the county is 743 m and the lowest elevation is 592 m (Latta 1948). Cropland, woodland, and grassland are mixed throughout the county and trees can be found in windbreaks and along streams. Most of the land in the study area is composed of either cropland or rangeland. The principal crops of the county are wheat and sorghum (United States Department of Agriculture 1986). There were 26,551.4 ha of Conservation Reserve Program (CRP) land in the county as of October 2010 (United States Department of Agriculture 2010).

The study was conducted on 4 fields, 2 experimental fields (with Surrogators) and 2 control fields (without Surrogators). The mean size of the fields was 103 ha with fields ranging in size from 64 to 161 ha. Fields occur as close as 20 m to as far as 3.2 km from one another. All fields were enrolled in the Conservation Reserve Program and planted with CP2 (native grasses) plantings. In 2009, food plot strips were planted on the fields; however, these were not replanted in 2010. The fields had control burns performed on them previously, but not in recent years (J. Johnson, Wildlife Management Technologies, personal communication).

METHODS

Leg banding

In 2009, we initially banded chicks using aluminum butt-end leg bands (National Band and Tag Co., Newport, KY) without any modifications. The bands were opened, placed around the leg of the chick, and each end was closed using a pair of banding pliers. We banded each chick prior to release from the surrogator. We banded 13 birds using this technique.

In 2009, we also banded chicks with aluminum leg bands that were used in tandem with plastic wrap-around bands. We banded the bird with the aluminum leg bands as described above, followed by attachment of a colored plastic band between the aluminum band and the foot. We banded a total of 373 chicks using this technique. Additionally, we banded 257 chicks exclusively with the wrap-around plastic bands.

In 2010, we used leg bands with pieces of cotton glued to the inside of the band. To attach the cotton, we applied a small amount of Loctite® Super Glue (Henkel Corporation, Westlake, OH) to the inside of a band and then attached the cotton to the glue. One cotton ball could adequately fill 5–6 bands. Prior to use, we allowed the glue to dry for at least 3–4 hours, preferably overnight. All bands were checked to determine if the cotton was attached securely or if the band had been overfilled with cotton. All birds were banded similarly to our banding technique in 2009. If the band had too much cotton to allow the band to fit on a bird's leg, we removed small amounts until the band fit securely, but did not pinch the leg. The birds were then reintroduced into the surrogator overnight and released the next morning. We banded 352 birds in this manner.

Radio-transmitters

In 2009, we attached 2.05-g radio-transmitters (Holohil Systems Ltd., Carp, ON) to 84 pheasant chicks by several gluing techniques. All techniques initially involved moving feathers on the bird's back away to expose bare skin, applying glue to the back of a transmitter, and pressing the transmitter firmly onto the skin. The transmitter was then held in place for 3–5 minutes until the glue dried. We tested 3 types of adhesive: rubber cement [Elmer's Products Inc., Columbus, OH], Loctite® Super Gel [Henkel Corp., Westlake, OH), and Super Glue® [Super Glue Corp., Rancho Cucamonga, CA] for attachment directly to the chicks as well as the effectiveness of attaching the radio-transmitter to a piece of gauze that was glued to the back of chicks. We used rubber cement and Loctite® Super Gel for evaluating use of gauze to attach radio-transmitters.

In 2010, we attached radio-transmitters by suturing 58 birds following methods described by Burkepile et al. (2002). We used the same radio-transmitters as were used for testing the gluing except that the radio-transmitters had been retrofitted with eyeholes at each end. We attached a ratio-transmitter to a chick by inserting an 18 gauge hypodermic needle (PSS World Medical Inc., Jacksonville, FL) through the skin between the scapulae, perpendicular to the dorsal midline. The suture (3-0 chromic gut sutures, PSS World Medical Inc., Jacksonville, FL) was then fed through the tip of the needle to the other side. The needle was then withdrawn, leaving the suture in place. This process was repeated below the first suture using the transmitter for determination of appropriate placement. After both sutures were inserted, we tied the transmitter into place using two square knots for each suture. We then snipped loose ends and applied super glue to the knots for further hold.

We assigned recovered transmitters to several categories depending on the circumstances it was recovered in. Anytime the transmitter was found detached without evidence that the bird had died, it was considered an attachment failure. The failure rate is the percentage of birds whose transmitters were found without evidence of death and the bird had not otherwise been lost. When the transmitters remained attached until signs indicated that the radio-transmitter's batteries had died, they were considered to have lasted the life of the transmitter. When the bird was lost and could not be relocated for any number of reasons the fate of the bird was considered unknown.

RESULTS

Aluminum Leg Band Only

The plain aluminum bands typically did not stay attached to the birds. This technique was used soon after the study was initiated. Soon after we began banding chicks, we found many of the leg bands on the ground close to the release site, indicating that the bands had slipped off the legs. Upon this realization, we stopped using aluminum bands alone and switched to another technique. Of the birds released with this type of band, only 1 bird was recovered; the bird was killed after colliding with a vehicle shortly before hunting season.

Aluminum Leg Band With Plastic Wrap-Around Band

The second technique used in 2009 was banding with both an aluminum band and a colored plastic band. We did not observe any band losses from this technique; however, we encountered other issues. Immediately evident was a "jingling" sound made by the aluminum band colliding with the plastic band. In the weeks after release, we also observed several of the banded birds limping. Nearly all of the birds recovered showed signs that their leg had been severely constricted by the plastic band. The band recovery rate for this technique was 1.94 % ($n = 6$). One of the birds was harvested during the hunting season in 2010, and that bird also exhibited signs of constriction.

Plastic Wrap-Around Band Only

The third technique for 2009 was the use of plastic wrap-around bands only. The band recovery rate for these birds was 1.6% ($n = 5$). These birds all showed signs of constriction. The least severe case of constriction was a depression in the leg where the band was located, while in the most severe case, the tissue of the leg had grown around the band.

Cotton-Filled Aluminum Bands

Cotton-filled bands appeared to be retained by the birds with no apparent problems of constriction. Upon examination of recovered mortalities after release, we observed that the cotton had compressed such that the bands were relatively loose, but secure on the leg. The cotton also began to degrade and slowly fall from the band as the birds grew. Except for 2 cases, the cotton had either come completely out of the band or the band only contained negligible remnants of cotton in all harvested banded birds. In these 2 cases, the cotton had compressed to a solid mass that caused noticeable irritation to the skin of the leg, but the constriction issue that occurred with the plastic bands was not observed. A total of 52 banded pheasants were recovered during the hunting season for a recovery rate of 16.1%.

Gluing Transmitters

During 2009, we attempted to glue transmitters to 77 pheasant chicks. Anytime the transmitter was found detached without evidence that the bird had died, it was considered an attachment failure. The failure rate is the percentage of birds whose transmitters were found without evidence of death and the bird had not otherwise been lost. Rubber cement alone (*n* = 30) had a failure rate of 70 % (*n* = 21) and transmitters remained attached an average of 4.4 days (SE = 1.04). The longest amount of time a transmitter with this treatment remained attached was 19 days. Loctite® Super Gel alone (*n* = 19) had a failure rate of 100% and transmitters remained attached an average of 1.63 days (SE = 0.33). The longest amount of time a transmitter was attached using Loctite® Super Gel was 7 days. This longer time is likely due to a gap in the tracking periods where the birds were tracked the first couple of days post release, and then were not tracked again until 7 days post release. Super Glue® alone (*n* = 7) had a failure rate of 85 % (*n* = 6) and all remained attached 1 day. Rubber cement and gauze (*n* = 7) had a failure rate of 71 % (*n* = 5) and they remained attached for 1.2 days (SE = 0.2). The longest a transmitter remained attached for rubber cement and gauze was 2 days. Rubber cement, gauze, and Super Gel (*n* = 10) had a failure rate of 100% and all failed on the day of release. No birds were tracked for the life of the transmitter. Fate was unknown for 2 birds.

Suturing Radio-Transmitters

During 2010, we used the suture technique to attach radio-transmitters to 58 chicks. The sutures had a failure rate of 11.4% (n = 6). In these cases, the sutures lasted on average 5.3 weeks before failing and 4 of the sutures held for the life of the transmitters. While birds were not recaptured to allow for an examination of sutures, there did not seem to be any issues, such as infection or inflammation of the skin, related to the suturing with birds observed in the field or on recovered bodies of deceased chicks.

DISCUSSION

Leg Banding

The use of aluminum leg bands alone was not effective, as many of the bands slipped off immediately after release. The 1 band recovered just prior to the hunting season was the exception. The use of plastic wrap-around leg bands in this study was also not effective. As evidenced by the band constriction of the legs observed on harvested birds and the low band returns, it is possible that the plastic bands led to the death of many birds from causes such as infection or an increased susceptibility to predation. Carver et al. (1999) predicted band constriction of legs would occur as chicks grow because of the difference in the size of the tarso-metatarsus between chicks and adult birds. Another factor with the plastic leg bands that could have further decreased band return rates is that hunters that harvested any birds off site could not report the birds unless they were aware of the study. We attempted to remedy this issue by advertising around the town of Greensburg and talking to other groups of hunters encountered in the field. While this possibly biased our band return rates at a lower rate, it is unlikely that many more birds were harvested off site and not reported since we did observe a low return rate on monitored fields and the band constriction was observed on all harvested birds.

The cotton-filled leg bands worked well. Many more bands were returned over the course of the season with no signs of significant constriction of the chick's legs as seen with the plastic bands. The 2 cases of irritation that were observed were assumed to come from a relatively large amount of cotton remaining in the bands, however, the irritation appeared minor and did not seem to have affected the bird's overall condition, as they appeared to be of approximately the same size and health as other harvested birds. In all other cases, the cotton had either come out completely or a small remnant was left in the band. To our knowledge, this is a novel technique for upland gamebirds that shows promise for use in future studies with gamebird chicks.

Radio Transmitters

The two techniques to attach transmitters were used because of challenges presented by radio-marking chicks. These challenges included the quick growth of the birds at this stage in life, and the need to minimize possible handicapping from both the attachment process and of the transmitter itself. Pheasants grow at a rapid rate in the first weeks of life, often reaching full adult size in about 20 weeks (Johnsgard 1999). For this reason, static, constrictive methods of transmitter attachment, such as harnesses or necklaces, would have been inappropriate for use in the same way using snugly fitted bands would be inappropriate for chicks (Carver et al. 1999). Concerns with any telemetry technique are the stresses and effects upon the bird caused by handling and the attachment of radio-transmitters (Bro et al. 1999). These effects can range from acute capture myopathy to chronic sub-lethal effects (Guthery and Lusk 2004, Abbott et al. 2005). We attempted to lessen negative effects of transmitters first by the use of glue, and when that was ineffective, using sutures for attachment. Suturing is minimally invasive compared to other techniques such as prong and suturing (Mauser and Jarvis 1991) and implantation (Gregg et al. 2007). Implantation is by nature traumatic and has shown effects such as irritation of the wound, local necrosis, and migration of the transmitter around the body (Korschgen et al. 1996; J. J. Lusk, Nebraska Game and Parks Commision, unpublished report). We also used relatively light transmitters, which Venturato et al. (2009) showed could lessen negative effects of transmitters in a study using pheasant hens in Italy.

Gluing techniques were first used as they are among the least invasive attachment techniques and there were no concerns of binding or constriction. However, gluing transmitters to the chicks was largely a failure with nearly all the transmitters detaching within a couple of days of placement. This is in contrast to studies where it was used effectively. In a study conducted with passerines, Johnson et al. (1991) found comparatively long retention times for transmitters attached by glue to blue jays (*Cyanocitta cristata*) ($\bar{x}$ = 20 d), American robins (*Turdus migratorius*) ($\bar{x}$ = 19 d), and brown thrashers (*Toxostoma rufum*) ($\bar{x}$ = 16 d), although northern cardinals (*Cardinalis cardinalis*) ($\bar{x}$ = 5 d) had much shorter retention times. It was speculated that the short retention times for the cardinals were due to the strong bills of the species allowing the birds to pry off the transmitters. This is potentially important because pheasants are larger and stronger than these passerines and could possibly detach the transmitters in a manner similar to the cardinals. Bowman et al. (2002) and Spears et al. (2002) both found that gluing was an effective way to attach transmitters to wild turkey poults (*Meleagris gallopavo*) with transmitters remaining attached for 27.6 days and 20.4 days, respectively. The Bowman et al. (2002) study was conducted in pens and the Spears et al. (2002) study was conducted in a different region and with a species that would likely spend more time in less dense habitats than occurred in our study, which could have facilitated increased retention times in their study.

Several reasons could account for the failure of gluing in our study. The first is the chemical natures of the glues might have been inappropriate for this type of usage, as some glues are advertised to bind more effectively to specific substances. However, Superglue®, or chemically similar glues, have been used in many successful studies (Johnson 1991, Bowman et al. 2002, Spears et al. 2002). Second, the chicks are young when released and are quickly growing and molting. The increase in size of the bird could likely result in the transmitters detaching more rapidly, and while we attempted to glue to bare skin, feathers were occasionally entrapped in the glue. If the feather was molted or otherwise lost it might have affected the attachment of the transmitter by weakening the glue's bond to the bird. Lastly, the habitat that the chicks used was typically dense. With the birds constantly brushing against stiff grasses that may have pushed and pried the transmitter, the bond could have constantly been under strain eventually leading to failure.

Suturing is a more invasive than gluing, but it is still a comparatively benign technique compared to implantation or the addition of prongs to the transmitter. The suturing technique worked well during our study. While it was more difficult to perform, once perfected, it was completed in approximately the same amount of time required for the gluing technique. This technique has been performed on other species with positive results. We performed the procedure as described by Burkepile et al. (2002), where it was shown to be safe and effective over a period as long as 42 days with greater sage-grouse (*Centrocercus urophasianus*) chicks. Dahlgren et al. (2010) also used the technique for greater sage-grouse chicks and achieved similar results.

We did not have any deaths that could be attributed to handling or transmitter effects with either method. However, it is possible that they occurred. Given our methodology in tracking the birds, it was not always possible to determine if mortality was due to predation or from another source that had been subsequently scavenged. It is also possible that sub-lethal effects of transmitters went undocumented and may have contributed to the high mortality rate observed in our study, either by increasing the chick's susceptibility to predation or some other handicapping, such as muscular damage or increased energy expenditure (Guthery and Lusk 2004, Abbott et al. 2005, Barron et al. 2010).

MANAGEMENT IMPLICATIONS

Currently, it is rare for upland gamebird chicks to be banded at a young age. This is in contrast with waterfowl, in which the use of specialized plasticine-filled bands is common (Blums et al. 1999, Amundson and Arnold 2010). The ability to band gamebird chicks could potentially result in more accurate dispersal data when the birds are harvested in the future. It would also allow for identification of individuals in studies of chick survival. The use of cotton filled leg bands on pheasant chicks appears to be a safe, effective method of banding young birds.

Given the results of our study, gluing cannot be recommended as a method to attach transmitters to gamebird chicks. Though used successfully in other studies, in our study it largely failed, and in the studies where it did succeed, the reported retention rates of the transmitters were less than those found in our study using suturing (Bowman et al. 2002, Spears et al. 2002). The suturing method of radio-transmitter attachment was very effective. Suturing is simple and quick to accomplish when practiced, and can be performed in similar amounts of time compared to other current techniques. The high retention rates and long retention times make this technique superior to gluing and the low impact of the technique on the birds also make it preferable to techniques such as implantation or the addition of a prong to the transmitter. Suturing could be used to gain better understanding of movements after dispersal of gamebird juveniles. Currently, it is common to attach a transmitter to the female to facilitate brood monitoring or less commonly, to subcutaneously implant transmitters on chicks. While the former is adequate for some studies, researchers are often only able to speculate at the fate of the chicks. The latter is traumatic and much more damaging than simple suturing. Suturing is a safe, effective way to monitoring gamebird chick survival and movements using radio-transmitters.

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VITA

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Major Field: Natural Resource Ecology and Management

Scope and Method of Study: I studied the pre- and post-release survival and habitat use of ring-necked pheasant (*Phasianus colchicus*) chicks released from a device called a Surrogator® from late spring to fall of 2009 and 2010. To accomplish this I banded all released chicks for future identification and used radio-telemetry to track a proportion of the chicks as they dispersed from the units. During this time I also monitored invertebrate and predator abundances on both treatment and control fields. During the pheasant hunting seasons of 2009–2010 and 2010–2011 I surveyed hunters for demographic data, and for impressions of surrogator-reared pheasant from those who harvested banded birds. During hunts, I monitored hunters on treatment and control fields to determine hunter behavior and recorded any banded birds harvested.

Findings and Conclusions: In-surrogator survival was typically high with and average of 85% ± 5 and 79% ± 8 in 2009 and 2010 respectively. Post-release mortality rates was generally high, especially for the first 2-3 weeks. The mean survival rate to 12 weeks post-release was 0.18% ± 0.06. Pheasant habitat selection typically did not differ from randomly paired points, except for the selection of slightly more dense vegetation. Predator abundances did not seem to be effected by the presence of released chicks. Hunters that came to the study fields were typically male, middle age, and experienced. The hunters who harvested banded birds typically had a positive impression of them and considered them closely comparable to wild birds. Band return-rates were 2% in 2009–2010 and 16% in 2010–2011.

ADVISER'S APPROVAL: Craig A. Davis