1992

Survival and movements of pheasant chicks in northern Iowa on differing agricultural landscapes

Dean Edward Ewing

Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd

Part of the Agriculture Commons, Natural Resources and Conservation Commons, Population Biology Commons, and the Poultry or Avian Science Commons

Recommended Citation
https://lib.dr.iastate.edu/rtd/16828

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
Survival and movements of pheasant chicks in northern Iowa on differing agricultural landscapes

by

Dean Edward Ewing

A Thesis Submitted to the Graduate Faculty in Partial Fulfillment of the Requirements for the Degree of MASTER OF SCIENCE

Department: Animal Ecology
Major: Wildlife Biology

Iowa State University
Ames, Iowa
1992
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>ACKNOWLEDGEMENTS</th>
<th>vi</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENERAL INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Explanation of Thesis Format</td>
<td>2</td>
</tr>
<tr>
<td>SECTION 1. EVALUATION OF IMPLANTED RADIO TRANSMITTERS</td>
<td>3</td>
</tr>
<tr>
<td>IN 1-DAY-OLD PHEASANT CHICKS</td>
<td></td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>4</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>6</td>
</tr>
<tr>
<td>METHODS</td>
<td>8</td>
</tr>
<tr>
<td>RESULTS</td>
<td>12</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>16</td>
</tr>
<tr>
<td>LITERATURE CITED</td>
<td>19</td>
</tr>
<tr>
<td>SECTION 2. MOVEMENTS AND USE OF COVER TYPES</td>
<td>23</td>
</tr>
<tr>
<td>BY RING-NECKED PHEASANT CHICKS</td>
<td></td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>24</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>25</td>
</tr>
<tr>
<td>METHODS</td>
<td>28</td>
</tr>
<tr>
<td>Study Area</td>
<td>28</td>
</tr>
<tr>
<td>Radiotelemetry</td>
<td>28</td>
</tr>
<tr>
<td>Time Periods</td>
<td>30</td>
</tr>
<tr>
<td>Nesting Cover</td>
<td>30</td>
</tr>
<tr>
<td>Use of Cover</td>
<td>30</td>
</tr>
<tr>
<td>Movements and Home Range</td>
<td>31</td>
</tr>
<tr>
<td>RESULTS</td>
<td>33</td>
</tr>
<tr>
<td>Nesting Cover</td>
<td>33</td>
</tr>
<tr>
<td>Use of Cover</td>
<td>34</td>
</tr>
<tr>
<td>Movements and Home Range</td>
<td>36</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>43</td>
</tr>
<tr>
<td>LITERATURE CITED</td>
<td>46</td>
</tr>
</tbody>
</table>
SECTION 3. SURVIVAL OF PHEASANT CHICKS IN NORTHERN IOWA ........................................ 48

ABSTRACT .............................................................................................................. 49

INTRODUCTION ..................................................................................................... 51

METHODS ............................................................................................................ 55
  Study Area ........................................................................................................ 55
  Radiotelemetry .................................................................................................. 55
  Weather ............................................................................................................. 57
  August Roadside Surveys .................................................................................. 58
  Estimation of Survival ....................................................................................... 58
    Product-Limit Estimates ................................................................................ 58
    Proportional Hazards ..................................................................................... 59

RESULTS ................................................................................................................ 61
  Nesting/Hatching ............................................................................................... 62
  Weather .............................................................................................................. 62
  August Roadside Surveys .................................................................................. 63
  Causes of Mortality ............................................................................................ 64
  Survival .............................................................................................................. 66
    Product-Limit Estimates ................................................................................ 66
    Proportional Hazards ..................................................................................... 66

DISCUSSION ........................................................................................................... 71

LITERATURE CITED ............................................................................................. 75

SUMMARY .............................................................................................................. 79

ADDITIONAL LITERATURE CITED ..................................................................... 81
LIST OF TABLES

SECTION 2

TABLE 1. Pheasant brood movements (m) during 3 time periods on Kossuth and Palo Alto study areas, northern Iowa, 1990-91 .................... 38

TABLE 2. Pheasant brood movements (m) relative to age during 3 time periods, northern Iowa, 1990-91 ........................................ 40
LIST OF FIGURES

SECTION 1
FIGURE 1. Growth of game-farm pheasant chicks implanted with radio transmitters (n = 17) compared with a control (n = 17), May-June, 1990 ............. 14

FIGURE 2. Growth of game-farm pheasant chicks in a control (n = 20) compared among groups treated by radio-transmitter implant only (n = 18), anesthetic only (n = 20), and radio-transmitter implant and anesthetic (n = 18), May-June, 1990 ............. 15

SECTION 2
FIGURE 1. Comparison of cover types on Kossuth and Palo Alto study areas, northern Iowa, 1990-1991 ........................................... 35

FIGURE 2. Box plots of the average daily linear distance moved by pheasant broods relative to age on Kossuth and Palo Alto study areas, northern Iowa, 1990-1991. The bottom and top edges of each box are located at the sample 25th and 75th percentiles, respectively. The center horizontal line is the sample median and the central plus (+) is the sample mean ......................... 41

SECTION 3
FIGURE 1. Kaplan-Meier survival estimates of pheasant chicks from hatch to 4 weeks of age on Kossuth and Palo Alto study areas, northern Iowa, 1990 .......................... 67

FIGURE 2. Kaplan-Meier survival estimates of pheasant chicks from hatch to 4 weeks of age on Kossuth and Palo Alto study areas, northern Iowa, 1991 ........................................ 68

FIGURE 3. Kaplan-Meier survival estimates of pheasant chicks from hatch to 4 weeks of age during 1990 and 1991 on 2 study areas in northern Iowa .... 69
I thank my co-advisors, Dr. Paul Vohs and Dr. William Clark, for their hard work, encouragement, support, and guidance.

I thank Anjeanette Perkins for her friendship, listening ear, assistance with field work and statistical analysis, and for braving 'Iowa's black desert' with me for over 14 months.

I commend the Iowa Department of Natural Resources and the Iowa Cooperative Fish and Wildlife Research Unit for their full support. Thanks to Dr. Terry Riley for support, encouragement, and enthusiasm.

This project could not have been completed without the hard work of several technicians. I acknowledge Bob Barta, Terry Dvorak, Bruce Fistler, Al Hancock, and Dave Hoffman.

I am indebted to my family for their total support, love, and encouragement. Thanks to Dad, Mom, Dan, Sue, Sheila, and Sheryl. I couldn't ask for a more wonderful family.

I especially thank my best friend and wife, Mary, for her love, encouragement, and for kindly urging me to finish my analysis. The dreams of our honeymoon and summer traveling, camping, and rafting out West encouraged me daily.

Finally, I thank a loving God who has provided me with peace amidst life's storms, joy despite daily struggles and defeats, and hope for tomorrow.
GENERAL INTRODUCTION

Agricultural technology and public policies have resulted in intensive land use throughout the midwestern U.S.A. Implementation of intensive farming practices has resulted in removal of fences, wetlands, groves, and odd areas and has created large monoculture fields. These landscape changes combined with "average" or worse winters have caused drastic declines in pheasant (Phasianus colchicus) populations in central Iowa (Farris et al. 1977).

Warner (1979) suggested that high mortality of pheasant chicks may be limiting pheasant populations. Hill and Robertson (1988) reported that most chick mortality occurred during the first 10-12 days after hatch.

Meyers et al. (1988) attempted to study chick survival using radioed hens raised in captivity and released to nest and raise broods. Excessive human disturbance occurred when accurate counts of chicks per brood were obtained. Mixing of broods further complicated their efforts. Recent technology provided microminiature transmitters capable of being implanted in day-old chicks and offered promise as a technique to determine chick survival of wild pheasants.

My initial effort was to document the effect of implantation on feather pecking and other behavior, growth, and development. Implantation was used in field studies of
wild chicks to: (1) determine the movements and home ranges of pheasant broods in 2 areas with differing agricultural landscapes, (2) define cover utilized by broods on these 2 landscapes, (3) relate movements and cover types to the proportion of available cover, (4) describe intrabrood dynamics such as brood mixing, chick movement in relation to parental hen movement, and predator-related movements, (5) estimate survival of chicks to 4 weeks of age, and (6) quantify causes of chick mortality.

Explanation of Thesis Format

The 3 manuscripts were organized and written under guidelines specified by the Iowa State University Graduate College for the alternate thesis format. A general introduction and a summary with cited references are provided to complete the thesis document. The manuscripts follow the guidelines for The Journal of Wildlife Management (Ratti and Ratti 1988) to facilitate submission to that journal. Authorship of the manuscripts is anticipated to be as follows:

Section I. Dean E. Ewing, William R. Clark, Paul A. Vohs.
Section II. Dean E. Ewing, Paul A. Vohs, William R. Clark, Terry Z. Riley.
Section III. Dean E. Ewing, William R. Clark, Paul A. Vohs, Terry Z. Riley.
SECTION 1. EVALUATION OF IMPLANTED RADIO TRANSMITTERS IN 1-DAY-OLD PHEASANT CHICKS
ABSTRACT

I studied game-farm pheasant (Phasianus colchicus) chicks implanted with microminiature transmitters to determine if surgery and implantation affected growth, behavior, or survival. Transmitters (1.2 g, 18 x 9 x 5 mm) were implanted subcutaneously in the interscapular region of the spinal tract in day-old chicks ($\bar{x} = 16.3$ g). The 14-cm whip antenna attached to the transmitter protruded from the mid-back region. Two experiments were conducted on pheasant chicks. The data on effects of a transmitter implant in Experiment 1 were compared to data derived from a control. In Experiment 2, the effects of anesthesia only, anesthesia and implant, and implant only were compared with a control. Chicks in Experiment 1 were weighed at intervals through 3 weeks; chicks in Experiment 2 were weighed at intervals through 4 weeks. Pecking behavior for both experiments was observed during 5-min periods twice each day for the first 10 days after hatch. Survival was calculated through 4 weeks of age. No significant differences in weight were found with repeated-measures ANOVA ($n = 34$, $P = 0.34$) between a group implanted only with transmitters vs. the control in Experiment 1. In Experiment 2, there were overall differences in weight of radio-implanted chicks with and without anesthesia, anesthesia only, and controls ($n = 76$, $P = 0.02$). The control chicks
were heavier ($P < 0.05$) at ages 9, 11, 14, and 21 days. There was no significant difference in weight among treatments at 28 days ($P = 0.07$). Implants had no effect on survival or on pecking rates of chicks among treatments in either experiment. I failed to reject the hypotheses that surgery and implantation had no effect on growth, behavior, or survival of pheasant chicks.
INTRODUCTION

Radiotelemetry has been used to study bird behavior, habitat use, and survival (Kenward 1987). Most researchers have assumed that attached transmitters do not adversely affect survival, growth, or behavior. However, transmitter effects have been evaluated primarily on mammals and birds >25 g using transmitters weighing >2 g (Sykes et al. 1990), and adverse effects have been found. For example, visibility and weight of the transmitter and method of attachment influenced behavior (Greenwood and Sargeant 1973, Perry 1981) and survival (Small and Rusch 1985, Marks and Marks 1987, Marcström et al. 1989) of some species. Means of attachment on birds include adhesive and velcro (Graber and Wunderle 1966, Raim 1978, Kålås et al. 1989, Sykes et al. 1990), harness (Sykes et al. 1990), and external suturing (Martin and Bider 1978, Mauser and Jarvis 1991). Effects of external attachments on bird behavior and survival were variable, depending on species.

Implantation offers potential advantages in studies where externally attached transmitters are inappropriate (Korschgen et al. 1984). Transmitters have been implanted in small rodents with no apparent adverse effects (Smith 1980, Wolff and Hurlbutt 1982, FitzGerald and Madison 1983, McShea and Madison 1984, Madison et al. 1985). Abdominal implants in
wild birds showed no adverse effects (Southwick 1973, Korschgen et al. 1984).

I used survival, pecking, and growth rates of pheasant chicks in different treatment groups to evaluate the hypotheses that surgery, anesthesia, and implantation would not adversely affect survival, behavior, or growth. This report documents the effects of implanting 1-day-old game-farm pheasant chicks with microminiature transmitters and describes a technique of implantation that minimizes feather pecking, abnormal behavior, growth, and development. The radio-implantation technique was approved by the Committee on Animal Care at Iowa State University and met recommendations of the American Ornithologists Union (AOU 1988).

I acknowledge A. L. Perkins for assistance in the collection of growth and behavior data. T. Z. Riley coordinated the project for the Iowa Department of Natural Resources (IDNR) and provided advice. W. R. Clark and P. A. Vohs wrote the original proposal to IDNR and provided guidance, statistical advice, editorial assistance. Funding was provided by IDNR and the Iowa Cooperative Fish and Wildlife Research Unit.
METHODS

Pheasant chicks less than 24 hours of age were obtained from Murray McMurray Hatchery, Webster City, Iowa\(^1\). Transmitter implants (18 x 9 x 5 mm) weighed 1.2 g, had a life expectancy of 40 days (Holohil Systems, Ltd., Woodlawn, Ont., Canada\(^1\)), and averaged 7.4% of each bird's body weight at implantation. A 14-cm extruding whip antenna (0.55-mm diameter nylon coated stainless steel stranded wire) was selected instead of an internal coiled antenna because the former provided an additional 400-450 m of reception. Both active and dummy transmitters were surgically implanted in chicks for the experiments.

Surgical equipment and transmitters were cold sterilized in aqueous benzalkonium chloride (Zephiran). Chicks were laid on a flat, electric heating pad during surgery to minimize heat loss. Down on the neck was moistened with Zephiran to expose the narrow cervical region (cervical apterium) that extends from head to trunk. The skin was lifted with fine-tip forceps prior to incision to avoid piercing muscles, arteries, and veins. An 8-mm incision using a surgical scalpel was made in the cervical apterium extending ventrally from the leading edge of the dorsal feather tract. A 2-mm diameter, blunt, stainless steel probe was inserted to disjoin the loose

\(^1\) Mention of the name does not constitute endorsement.
fibroelastic connective tissue (subcutaneous connective tissue or superficial facia). A space was created extending from the incision to the mid-back region via the dorsal midline. A hollow stainless steel tube (ID of 1.5 mm, OD of 2.0 mm) was inserted beneath the skin to facilitate threading the antenna to the rear of the cavity. The distal end of the needle-tipped tube was pushed through the skin near the mid-back point of exit. The antenna was threaded through the tube, and the tube was removed through the antenna exit site. The transmitter was pulled gently into position completely posterior to the incision in the interscapular region of the spinal tract, thus avoiding pressure on the incision. The incision was closed with a mattress stitch using 4-0 polyglycolic acid suture.

I compared the effects of no anesthesia with methoxyflurane on game-farm pheasant chicks. Methoxyflurane is considered to be the safest volatile agent for induction of anesthesia in birds (Green 1979, Mandelker 1987). Chicks to be anesthetized with methoxyflurane were placed in a 1-1 glass jar containing 0.1 ml of methoxyflurane on a cottonball attached to the side. A glass lid was placed on the jar until the chicks reached the stages of deep narcosis or light anesthesia. In these stages chicks exhibited (1) little to no response to sound; (2) minimal fluttering or occasional shrill cries when provoked by a painful stimuli; (3) rapid, deep, and
regular respiration that often became irregular following stimulation; (4) the presence of normal reflexes (palpebral, corneal, cere, pedal), but a lack of voluntary movement; and (5) no response to vibration or postural change (Arnall 1961).

I conducted preliminary trials with methoxyflurane on both domestic chicken (Gallus gallus) chicks (n = 5) and game-farm pheasant chicks (n = 5) to estimate an optimal induction time. Chicks were given anesthesia until respiratory arrest. Because domestic chicks were heavier at hatch than pheasant chicks, I hypothesized that domestic chicks would tolerate greater dosages of methoxyflurane than pheasant chicks.

Some treatment groups in the 2 main experiments received no anesthetic because young birds are relatively insensitive to pain (AOU 1988), particularly subcutaneous incisions (Green 1979). Sex of chicks was ignored because rates of development during the first few weeks are unrelated to sex (Thomas and Bailey 1973).

I followed the diet and floor space recommendations of Thomas and Bailey (1973) and Cain et al. (1984) to assure normal behavior and growth of pheasant chicks. Feather pecking is a normal behavior in pheasant chicks and not entirely related to intraspecific competition (Hoffmeyer 1969). Therefore, feather pecking experiments were conducted to determine if this behavior increased due to transmitter implant or external antennae.
Two experiments were conducted. Chicks in Experiment 1 were weighed at days 1, 3, 5, 7, 9, 16, and 23. Chicks in Experiment 2 were weighed at days 1, 3, 5, 7, 9, 11, 14, 21, and 28. Pecking behavior was observed during 5-min periods twice each day for the first 10 days of life at approximately 0800 and 1800. Survival was calculated through 4 weeks of age. In Experiment 1, I compared growth, behavior, and survival of a treatment group implanted with a transmitter without anesthesia (n = 17) vs. a control group (n = 17). In Experiment 2, I compared a control group (n = 20) with 3 treatments: anesthesia and implant (n = 18), implant only (n = 18), and anesthesia only (n = 20). The pattern and relative measure of variation in growth between the treatments and control were examined.

Transmitters were implanted, chicks were placed in an indoor pen for 2 weeks, and were moved to an outdoor pen for the final 2 weeks. Chick densities in the indoor pen were 0.24 chicks/m² for Experiment 1 and 0.12 chicks/m² for Experiment 2. Densities in the outdoor pen were 2.06 chicks/m² for the first experiment and 0.92 chicks/m² for the second. Chicks were fed grower diets containing 22% protein and a metabolizable energy level of 2970 kcal/kg (Cain et al. 1984). The feed contained no antibiotics.
RESULTS

All surgeries were successful, and all chicks survived to the end of the experiments. During preliminary trials, game-farm pheasant chicks easily overdosed and died when induced with methoxyflurane for over 5 min, while domestic chicken chicks did not. The domestic chicks weighed more ($\bar{x} = 34.6$ g) than the pheasant chicks ($\bar{x} = 17.3$ g). Optimal induction time was estimated to be approximately 30 sec for pheasant chicks.

Pheasant chicks receiving methoxyflurane during the 2 main experiments averaged an overall induction time of 30 sec (range = 20-60 sec). All anesthetized chicks were alert within 5 min post anesthesia. Chicks anesthetized and implanted with transmitters were also alert within 5 min post surgery but did not obtain normal pedal reflexes for 1-2 hours. However, after 1-2 hours chicks experienced no apparent adverse behavioral or physiological effects. Chicks not receiving an anesthetic were alert and obtained normal pedal reflexes within 5 min post surgery.

In my experiments, approximately 10% of the chicks began to eject or had ejected their transmitters by 4 weeks. However, there were no significant signs of infection on any chicks. The sites of ejected transmitters exhibited dry skin and skin sloughing prior to transmitter loss.

I found no significant differences in weight with
repeated measures ANOVA between implanted and control groups (Fig. 1) \((F = 0.92, 1,32 \text{ df}, P = 0.34)\) in Experiment 1. Chicks pecked at the head, tail, and wing regions of others, but rarely pecked at transmitter antennae. No significant difference was detected between pecks received and pecks given between implanted and control groups \((\chi^2 = 0.040, 1 \text{ df}, P = 0.84)\).

In Experiment 2, the control group gained weight faster than the treatment groups based on the overall ANOVA (Fig. 2) \((F = 3.62, 3,72 \text{ df}, P = 0.02)\). Significant differences occurred at days 9 \((F = 4.10, P = 0.01)\), 11 \((F = 3.12, 3,72 \text{ df}, P = 0.03)\), 14 \((F = 3.76, P = 0.01)\) and 21 \((F = 3.62, P = 0.02)\). However, there was no significant difference in weight at 28 days \((F = 2.43, P = 0.07)\). There was no significant difference in pecks received or pecks given between the control and treatment groups \((\chi^2 = 3.29, 3 \text{ df}, P = 0.35)\).

No differences in the pattern of variation between treatments and control were detected in either experiment. In Experiment 1, the coefficient of variation (CV) increased from an average of 7.8% at day 1 to 15.1% at day 23. The CV in Experiment 2 increased from an average of 10.8% at day 1 to 13.3% at day 28. Variability among chicks within treatments increased with time in both experiments.
FIG. 1. Growth of game-farm pheasant chicks implanted with radio transmitters (n = 17) compared with a control (n = 17), May–June, 1990.
FIG. 2. Growth of game-farm pheasant chicks in a control (n = 20) compared among groups treated by radio-transmitter implant only (n = 18), anesthetic only (n = 20), and radio-transmitter implant and anesthetic (n = 18), May–June, 1990.
DISCUSSION

Methoxyflurane is rapidly absorbed by fatty tissues, is slowly released into venous blood, and prolongs induction and recovery periods (Byles and Dobkin 1971). Therefore, methoxyflurane may have greater limitations when used on birds with a smaller body size. Methoxyflurane was effective when administered less than 60 sec per chick. Methoxyflurane is useful as an anesthetic on chicks that will remain in captivity.

Unanesthetized birds show minimal evidence of pain during insertion (AOU 1988), and use of an anesthetic prolongs the period between removal from and return to the wild and parental care. With experience, surgery can be conducted on an unanesthetized chick in less than 5 min, and the chick is ready for immediate release. Thus, quick release of wild chicks to the parental hen is best accomplished without anesthetic.

Implanted transmitters in the backs of birds have caused skin to rupture and infection to occur in some species (AOU 1988). In my experiments, approximately 10% of the chicks began to eject or had ejected their implant by 4 weeks of age. Ejection of implants can be reduced by suturing the surgical site and the antenna exit site tightly to prevent air from entering beneath the skin and causing drying. The use of an
implant potted in Elvax paraffin might lessen the number of ejections as Elvax contains a chemical ingredient that prevents the immune system from forming a cyst around the implanted transmitter (Madison et al. 1985). A means of anchoring the transmitter at the fore end (Mauser and Jarvis 1991) might reduce the ejection rate.

Final weights of chicks in all treatment groups did not differ significantly from the control. In Experiment 1, control and implant-only groups added weight at the same rate. In Experiment 2, chicks in the control group reached slightly greater weights than the treatment groups at days 9-21. However, the final weights of chicks at 28 days was not different between the control and treatments in Experiment 2. This result could be due to catch-up growth among treated chicks that grew slower initially. More likely, it was due to the increasing variance in weights. This variation influenced our ability to detect treatment differences, especially toward the end of the experiments.

Pecking is a normal behavior in pheasant chicks (Hoffmeyer 1969). Pecking rates were not different between control group and treatments in either experiment. Chicks did not peck at the surgical site or at the external antenna. Chicks containing a transmitter pecked at other chicks at the same rate as the controls. This suggests that implanted chicks expressed and received normal pecking behavior and
experienced no change in social dominance.

I accepted my original hypotheses that surgery and implantation did not adversely affect weight gain, behavior, or survival of pheasant chicks. It is possible that chicks implanted with transmitters and returned to the wild could be disadvantaged initially by their lower weights. However, treated chicks in captivity ultimately reached similar body weights as controls and exhibited no abnormal behavior. Despite some problems with transmitter ejection and the prolonged recovery required by anesthetized birds, induction and surgical trauma caused no immediate problems. Implantation of a radio transmitter in day-old pheasant chicks was simple and effective. Treated animals grew and behaved similarly to controls. Ejection was minimal, and no chicks died. Therefore, the technique was judged feasible for field studies. I successfully used the implantation technique without anesthesia in assessing post-hatch mortality in the field (Ewing 1992).
LITERATURE CITED


Green, C. J. 1979. Animal anesthesia. Laboratory Animal


bands. J. Wildl. Manage. 53:808-810.


SECTION 2. MOVEMENTS AND USE OF COVER TYPES BY RING-NECKED PHEASANT CHICKS
ABSTRACT

I describe movements and cover use of pheasant (Phasianus colchicus) broods from hatch to 28 days of age on 2 study areas of differing agricultural landscapes. Transmitters were implanted in 133 day-old pheasant chicks during 1990-1991. Chicks were monitored daily from hatch to 4 weeks of age. Grasses/hay comprised 25.6% of the cover of the Palo Alto Study Area (PSA) but only 9.5% on the Kossuth Study Area (KSA). Row crops comprised 85.0% of the cover on KSA but only 54.6% on PSA. Brome, alfalfa, and brome/alfalfa mixes were the dominant vegetation at 84.8% of the nests of broods containing chicks implanted with radio transmitters. No differences in the distances moved by broods were detected between study areas. Broods tended to move greater distances as they grew older, however, there was large variation among broods. Immediately following a mammalian attack that killed at least 1 radioed chick in each brood, 22 hens moved their broods <200 m, 7 hens moved their broods 201-399 m, and 5 hens moved their broods 400-1000 m. Four chicks left parental hens and joined other broods. Although grasses/hay comprised only 9.5% of the cover on KSA, chicks were located in grasses/hay 65.5% of the time in 1990 and 100% in 1991. On PSA, grasses/hay comprised 25.6% of the cover, but 95.1% of the locations in 1990 and 93.0% in 1991 were in this cover type.
INTRODUCTION

Brood movements and cover usage are important to understanding brood survival and population dynamics. Warner (1979) suggested that high mortality of pheasant chicks may be limiting to pheasant populations. Poor chick survival has been implicated in dramatic declines in gray partridge (*Perdix perdix*) populations (Potts 1986).

Results of home-range studies of pheasant broods during the first 2 weeks after hatch differ due to differences in cropland diversity and landscape heterogeneity. For example, a brood's home range at 10 days of life has been estimated at 4.8 ha in Britain (Hill and Robertson 1988), 5-10 ha in Illinois (Warner 1979), and 2-4 ha (Kuck et al. 1970) and 11 ha (Hanson and Progulske 1973) in South Dakota. When food is abundant, broods have been known to spend the entire summer within a 20.2-ha area (Weigand and Janson 1976). Warner (1984) noted that broods hatched in a monoculture system moved greater distances and ranged over larger areas during the first 4 weeks posthatch than broods that hatched in diverse crop systems.

Pheasant brood habitat during the first 4 weeks of life has been described (Warner 1979, 1984, Meyers et al. 1988) and centers on small grains, hay, and grasses. Warner (1979) found hay and oats covered only 6.4% of his study area in
Illinois, yet contained approximately 50% of the locations for chicks under 4 weeks of age. Meyers et al. (1988) postulated that unharvested grain fields in Polk County, Oregon provided broods with efficient travel and escape routes. Warner (1984) reported the oats-hay complex to be attractive to chicks due to ease of movement and an abundance of insects.

Brood movement and habitat use have been examined by radio-marking hens, however, sample sizes have been small (Warner 1979). No studies on brood movements and cover usage have involved radioing day-old chicks. However, recent technology has created microminiature transmitters for implanting of radios in chicks (Ewing 1992).

My objectives were to (1) determine movements and home ranges of day-old to 4-week old pheasant broods in 2 areas with differing agricultural landscapes; (2) identify the type of cover utilized by broods on these 2 landscapes; (3) relate movements and cover types to the proportion of available habitat; and (4) describe intrabrood dynamics such as brood mixing, chick movement in relation to parental hen movement, and predator-caused movements.

I acknowledge R. M. Barta, T. J. Dvorak, B. A. Fistler, A. W. Hancock, D. D. Hoffman, R. J. Munkel, and A. L. Perkins for the collection of field data. B. A. Behl, T. R. Bishop, T. J. Dvorak, and P. A. Vohs assisted with the Map and Image Processing System. T. Z. Riley coordinated the project for
the Iowa Department of Natural Resources (IDNR) and provided advice. W. R. Clark and P. A. Vohs wrote the original proposal to IDNR and provided statistical advice, discussion, and editorial assistance. Funding was provided by IDNR and the Iowa Cooperative Fish and Wildlife Research Unit.
METHODS

Study Areas

Parameters related to pheasant chicks were evaluated on 2 study areas in northern Iowa. The Palo Alto study area (PSA) was a 124.3-km² site located on the common border of Palo Alto and Clay counties in northwestern Iowa. Physiography varied from nearly level farmland to rolling hills. Permanent cover was present on tracts of idle ground planted primarily in brome and on 2 state-owned wetland complexes. Row crops were primarily corn and soybeans. The Kossuth study area (KSA) was a 93.2-km² site located in Kossuth County, 8.0 km west of Buffalo Center, northcentral Iowa. Physiography was nearly level. The predominant land use was row-cropping (corn and soybeans). No state-owned property occurred on the study area. August roadside counts during 1990 and 1991 indicated greater pheasant hen and brood numbers on PSA than KSA (Ewing 1992).

Radiotelemetry

Hens were fitted with radio transmitters during winter and monitored through spring (Perkins 1992). Nests were marked at a distance with flagging when hen's radio signal
projected steadily from the nest site for 3-5 consecutive days. Hens were monitored daily during incubation, several times daily as hatch date approached, and every 2 hours during hatch until the hen moved from the nest. The clutch was assumed to be hatching when the hen's radio signal fluctuated in intensity. Hens were flushed from their broods near the nest site within 24 hours after hatch. A tape-recording of a hen's brood-gathering call (Heinz 1973) was played 30-60 sec after flushing until 3 chicks were caught. Response to the brood-gathering call was immediate, and the desired 3 chicks were usually caught within 5 min.

Captured chicks were transported to the field station, weighed, and implanted with a microminiature transmitter (Ewing 1992). Surgery lasted <5 min per chick, and chicks were usually returned to the hen within 30 min of capture.

Vehicle-mounted and hand-held antenna-receiver systems were used to locate hens and chicks by triangulation. Radio locations of the hen were assumed to represent that of her chicks if the chicks' coordinates were within the error polygon of the hen. A chick found a notable distance from the hen was located separately.
Time Periods

Chicks were located daily during 4 time periods for 4 weeks to relate movements to time of day (Warner 1979). Time periods used were: (1) morning (sunset - 3 hours after sunrise), (2) midday (5 hours after sunrise - 8 hours after sunrise), (3) evening (4 hours before sunset - sunset), and (4) night (1 hour after sunset - 1 hour before sunrise). Sunrise and sunset times were based on Central Standard Time.

Nesting Cover

After hatch, data on dominant plant species, field size, and habitat type (i.e., idle field, fenceline, road ditch) were recorded. State-owned land, Conservation Reserve Program, and Annual Conservation Reserve lands were included as idle fields. Field size determination was subjective because fields were often separated by a ditch, fenceline, creek, or road, and these borders were usually not barriers to the broods. Interconnecting fields also complicated field size determination.

Use of Cover

Cover types on both study areas and radio locations per
cover type were analyzed using the Map and Image Processing System (MIPS) version 2.9 (MicroImages, Inc., Lincoln, Neb.). Cover types were defined as (1) row crops (corn, soybeans, and sorghum), (2) grasses/hay (oats, grasses, hay, and alfalfa), (3) woody vegetation (shrubs and shelterbelts), (4) edge/strip (roadside, ditches, and railroad), (5) wetland/water, and (6) other (farmstead, school, cemetery, and unclassified). Grasses, oats, hay, and alfalfa were grouped into 1 cover type because of similarity in vegetative structure and growth phenology (Warner 1979). The percentage of cover types on PSA and KSA were averaged across years because each cover type differed by <1% between years.

The number of locations per brood per week was usually <25. The small number of weekly locations was not adequate to accurately calculate home range by week, therefore, a brood's locations were pooled for the first 4 weeks of life or until the last radioed chick in that brood died prior to the completion of 4 weeks of life.

Movements and Home Range

Mobility of broods was measured as the linear distance between the roost and a daytime location. Analysis of variance (ANOVA) (SAS Inst., Inc. 1985a) was used to test for changes in mobility between years, study areas, and age of
chicks by time period. A linear regression was used to
determine the relationship between distance and age. Box
plots were used to show the variation in distances moved
relative to years and study areas (SAS Inst., Inc. 1985b:351).

Home ranges were calculated using the harmonic mean
method (Dixon and Chapman 1980) and MIPS. Sample-size
criteria required isopleths surrounding 80% of sets of ≥25
random, independent points. Home ranges were compared between
years, study areas, and relative to brood age using ANOVA.
RESULTS

Radio transmitters were implanted during 1990-91 in 133 day-old pheasant chicks representing 47 broods. Forty-eight chicks from 16 broods were radio-implanted on PSA in 1990, and 57 chicks from 19 broods were radio-implanted in 1991. Nineteen chicks from 7 broods were radio-implanted on KSA in 1990, and 9 chicks from 3 broods were radio-implanted in 1991. Transmitters were implanted into 3 chicks per brood, except 2 broods on KSA in 1990 where only 2 chicks per brood were implanted with radios due to capture difficulties. All chicks were <24 hours of age when radio-implanted.

Nesting Cover

Hens with radio-implanted chicks located 76.1% (n = 39) of their nests in idle fields. Nest locations of 15.2% of the hens (n = 7, 3 on KSA, 4 on PSA) were in road ditches or along railroads. Idle fields containing nests from which radio-implanted chicks hatched ranged in size from 4.0-69.7 ha (n = 6) on KSA during 1990, 9.7-68.7 ha (n = 14) on PSA during 1990, and 1.0-68.7 ha (n = 17) on PSA during 1991. Two nests on KSA during 1991 were in a 69.7-ha idle field. However, 75.0% of nests (n = 8) on KSA and 80.6% of nests (n = 31) on PSA were located in idle fields >20 ha. Brome, alfalfa, and
brome/alfalfa mixes constituted the dominant vegetation at 84.8% of nests of hens with radio-implanted chicks. There was no significant differences between 1990 and 1991 in the proportion of nests located in brome and/or alfalfa and those located in all other plant species combined on KSA ($\chi^2 = 2.50$, 1 df, $P = 0.11$) nor on PSA ($\chi^2 = 0.06$, 1 df, $P = 0.81$).

Use of Cover

Grasses/hay comprised 25.6% of the cover on PSA but only 9.5% on KSA, while row crops consisted of 85% of the cover on KSA but only 54.6% on PSA (Fig. 1). Wetlands were found on 13.6% of PSA but <1.0% on KSA. Over 80% of the cover on both study areas existed in 2 cover types: row crops and grasses/hay. The percentage of row crops on PSA was 30.4% less than KSA, but 27.7% of this difference was explained by PSA having 15.1% more grasses/hay and 12.6% more wetland/water. KSA contained only 4 grasses/hay fields >20 ha while PSA, which is 33% larger than KSA, contained 20 grasses/hay fields >20 ha including 8 fields 70-100 ha and 3 fields >100 ha.

Broods on KSA were located 65.8% in grasses/hay and 34.1% in row crops during 1990 ($n = 511$ locations) and 100% in grasses/hay during 1991 ($n = 77$ locations). On PSA, 95.1% and 93.0% of the locations were in grasses/hay during 1990 ($n$
Row crops comprised only 4.4% of the locations in 1990 and 7.7% in 1991 on PSA. Locations of 3 broods during 1990 and 3 broods during 1991 on PSA were exclusively in grasses/hay. These 6 broods were never recorded near any other cover type. They spent all 4 weeks in the center of large (>20 ha) idle grasslands. Although row crops appeared to be an important component used by broods on KSA during 1990, much variability existed among broods. For example, 2 broods on KSA during 1990 were located over 50% of the time in row crops while all locations of a third brood were in grasses/hay. In total, row crops were used by broods <10% of the time on KSA during 1991 and PSA during 1990 and 1991, and broods were found predominantly in grasses/hay regardless of age. I did not relate movements to cover types or use of cover types relative to chick age, because of the predominant use of the grasses/hay cover type.

Movements and Home Range

All broods stayed within 100 m of the nest location for at least the first 2 days of life. After 2 days of life, the distance a brood was from its nest varied from 5 m to over 1000 m. Chicks appeared to stay within 5 m of the hen when moving, and most chicks stayed with the parental hen for all 4
weeks of observation. However, 1 radio-implanted chick from each of 4 separate broods left the parental hen and joined another brood.

There were no significant differences in home ranges of chicks between 1990 (n = 19, $\bar{x} = 58.68$ ha, SE = 21.50 ha) and 1991 (n = 16, $\bar{x} = 19.90$ ha, SE = 4.61 ha, $F = 0.43$, 1,22 df, $P = 0.52$) or between KSA (n = 9, $\bar{x} = 52.49$ ha, SE = 33.04 ha) and PSA (n = 26, $\bar{x} = 38.38$ ha, SE = 12.59 ha, $F = 0.04$, 1,22 df, $P = 0.84$). No differences in home range were detected ($F = 0.07$, 3,22 df, $P = 0.97$) between broods at age 1 (n = 2, $\bar{x} = 8.23$ ha, SE = 5.38), age 2 (n = 10, $\bar{x} = 23.67$ ha, SE = 6.56), age 3 (n = 10, $\bar{x} = 30.61$ ha, SE = 9.68), and age 4 weeks (n = 11, $\bar{x} = 75.83$ ha, SE = 36.05).

During 1990, there were no significant study area differences in brood movements during morning ($F = 0.04$, 1,21 df, $P = 0.85$), midday ($F = 0.12$, 1,20 df, $P = 0.73$), and evening time periods ($F = 2.64$, 1,21 df, $P = 0.12$)(Table 1). Only distances of chicks through 3 weeks of age were used to test study area differences for 1991, because no radio-implanted chicks on KSA lived to week 4 during 1991. No study area differences in 1991 were detected during morning ($F = 0.11$, 1,21 df, $P = 0.74$) or evening time periods ($F = 1.82$, 1,20 df, $P = 0.19$), but broods on KSA moved significantly greater distances than broods on PSA ($F = 11.69$, 1,20 df, $P < 0.01$) during the midday time period. However, differences
Table 1. Pheasant brood movements (m) during 3 time periods on Kossuth and Palo Alto study areas, northern Iowa, 1990-91.

<table>
<thead>
<tr>
<th></th>
<th>KSA</th>
<th></th>
<th>PSA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>x</td>
<td>SE</td>
<td>n</td>
</tr>
<tr>
<td>1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morning</td>
<td>118</td>
<td>104.45</td>
<td>10.44</td>
<td>224</td>
</tr>
<tr>
<td>midday</td>
<td>119</td>
<td>167.59</td>
<td>19.00</td>
<td>209</td>
</tr>
<tr>
<td>evening</td>
<td>123</td>
<td>143.85</td>
<td>15.13</td>
<td>203</td>
</tr>
<tr>
<td>1991</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morning</td>
<td>27</td>
<td>88.17</td>
<td>14.02</td>
<td>168</td>
</tr>
<tr>
<td>midday</td>
<td>26</td>
<td>183.83</td>
<td>26.59</td>
<td>159</td>
</tr>
<tr>
<td>evening</td>
<td>26</td>
<td>185.32</td>
<td>25.46</td>
<td>154</td>
</tr>
</tbody>
</table>
between study areas during 1991 may be incorrect due to a sample size of 3 broods on KSA that year.

During 1990, older broods usually moved greater linear distances than younger broods during morning ($F = 3.47, 3,313$ df, $P = 0.02$), midday ($F = 8.80, 3,300$ df, $P < 0.01$), and evening ($F = 3.60, 3,300$ df, $P = 0.01$) time periods (Table 2). Age differences across study areas were not estimated during 1991 because of the small sample size on KSA. Age differences on PSA during 1991, revealed no significant differences during the morning period ($F = 0.14, 3,164$ df, $P = 0.94$). However, differences were detected during the midday ($F = 4.37, 3,155$ df, $P < 0.01$) and evening ($F = 6.92, 3,150$ df, $P < 0.01$) time periods.

The average daily linear distances moved by broods relative to age were highly variable (Fig. 2), and age was not a good predictor of the distance moved ($r^2 = 0.03$) when years and study areas were combined. For example, during 1990 on PSA, the average daily linear distance ranged from 0.4-769.3 m at age 1, 2.1-977.3 m at age 2, 1.6-1033.8 m at age 3, and 10.6-1094.0 m at age 4 weeks. Similarly, during 1990 on KSA, linear distances ranged from 2.1-844.5 m at age 1, 8.9-608.4 m at age 2, 9.1-589.1 m at age 3, and 21.6-1505 m at age 4. The mean daily movement on PSA during 1990 increased from age 1 to age 4 by 94.8 m, but the median increased only by 39.3 m. Similarly, on KSA, the mean daily movement during 1990
Table 2. Pheasant brood movements (m) relative to age during 3 time periods, northern Iowa, 1990-91.

<table>
<thead>
<tr>
<th>AGE</th>
<th>1 WEEK</th>
<th>2 WEEKS</th>
<th>3 WEEKS</th>
<th>4 WEEKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>$\bar{x}$</td>
<td>SE</td>
<td>n</td>
</tr>
<tr>
<td>1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morning</td>
<td>111</td>
<td>94.28</td>
<td>10.59</td>
<td>102</td>
</tr>
<tr>
<td>midday</td>
<td>109</td>
<td>144.33</td>
<td>11.75</td>
<td>97</td>
</tr>
<tr>
<td>evening</td>
<td>108</td>
<td>161.33</td>
<td>16.03</td>
<td>99</td>
</tr>
<tr>
<td>1991</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>morning</td>
<td>109</td>
<td>87.91</td>
<td>12.23</td>
<td>50</td>
</tr>
<tr>
<td>midday</td>
<td>101</td>
<td>127.04</td>
<td>8.55</td>
<td>49</td>
</tr>
<tr>
<td>evening</td>
<td>100</td>
<td>128.89</td>
<td>8.97</td>
<td>50</td>
</tr>
</tbody>
</table>
FIG. 2. Box plots of the average daily linear distance moved by pheasant broods relative to age on Kossuth and Palo Alto study areas, northern Iowa, 1990-1991. The bottom and top edges of each box are located at the sample 25th and 75th percentiles, respectively. The center horizontal line is the sample median and the central plus (+) is the sample mean.
increased from age 1 to age 4 by 149.5 m, but the median increased only by 43.7 m. However, during 1991, the variation in daily linear distances relative to age was less than in 1990 (Fig. 2). During 1991, the increase of the mean daily movement differed by <12 m from the median from age 1 week to age 4 weeks for both study areas.

 Movements of individual broods within sites were more variable in 1990 than 1991, particularly on PSA (Table 1). During 1990, there was a significant contribution to overall variability by movements of broods within sites during morning ($F = 2.05, 21,313$ df, $P < 0.01$), midday ($F = 2.31, 20,300$ df, $P < 0.01$), and evening ($F = 3.51, 18,300$ df, $P = 0.01$). However, during 1991, brood movements did not contribute significantly to overall variability within sites during morning ($F = 1.26, 21,167$ df, $P = 0.21$), midday ($F = 1.34, 20,158$ df, $P = 0.16$), and evening ($F = 1.21, 20,153$ df, $P = 0.25$) time periods.

 Immediately following a mammalian attack that killed at least 1 radioed chick in each brood, 22 hens moved their broods <200 m, 7 hens moved their broods 201-399 m, and 5 hens moved their broods 400-1000 m. Two hens moving 400-1000 m stayed within the same idle grassland, and 3 of 5 left their idle field, crossed at least 1 road during the movement, and entered another idle grassland.
DISCUSSION

Capture of chicks was simple and efficient. Implantation of transmitters was successful, and release of chicks was routine. The technique of implantation proved uncomplicated and effective for field studies. However, I encountered difficulty in capturing adequate numbers of chicks on KSA because of low hen numbers, particularly following a low overwinter survival of hens during 1990-91 (Perkins 1992).

Most hens nested in large (>20 ha) idle fields of grasses/hay and placed nests in vegetation composed of brome, alfalfa, or a mix of brome and alfalfa.

Grasses/hay was the most used cover type on both areas. Several broods on both study areas were located exclusively in grasses/hay during the 4 weeks of observation. Chicks on KSA were found in grasses more often during 1991 than 1990, but sample sizes were small both years. With the exception of 2 broods on KSA during 1990, grasses/hay was the primary cover type used by all broods during the first 4 weeks of life. I was unable to determine why 2 broods on KSA in 1990 chose to use row crops extensively.

Despite higher pheasant densities and more grasses/hay cover on PSA, movements did not differ between study areas. Pheasant broods on KSA used idle fields similar to that on PSA and avoided the monoculture crop system typical of KSA.
Broods on both study areas seldom moved out of non-contiguous idle grasslands. Basically, a grass field on KSA appeared to serve the same purpose as a grass field on PSA, even though there was less grasses/hay cover and less pheasants on KSA.

The mean home range size of broods increased with age, however, the standard deviation also increased so no significant differences were detected in homerange relative to age. Larger sample sizes might have increased my ability to detect differences. I was unable to relate hen age to brood homerrange size and movements because the age of most hens was unknown.

The movements of chicks on PSA and KSA were similar for all 3 daytime periods. During 1990, chicks increased their daily movements as they grew older. However the median daily movement remained relatively constant from age 1-4 weeks. During 1991, few birds on both areas survived behind 2 weeks after hatch (Ewing 1992), so a trend in movements relative to age was not detected. Overall, age was not a good predictor of distances moved because of large variability between broods on both study areas and a small sample size on KSA during 1991. Mammal attacks probably influenced the movement of some broods. Thus, predator-caused movements may have increased some of the variability found between broods. Warner (1979) found that the weekly range of broods in Illinois grew exponentially from 1 to 9 weeks of age. The variation in
brood movements within both study areas and the shorter
duration (4 weeks) in this study made it difficult to
determine a trend in movement relative to age.

Overall, the abundance of large idle grasslands dominated
by brome and alfalfa appeared essential for nesting and brood
rearing. There were not conclusive differences in brood
movements between study areas. This may be because chicks on
both areas were marked in idle grasslands, lived, and died
there. Movements by broods were highly variable and not
directly related to age. This variability could not be
explained by landscape characteristics. Future research might
benefit from relating brood movements to hen age, predator
abundance, insect abundance, and microhabitat characteristics.
LITERATURE CITED


SECTION 3. SURVIVAL OF PHEASANT CHICKS IN NORTHERN IOWA
ABSTRACT

I implanted transmitters in 133 day-old pheasant (Phasianus colchicus) chicks during 1990-91 on 2 areas in northern Iowa and calculated survival to 4 weeks of age. Survival of pheasant chicks on the Kossuth Study Area was 0.54 (SE = 0.14) in 1990 and 0.30 (SE = 0.18) in 1991, and 0.52 (SE = 0.08) in 1990 and 0.24 (SE = 0.07) in 1991 on Palo Alto Study Area. Differences were not detected between study areas, but when study areas were pooled, there was a significant difference between survival to 4 weeks in 1990 ($\hat{S} = 0.52$, SE = 0.07) and 1991 ($\hat{S} = 0.21$, SE = 0.07). Mammalian predation and exposure accounted for 98.6% of chick mortalities. Fox, mink, and weasel were the primary mammalian predators. Seven chicks died of exposure on days when at least a trace of rainfall fell, and 4 of 7 died on days of heavy rainfall ($\bar{X} = 0.96$ cm, range = 0.68-3.38 cm). A Cox's proportional hazards model was used to determine if rate of survival was related to 8 continuous or discrete covariates including study area, age of the hen, brood size at hatch, chick weight at capture, average daily linear distance moved, specific brood number, percentage of a brood's locations in row crops, and the percentage of a brood's locations in grasses/hay. None of the covariates met the most stringent entrance and removal criteria of $P < 0.10$ and $P > 0.10$. I
concluded that circumstances related to deaths were too variable to successfully model the hazard.
INTRODUCTION

Since the 1950's, new agricultural technology and public policies resulted in more intensive land use with associated losses of pheasant habitat. The general result was reduced pheasant numbers over much of the midwestern U.S.A. (Etter et al. 1988). For example, in Iowa, August roadside counts of pheasants declined from 41.1 pheasants per 10 miles in 1958 to 10.1 pheasants per 10 miles in 1975 in the cash grain region, an area considered prime pheasant range in the early 1940's and mid-1950's to mid-1960's (Farris et al. 1977).

Warner (1979) suggested that high mortality of pheasant chicks might limit pheasant population growth. Poor chick survival was implicated in dramatic declines in gray partridge (Perdix perdix) populations (Potts 1986). Hill and Robertson (1988) found most pheasant chick mortality occurred during the first 10-12 days after hatch. Errington and Hamerstrom (1937) estimated brood mortality between hatch and 2 weeks of age at 25% and nearly 50% by 9 weeks. Predation, accidents, disease, hail storms, heavy rains, or losses due to scattering were often cited as important mortality factors for pheasant chicks (Farris et al. 1977, Hill and Robertson 1988), but little data existed to support such theories.

Estimates of survival have been based on: (1) changes in brood size associated with marked adults (Baskett 1947, Hill
and Robertson 1988), (2) roadside and field counts of unmarked broods at various times throughout the summer (Baskett 1941, Kozicky 1951, Wagner et al. 1965, Gates and Hale 1975), and (3) comparison of mean brood size at 6 weeks of age to the average number of young that hatch per nest (Errington and Hamerstrom 1937). The first 2 methods depend on the assumption of equal sightability at each resampling time, and can be substantially biased by weather, habitat, and bird age. Baskett (1947) noted that chicks less than 3 weeks of age relied on concealment rather than flight when disturbed. Meyers et al. (1988) attempted to determine habitat use and brood survival relationships, but encountered difficulty in obtaining accurate counts of chicks. They defined a brood as alive if at least 1 chick was alive per brood and estimated brood survival because they could not get reliable estimates of survival of chicks. Estimates based on mean size of broods at 6 weeks of age failed to account for lost broods. Furthermore, none of the methods enabled the researchers to study cause-specific mortality. Additionally, mixing and combining of broods further biased estimates of mean brood size (Errington and Hamerstrom 1937, Baskett 1941, Meyers et al. 1988).

August roadside counts are used in Iowa to index annual productivity and relative abundance of pheasant numbers including the numbers of hens with broods and chicks per brood.
(Suchy et al. 1991). The counts by the Iowa Department of Natural Resources (IDNR) are conducted during the first 15 days of August each year and follow methods described by Klonglan (1955). Each count is conducted on a 30-mile transect. I obtained data from IDNR August roadside counts made during 1990 and 1991 on KSA and PSA to compare with survival estimates of radio-implanted chicks. However, roadside counts are biased because they fail to account for brood combining and brood mixing. These phenomena occur in pheasant chicks less than 4 weeks of age (Ewing 1992) and more noticeably and perhaps more frequently in chicks 8 weeks of age and older (Errington and Hamerstrom 1937, Baskett 1941, Meyers et al. 1988).

Recent technology allowed creation of microminiature transmitters attachable to birds <20 g body weight. I recommended implanting microminiature transmitters in 1-day-old pheasant chicks to obtain accurate and precise estimates of chick survival (Ewing 1992). Telemetry allows cause-specific mortality factors to be determined and data to be collected on an animal's movements before death (Clark et al. 1989, White and Garrott 1990).

I estimated survival of pheasant chicks from hatch to 4 weeks of age on 2 study areas within differing agricultural landscapes. Causes of chick mortality were determined, and relationships to movements, habitat use, and population
variables were analyzed. I used August roadside surveys of pheasants gathered by the IDNR to compare survey results to survival of radio-implanted chicks.

I acknowledge R. M. Barta, T. J. Dvorak, B. A. Fistler, A. W. Hancock, D. D. Hoffman, R. J. Munkel, and A. L. Perkins for the collection of field data. T. Z. Riley coordinated the project for IDNR and provided advice. W. R. Clark and P. A. Vohs wrote the original proposal to IDNR and provided statistical advice, discussion, and editorial assistance. Funding was provided by IDNR and the Iowa Cooperative Fish and Wildlife Research Unit.
METHODS

Study Areas

Survival and movements of pheasant chicks were evaluated in northern Iowa. The Palo Alto study area (PSA) was a 124.3-km² site located on the common border of Palo Alto and Clay counties in northwestern Iowa. Physiography varied from nearly level farmland to rolling hills. Permanent cover was present on tracts of idle ground planted primarily in brome and on 2 state-owned wetland complexes. Row crops were primarily corn and soybeans. The Kossuth study area (KSA) was a 93.2-km² site located in Kossuth County, 8.0 km west of Buffalo Center, northcentral Iowa. Physiography was nearly level. The predominant land use was row-crop agriculture (corn and soybeans). No state-owned property occurred on the study area.

Radiotelemetry

Transmitters were attached to hens during autumn and winter, and hens were monitored through spring (Perkins 1992). Nests of radioed hens were marked at a distance with flagging when the hen's radio signal transmitted steadily from the nest site for 3-5 consecutive days. Hens were monitored daily
during incubation, several times daily as hatch date approached, and every 2 hours during hatch until the hen left the nest. The clutch was assumed to be hatching when the radio signal fluctuated in intensity. Hens were flushed from their brood near the nest site within 24 hours after hatch. A tape-recording of a hen's brood-gathering call (Heinz 1973) was played 30-60 sec after flushing until 3 chicks were caught. Response to the brood-gathering call was immediate, and the desired 3 chicks were usually caught within 5 min.

Captured chicks were transported to the field station, weighed, and implanted with a microminiature transmitter (Ewing 1992). Surgery lasted <5 min per chick, and chicks were usually returned to the hen within 30 min of capture. Clutch size, number of hatched eggs, date of hatch, and age of the chicks at capture were recorded after hatch.

Chicks were monitored daily from day of hatch to 4 weeks of age. Vehicle-mounted and hand-held antenna-receiver systems were used to locate chicks by triangulation. A chick was assumed alive if its signal projected from the same location as the parental hen and was fluctuating in intensity indicating movement. A chick was approached with a hand-held antenna-receiver system if the chick's signal projected steadily and not from the direction of the hen. Chick mortalities were investigated within 24 hours of death. Cause of death was determined from field necropsy, predator tracks,
and other signs near the carcass when possible. Sources of predation were distinguished by fecal deposits, tracks, den signs, and other characteristics (Einarsen 1956, Murie 1974) found near a chick's transmitter and carcass. However, the predator species could not be determined in all cases because of lack of species-specific signs left at the mortality site.

A chick was censored if the transmitter failed, was lost or found without evidence of a mortality, or a chick survived past the fourth week (Pollock et al. 1989). The censor date was designated as the midpoint between the last radio location and the first date the chick was not located.

Weather

Temperature and rainfall data were obtained from climatological data compiled by the National Oceanic and Atmospheric Administration. I used temperature and rainfall data gathered at Emmetsburg, Iowa, as representative of PSA and data gathered at Swea City, Iowa, as representative of KSA. The Emmetsburg weather station is located approximately 16 km southeast of PSA, and the Swea City weather station is located approximately 16 km west of KSA. Differences in the daily minimum temperature for May and June were analyzed using analysis of variance (ANOVA) (SAS Inst., Inc. 1985). Daily rainfall was compared with daily minimum temperature on the
day and the preceding day that a chick was determined to have died from exposure.

August Roadside Surveys

Six roadside surveys were conducted on KSA and 7 on PSA during the first 15 days of August each year. ANOVA was used to test for differences in the number of hens with broods and chicks per brood between years and study areas.

Estimation of Survival

**Product-Limit Estimates.**—Kaplan-Meier (KM) product-limit estimates and survival distributions (Kaplan and Meier 1958) were calculated to estimate survival probability to age after hatch using procedure LIFETEST (SAS Inst., Inc. 1985:529-557). I used logrank tests (Cox and Oakes 1984) to test for differences in survival rates between study areas and years. The sample size on KSA in 1991 was small, and the percentage of censoring was large. \( \hat{S} \) went to 0.00 when the last radioed chick died. Therefore an adjusted final survival rate defined by Lawless (1982:84-88) as,

\[
\frac{[\hat{S}(t_j) + \hat{S}(t_j + 0)]}{2}
\]
was used to give a more reasonable estimate of the survival function. The variance and standard error (SE) of the adjusted \( \hat{S} \) were hand-calculated (Cox and Oakes 1984:51).

**Proportional Hazards.**—The Kaplan-Meier method of calculating survival assumes independent survival among chicks. Therefore, mortality was assumed independent for all individuals, even though 3 chicks per brood were marked. More than 1 chick per brood was radioed because of the additional information provided (i.e. losses within broods). I tested the assumption of chick independence by assigning each brood a number and entering that covariate into the Cox proportional hazards model.

A Cox's proportional hazards linear model was used to determine if rate of survival was related to 1 or more continuous or discrete covariates. Cox regression was done on BMDP, P2L (Hopkins 1990). Covariates with a positive coefficient increased instantaneous mortality, and those with negative coefficients decreased instantaneous mortality. The magnitude of a coefficient indicated the relative effect the covariate had on survival (Sievert and Keith 1985).

I stratified the 'year' covariate because 1990 and 1991 were not proportional. The covariate 'average linear distance moved' was not treated as time varying because distances were not significantly related to age (Ewing 1992). I included 8 covariates in the model procedure: study area (KSA and PSA),
age of the hen (adult, juvenile, or unknown), brood size at hatch, chick weight at capture (g), average daily linear distance moved (m), specific brood number, percentage of a brood's locations in row crops, and the percentage of a brood's locations in grasses/hay. A forward stepwise procedure was used to enter and remove covariates from the model. During the first run, covariates were entered and removed from the model at $P < 0.25$ and $P > 0.30$, respectively. All 8 covariates were used in a second run where I attempted to refine the model building process and use more stringent entrance and removal criteria of $P < 0.10$ and $P > 0.10$. 
RESULTS

Forty-eight chicks from 16 broods were radio-implanted on PSA in 1990, and 57 chicks from 19 broods were radio-implanted in 1991. Nineteen chicks from 7 broods and 9 chicks from 3 broods were radio-implanted on KSA in 1990 and 1991, respectively. Two broods on KSA in 1990 had only 2 chicks per brood radio-implanted due to failure to capture a third chick. All chicks were ≤24 hours of age when radio-implanted. Weights of day-old radio-implanted chicks on KSA (n = 28, \( \bar{x} = 18.28 \) g, SE = 0.38) were significantly greater (F = 10.59, 1,135 df, P = 0.001) than those on PSA (n = 111, \( \bar{x} = 16.97 \) g, SE = 0.24), but no significant year differences (F = 3.41, 1,135 df, P = 0.07) were detected.

Censoring occurred primarily due to radio failure or transmitter ejection. Ejected transmitters (n = 12, \( \bar{x} = 13.33 \) days, SE = 1.28) usually had at least 0.5 cm\(^2\) of dried skin attached. Transmitters from mammalian-killed chicks had no large sections (≥0.5 cm\(^2\)) of dried skin attached. Ejection was not always identifiable but occurred in at least 10-15% of all radioed chicks. Excluding individuals surviving through the fourth week, censoring occurred in 34.6% of the radioed chicks; 42.1% on KSA in 1990, 37.5% on KSA in 1991, 44.4% on PSA in 1990, and 28.1% on PSA in 1991.
Nesting/Hatching

The median hatch date with study areas combined was similar for both years: 20 June 1990 and 21 June 1991. First broods were marked with radio-implanted chicks on 28 May 1990 and 3 June 1991 on PSA and 7 June 1990 and 6 June 1991 on KSA.

Clutch sizes did not differ between 1990 ($n = 24$, $\bar{x} = 11.50$ eggs, SE = 0.49), and 1991 ($n = 21$, $\bar{x} = 12.47$ eggs, SE = 0.44, $F = 1.29$, 1,41 df, $p = 0.26$) or between KSA ($n = 9$, $\bar{x} = 11.00$ eggs, SE = 0.87) and PSA ($n = 36$, $\bar{x} = 12.19$ eggs, SE = 0.35, $F = 0.05$, 1,41 df, $p = 0.82$). No difference was detected between number of hatched chicks/nest of radio-implanted broods between 1990 ($n = 24$, $\bar{x} = 10.50$ chicks, SE = 0.52) and 1991 ($n = 21$, $\bar{x} = 11.28$ chicks, SE = 0.52, $F = 1.65$, 1,41 df, $p = 0.21$) or between KSA ($n = 9$, $\bar{x} = 10.11$ chicks, SE = 0.89) and PSA ($n = 36$, $\bar{x} = 11.06$ chicks, SE = 0.41, $F = 0.06$, 1,41 df, $p = 0.81$).

Weather

No significant differences were detected between the minimum May temperature on KSA ($n = 31$, $\bar{x} = 10.17$ C, SE = 1.00) and PSA ($n = 31$, $\bar{x} = 10.02$ C, SE = 1.00, $F = 0.03$, 1,120 df, $p = 0.87$), or the minimum June temperature on KSA ($n = 30$, $\bar{x} = 16.78$ C, SE = 0.73) and PSA ($n = 30$, $\bar{x} = 16.75$ C, SE = 0.73).
However, the minimum May temperature was significantly colder in 1990 ($n = 31, \bar{x} = 7.88\,^\circ C, SE = 0.69$) than in 1991 ($n = 31, \bar{x} = 12.31\,^\circ C, SE = 1.10, F = 22.76, 1,120\, df, p < 0.01$). Also, the minimum June temperature was significantly colder in 1990 ($n = 30, \bar{x} = 15.94\,^\circ C, SE = 0.81$) than in 1991 ($n = 30, \bar{x} = 17.60\,^\circ C, SE = 0.61, F = 5.18, 1,116\, df, p = 0.02$).

Six chicks died of exposure on PSA in 1990 and 1 on PSA in 1991. Four of the 7 chicks died during heavy rain ($\bar{x} = 0.96\, cm$, range = 0.68-3.38 cm). The remaining 3 chicks died on days when a trace of rainfall was recorded and the minimum daily temperature was below the monthly average minimum temperature ($n = 3, \bar{x} = 15.37\, ^\circ C$, range = 14.44-16.11 $^\circ C$).

August Roadside Surveys

The number of hens seen with a brood was not significantly different between 1990 ($n = 13, \bar{x} = 8.15$ hens/transect, SE = 2.13) and 1991 ($n = 13, \bar{x} = 7.08$ hens/transect, SE = 1.67, $F = 0.50, 1,22\, df, p = 0.49$).

However, significantly more hens were observed with broods ($F = 67.84, 1,22\, df, p < 0.001$) on PSA ($n = 14, \bar{x} = 12.93$ hens/transect, SE = 1.23) than on KSA ($n = 12, \bar{x} = 1.42$ hens/transect, SE = 0.36). There was no significant difference in the number of chicks observed ($F = 0.00, 1,22$
df, $P = 0.94$) between 1990 ($n = 13$, $\bar{x} = 45.07$ chicks/transect, $SE = 13.17$) and 1991 ($n = 13$, $\bar{x} = 43.92$ chicks/transect, $SE = 9.60$) for both areas combined. But significantly more chicks ($F = 53.44$, $1,22$ df, $P < 0.001$) were seen on PSA ($n = 14$, $\bar{x} = 75.50$ chicks/transect, $SE = 8.01$) than KSA ($n = 12$, $\bar{x} = 8.33$ chicks/transect, $SE = 2.15$). Similarly, there was no significant difference ($F = 0.23$, $1,22$ df, $P = 0.63$) between the number of broods seen during 1990 ($n = 13$, $\bar{x} = 9.85$ broods/transect, $SE = 2.34$) and 1991 ($n = 13$, $\bar{x} = 10.46$ broods/transect, $SE = 2.18$), but significantly more broods ($F = 128.20$, $1,22$ df, $P = 0.001$) were seen on PSA ($n = 14$, $\bar{x} = 16.86$ broods/transect, $SE = 1.06$) than KSA ($n = 12$, $\bar{x} = 2.33$ broods/transect, $SE = 0.48$). The chick/brood ratio was not significantly different ($F = 0.63$, $1,22$ df, $P = 0.44$) between 1990 ($n = 13$, $\bar{x} = 3.66$ chicks/brood/transect, $SE = 0.49$) and 1991 ($n = 13$, $\bar{x} = 3.98$ chicks/brood/transect, $SE = 0.24$). The ratio was significantly different ($F = 6.19$, $1,22$ df, $P = 0.02$) between KSA ($n = 12$, $\bar{x} = 3.17$ chicks/brood/transect, $SE = 0.46$) and PSA ($n = 14$, $\bar{x} = 4.38$ chicks/brood/transect, $SE = 0.23$).

Causes of Mortality

Mammalian predation accounted for 88.6% of all known mortalities ($n = 70$) and 100% of known mortalities on KSA ($n =$
12) during 1990 and 1991. On PSA, mammalian predation accounted for 94.6% of known mortalities (n = 37) in 1991. However, in 1990, mammalian predation accounted for only 71.4% of the mortalities on PSA (n = 21), and exposure accounted for the remaining 28.6%. The relative proportion of mortalities due to mammalian predation on PSA in 1991 was significantly greater than in 1990 ($\chi^2 = 6.05, 1$ df, $P = 0.01$). Exposure accounted for 10.0% of all known mortalities on PSA for both years were combined. All chicks that died of exposure (n = 7) were <5 days of age. Thus, mammalian predation and exposure accounted for 98.6% of all known mortalities on the 2 study areas. In 1990, 100% of the known mortalities on PSA occurred during the first 14 days. This was significantly greater (likelihood $\chi^2 = 4.76, 1$ df, $P = 0.03$) than 1991 when only 86.5% of chicks on PSA died within 14 days after hatch. There was no documentation of mortalities from disease or avian predation.

Fox, mink, and weasels were the primary predators of pheasant chicks. Fox usually killed only 1 radio-implanted chick at a time, while mink and weasels often killed >1 chick at a time. All 3 radioed chicks were killed by a mammal in 10 of 45 broods. Of these, 4 broods lost all 3 radioed chicks in 1 day, and 4 broods lost 2 of 3 radioed chicks in 1 day. A hen was not found with any remaining chicks on 4 occasions in which all radioed chicks in a brood were killed by a mammal.
Nine transmitters were dug from mink and weasel dens, and on 1 occasion, 9 chicks, including 3 radioed chicks from the brood, were killed by a weasel and found together. Radio-implanted chicks killed by a weasel or mink were found dead with more than 2 nonradio-marked chicks on 7 occasions.

Survival

**Product-Limit Estimates.**—I radioed 133 chicks during the 2-year study. The survival estimate of pheasant chicks to 4 weeks for the summer of 1990 on KSA ($n = 19$) was 0.54 (SE = 0.14). This was not significantly different ($\chi^2 = 0.39$, 1 df, $P = 0.53$) than the survival estimate during 1990 on PSA ($n = 48$, $\hat{S} = 0.52$, SE = 0.08)(Fig. 1). During 1991, the survival estimate for chicks on KSA ($n = 9$) went to 0.00. However, the final adjusted survival on KSA was 0.30 (SE = 0.18). This was not significantly different ($\chi^2 = 0.16$, 1 df, $P = 0.68$) than the survival estimate on PSA ($n = 57$, $\hat{S} = 0.24$, SE = 0.07)(Fig. 2). When survival estimates on the study areas were pooled within years, there was a significant difference between 1990 ($\hat{S} = 0.52$, SE = 0.07) and 1991 ($\hat{S} = 0.21$, SE = 0.07, $\chi^2 = 5.27$, 1 df, $P = 0.02$)(Fig. 3).

**Proportional Hazards.**—During the first run of the Cox model, I used all 8 covariates with entrance and removal criteria of $P < 0.25$ and $P > 0.30$, respectively. Two of the 8
FIG. 1. Kaplan-Meier survival estimates of pheasant chicks from hatch to 4 weeks of age on Kossuth and Palo Alto study areas, northern Iowa, 1990.
FIG. 3. Kaplan-Meier survival estimates of pheasant chicks from hatch to 4 weeks of age during 1990 and 1991 on 2 study areas in northern Iowa.
covariates met the criteria for the first run. These covariates were average daily linear distance ($\chi^2 = 1.93, 1$ df, $P = 0.17$) and the percentage of the bird's locations in row crops ($\chi^2 = 3.82, 2$ df, $P = 0.15$). The negative coefficient value for average daily linear distance ($\hat{\beta} = -0.0048$, SE[$\hat{\beta}$] = 0.0036) indicated that greater distances moved by chicks had a negative influence on the hazard. The positive coefficient value for the percentage of the bird's locations in row crops ($\hat{\beta} = 0.0108$, SE[$\hat{\beta}$] = 0.0081) indicated that greater percentages of locations in row crops had a positive influence on the hazard. A chick's chance of survival decreased as it used row crops more, however, as a chick increased the average daily linear distance moved its chance of survival increased.

All 8 covariates were used in a second model building process in which more stringent entrance and removal criteria of $P < 0.10$ and $P > 0.10$ were used. However, none of the following covariates met the entrance criteria and were therefore not related to the hazard: study area ($P = 0.27$), hen age ($P = 0.54$), brood size at hatch ($P = 0.99$), chick weight at capture ($P = 0.80$), average daily linear distance moved ($P = 0.17$), specific brood number ($P = 0.82$), the percentage of brood's locations in row crops ($P = 0.15$), and the percentage of brood's locations in grasses/hay ($P = 0.22$).
DISCUSSION

Transmitter implantation was simple and effective. Application of the technique provided an unbiased method of determining chick losses and sources of mortality. However, I encountered difficulty in capturing adequate numbers of chicks on KSA because of low hen numbers, particularly following a low overwinter survival of hens during 1990-91 (Perkins 1992).

Nesting information did not explain the differences in survival between 1990 and 1991. The median hatch date in 1990 differed from 1991 by only 1 day. Also, the clutch and hatch sizes were not different between years or study areas.

The weather in summer 1990 was colder and wetter than 1991 and may have influenced the proportion of mortality in 1990 that was due to exposure. However, 1991 had a lower survival rate.

August roadside surveys revealed far fewer hens with broods, total chicks, and total broods seen on KSA than PSA. Fewer chicks/brood were seen on KSA than PSA, however, the difference was not as significant as the first 3 categories listed above. Those 3 categories (hens with broods, total chicks, and total broods) suggest differences in the population levels between the 2 study areas. The last category (chicks/brood) is more consistent with the survival results showing a lack of difference between KSA and PSA.
Additionally, the greater chick per brood ratio found on PSA may not indicate greater chick survival. Rather, greater pheasant densities on PSA may result in more brood mixing and brood combining. The yearly differences in roadside counts were not consistent with the survival results from this study. In fact, only the number of chicks per transect is in the correct direction (1990 > 1991). The number of broods/transect and chicks/brood were in the opposite direction.

Mammalian predation was the primary source of chick mortality during 1990 and 1991. Fox, mink, and weasels were the only predators documented as killing radio-implanted chicks. Instances of surplus killing by mink and weasels suggest that these predators could have significant effects on brood survival, however the impact is unknown. Cold, wet weather appears to contribute to or be a direct cause of mortality but apparently does not depress the overall survival.

The survival between KSA and PSA did not differ. However the survival during 1991 was significantly lower than 1990. Cox's proportional hazards linear model showed that no specific characteristics of the study areas had an effect on the hazard. Hen age was used as a covariate. However, the age of many hens was unknown and this may have restricted the Cox model from detecting any relationship between hen age and
the hazard. I also hypothesized that the specific brood number might influence survival since several chicks were often killed simultaneously by mink and weasels. However, many of the surplus killings involved 1 radio-implanted chick and several unmarked chicks. The killing of more than 1 radio-implanted chick per brood in a day by a mink or weasel occurred in only 8 broods. Thus, there may not have been enough radio-implanted chicks per brood to detect specific brood effects on the hazard. In the final Cox analysis, I was unable to model survival with any of the original covariates, but the first Cox analysis suggests that greater distances moved by chicks may negatively influence the hazard and greater percentages of locations in row crops may positively influence the hazard.

Results indicated that when survival estimates were pooled by year, 48-79% of pheasant chicks died before they reached 4 weeks of age. Mammalian predation accounted for nearly 90% of all mortalities and cold, wet weather may have contributed to the death of chicks that died of exposure. Brood size was not initially different between study areas or years. Although there were year to year differences in chick survival, there were not conclusive differences between study areas. This may be because chicks on both areas were marked in idle grasslands, lived, and died there. Roadside surveys simply are not sensitive enough to pick up changes in chick
survival probably due to brood mixing and combining which occurs occasionally in young broods (<4 weeks) and more frequently in older broods. The results of this study suggest that the survival of chicks does not explain the population differences between two areas with differing landscapes. Rather, population level differences may be better explained by overwinter hen survival (Perkins 1992) or possibly nest success or nest-site survival of hens. Future research on chick survival might be directed toward determining whether hen age, field size, insect abundance, predator abundance, and weather variables have an impact on chick survival, since I was unable to evaluate these factors thoroughly.
LITERATURE CITED

in northern Iowa on differing agricultural landscapes.

Farris, A. L., E. D. Klonglan, and R. C. Nomsen. 1977. The
ring-necked pheasant in Iowa. Iowa Conservation
Commission, Des Moines. 147pp.

central Wisconsin pheasant population. Wisconsin Dep.

(Phasianus colchicus) to conspecific calls. Anim. Behav.

Hill, D. A., and P. A. Robertson. 1988. The pheasant:
ecology, management, and conservation. BSP Professional

Hopkins, A. 1990. Survival analysis with covariates. Pages
769-806 in W. J. Dixon, ed. BMDP Statistical Software

from incomplete observations. J. Am. Stat. Assoc.
53:457-481.

Klonglan, E. D. 1955. Factors influencing the fall roadside

Kozicky, E. L. 1951. Juvenile ring-necked pheasant mortality
and cover utilization in Iowa, 1949. Iowa State College


SUMMARY

Implantation of a radio transmitter in day-old pheasant chicks was a simple and effective procedure. No chicks died during the implantation process. Induction and surgical trauma caused no immediate problems. Some problems were encountered with transmitter ejection and prolonged recovery of anesthetized birds as compared with those not anesthetized. Treated animals grew and behaved similar to controls.

Radio-marked hens were followed through the nesting phase to hatching. Radio-tagged hens chose brome/alfalfa as the preferable nesting habitat. During 2 field seasons, 133 day-old pheasant chicks were implanted with microminiature transmitters. Hen and brood were followed for 4 weeks or until chick transmitters were recovered or lost. No differences were detected between study areas in the distances chicks moved. The quality of a grass field in KSA seemed as effective in raising a brood to 4 weeks of age as did a similar area on PSA, but more and larger grass fields occurred on PSA. Chicks tended to move greater distances as they grew older, but variability existed among birds. Age of chick, habitat type, and encounters with predation might influence movements.

Survival between study areas did not differ, but survival was significantly greater in 1990 than 1991. Mammalian
predation accounted for nearly 90% of all mortalities. Fox, mink, and weasel were the primary mammalian predators of pheasant chicks. The results indicated that when survival estimates were pooled by year, 48-79% of pheasant chicks died before they reached 4 weeks old for 1990-1991.
ADDITIONAL LITERATURE CITED


