



128
408
THS

THESIS



This is to certify that the

thesis entitled

Sichuan, Ring-necked, and F1 Hybrid Hen Pheasant
Survival and Reproduction in Southern
Michigan Habitats

presented by

John Alan Niewoonder

has been accepted towards fulfillment
of the requirements for

Master of Science degree in Fish. & Wildl.

A handwritten signature in black ink, reading "Harold A. Prince".

Major professor

Date 3/30/95

LIBRARY
Michigan State
University

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.

DATE DUE	DATE DUE	DATE DUE
MAY 21 1998		
3693013		
JUN 2 1997		

MSU is An Affirmative Action/Equal Opportunity Institution

c:\crl\dtduea.pm3-p.1

**SICHUAN, RING-NECKED, AND F1 HYBRID HEN PHEASANT SURVIVAL
AND REPRODUCTION IN SOUTHERN MICHIGAN HABITATS**

By

John Alan Niewoonder

A THESIS

**Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of**

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1995

ABSTRACT

SICHUAN, RING-NECKED, AND F1 HYBRID HEN PHEASANT SURVIVAL AND REPRODUCTION IN SOUTHERN MICHIGAN HABITATS

By

John Alan Niewoonder

Genetic differences in plumage, behavior and habitat preferences have been demonstrated between Sichuan and ring-necked pheasants. Survival and productivity of Sichuan, ring-necked, and F1 hybrid hens hatched and reared in captivity and released in Barry and Eaton counties were evaluated. Four release sites with varied habitat were selected and 96 Sichuan, 88 ring-necked and 76 F1 hybrid radio-collared hens were released in early April of 1993 and 1994.

Survival probabilities of hybrids (0.350) were over double the values for ring-necked (0.162) and Sichuan females (0.105). Avian and mammalian predators killed 54% and 19% of the hens, respectively. Clutch size of first nest attempts and nest success for hybrids were intermediate between Sichuan and ring-necked females. The heterotic effects of greatest survival by hybrid females resulted in seasonal production of 3.1 chicks per hen released compared with 1.5 and 0.8 chicks per hen for ring-necked and Sichuan hens, respectively.

ACKNOWLEDGEMENTS

This study was funded through the Wildlife Conservation and Restoration Act Pittman-Robertson Project Number W-127-R. All phases of the study were undertaken in conjunction with a long-term pheasant research effort initiated by the Rose Lake Wildlife Research Station.

This project required the efforts of many individuals. Thanks are extended to members of the Rose Lake staff including: Glenn Belyea, Greg Bragdon, Tom Cooley, Dave Creed, Stephanie Hogle, Paula Somes, Bill Scullon and Bruce Warren for assistance in handling of birds, instruction of telemetry techniques, and necropsy work.

I would like to thank and acknowledge Dr. Harold H. Prince, my major advisor, for his guidance, patience and support. Additional thanks to Dr. Donald L. Beaver, and Dr. Scott R. Winterstein for serving on my graduate committee. Special thanks go to David R. Luukkonen for serving as Michigan DNR representative and co-investigator on this study and for his invaluable assistance throughout the project.

Additional appreciation is extended to Carol Baumann, Linda Briggs, Cheryl Cunningham, Dave Denomme, Chad Fox, Anita Moon, Steve Moore, Dave Morton, Lori Neely, Mark Smith and

Michael Whitt for assistance with field work in 1993. Mark Boersen, Dave Dortman, Elliot Grondin, Leslie Jagger, Mike Kurncz, Mark Ledebuhr and Mike Parker are acknowledged for assistance with field work in 1994.

Thanks to Cathy Flegel for assistance with analysis and report preparation, Lori Neely for data entry and countless hours of digitizing and to Gary Roloff for assistance with GIS.

Thanks are also due to fellow graduate students Linda Briggs, Jennifer Dorset-Derby, Cathy Flegel, Mike Monfils, Timothy R. VanDeelen, Michael Whitt and especially Charlotte E. Lawrence for assistance, support and friendship.

Finally, I would like to thank my parents Marvin and Johanna, my brothers and sisters-in-law, and most of all my wife Kristin for all their love, support and prayers over the years.

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
INTRODUCTION.....	1
METHODS.....	4
Study area.....	4
Stocks.....	6
Rearing.....	6
Release.....	7
Dispersal.....	8
Survival.....	8
Mortality.....	10
Nesting.....	10
RESULTS.....	13
Land use/habitats.....	13
Dispersal.....	15
Survival.....	16
Mortality.....	20
Nesting.....	22
Production.....	27
DISCUSSION.....	30
LITERATURE CITED.....	38

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Land use for the 4 study sites during the 1993 field season.....	14
2. Dispersal distances (km) of Sichuan, ring-necked, and Sichuan x ring-necked F1 hybrid hen pheasants, combined over all 4 study sites, during the 1993 and 1994 field seasons.....	16
3. Survival probabilities($\pm$ SE) of Sichuan, ring-necked and F1 hybrid hen pheasants for the 214 day study period(1 April - 31 October).....	17
4. Daily survival probabilities $\pm$ SE of Sichuan, ring-necked and F1 hybrid hen pheasants during specific time periods.....	20
5. Average clutch size ($\pm$ SE) of first and second nests of Sichuan, ring-necked, and Sichuan x ring-necked F1 hybrid hen pheasants, combined over all 4 study sites, during the 1993 and 1994 field seasons.....	25
6. Nest success rates for all nests for Sichuan, ring-necked, and Sichuan x ring-necked hybrid hen pheasants, combined over all 4 study sites, during the 1993 and 1994 field seasons.....	26
7. Number of chicks hatched by race and nesting attempt during the 1993 and 1994 field seasons	29

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Location of study areas in Barry and Eaton counties of southern Michigan. (T= Thornapple, B= Baltimore, K= Kalamo/Maple Grove, O= Oneida/Benton).....	5
2. Sichuan, ring-necked and F1 hybrid hen survival(1 April - 31 October) during the 1993 and 1994 field seasons.....	18
3. Causes of mortality for Sichuan, ring-necked and F1 hybrid hen pheasants during the 1993 and 1994 field seasons. Other category included farm equipment, exposure and malnutrition.....	21
4. Percentage of first nest initiations for all hen pheasants, combined over all study areas, during the 1993 and 1994 field seasons.....	23

INTRODUCTION

Survival probability of female common pheasants (*Phasianus colchicus*) is a function of weather conditions, predator abundance, life stages, habitat preferences, habitat availability and habitat juxtaposition. Pheasants select distinct habitat types for prenesting, nesting, brood rearing, fall assembly, and wintering (Hanson and Progulske 1973, Whiteside and Guthery 1983, Myers et al. 1988, Gatti et al. 1989, Leptich 1992). Availability of quality habitat that meets the year-round requirements of pheasants is the key to successful pheasant reproduction and survival.

Habitat loss and change has resulted in the decline of ring-necked pheasants in southern Michigan that has occurred over the past 40 years (Prince et al. 1988). The release of a race of pheasant that can utilize a broad spectrum of habitat types may result in a resurgence in numbers despite this trend.

There are 32 races of the common pheasant in Asia. Differences in these races have developed due to isolation and uniqueness of native habitats (Delacour 1977, Johnsgard 1986). Some habitats in China that are used by common pheasants are

comparable to habitats in Michigan that are not being used by ring-necked pheasants (*P. c. torquatus*).

It was determined, based on habitat utilization and accessibility of native populations, that Strauch's pheasant (*P. c. strauchi*) was the best suited for an introduction to Michigan (Prince et al. 1988). This sub-species is being called the Sichuan pheasant by the Michigan Department of Natural Resources (MDNR). It is believed that Sichuan pheasants occupy a different habitat niche than the subspecies currently established in North America.

The current strategy of the "Sichuan Project" is to establish Sichuan pheasants in habitat in Michigan now void or nearly void of common pheasants, and to maximize sizes of founding populations. Nearly all pheasant introductions in the United States had European game farm background, having been imported there from China hundreds of years earlier (Squibb 1985). In Europe, pheasants were undoubtedly exposed to inbreeding and artificial selection that may have decreased genetic diversity and diminished the ability to survive in wild conditions. Sichuan pheasants imported to Michigan were also exposed to game farm conditions, however, this was for only a short time and precautions were taken to prevent inbreeding and other negative effects. It was hoped that genetic input from the wild Sichuan line could help increase genetic diversity of Michigan's pheasant population as well as provide pheasants which utilize different habitats.

Investigation of the impact of the introduction of Sichuan pheasants on ring-necked pheasant populations established from previous programs can provide a baseline for research on the importance of each subspecies and the hybrid condition to the development of robust populations of pheasants.

This study is based on the premise that survival and reproductive success of Sichuan, ring-necked, and Sichuan x ring-necked F1 hybrid pheasants should be similar because of the common genetic background. This study compares survival and reproduction of the 2 races and their hybrids released in common environments representative of southern Michigan.

METHODS

Study area

The release sites were selected to provide a range of habitats suitable for comparison of the 3 lines of pheasant. All sites were located in Barry and Eaton counties in southern Michigan. Four township-sized areas (9,325 ha) were used as release sites and included Baltimore township (T. 2 N., R. 8 W.) and Thornapple township (T. 4 N., R. 10 W.) in Barry county, Oneida/Benton townships (T. 4 N., R. 4 W. S 1/2 and T. 3 N., R. 4 W. N 1/2) in Eaton county, and Kalamo/Maple Grove townships (T. 2 N., R. 7 W. E 1/2 and T. 2 N., R. 6 W. W 1/2) on the Barry-Eaton county border (Figure. 1).

Habitat and land use for each study area was evaluated using the Geographical Information System (GIS) PC ARC/INFO. Maps were generated from color-infrared aerial photos (36" X 36", scale = 1:14,500) by tracing habitat boundaries with fine tipped permanent markers. Habitat boundaries were entered into the data base on a 12" X 12" digitizing tablet. Ground truthing was done during the spring and summer of 1993.

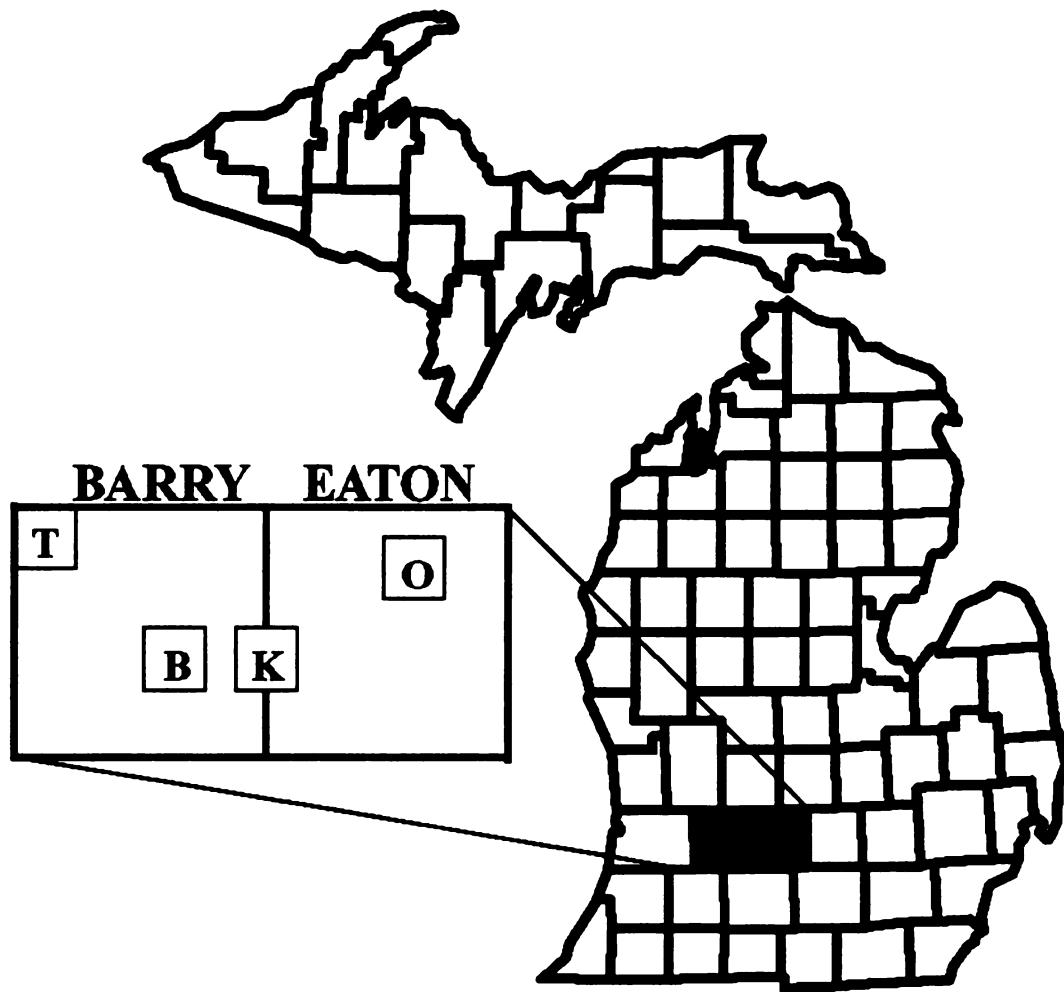


Fig. 1. Location of study areas in Barry and Eaton counties of southern Michigan (T=Thornapple, B=Baltimore, K=Kalama/Maple Grove, O=Oneida/Benton).

Stocks

Four groups of 50 chicks, representing all breeding combinations including Sichuan, ring-necked, and Sichuan x ring-necked F1 reciprocal crosses were reared together and maintained in outdoor pens throughout the entire year. Sichuans were hatched from eggs laid by birds hatched from eggs taken directly from Sichuan Province. Ring-necks were hatched from eggs layed by Michigan ring-necked pheasant stocks maintained by the Michigan DNR. The hybrids are the F1 products of reciprocal crosses between the Sichuans and the Michigan ring-necks. Throughout the rearing process, care was taken to provide a similar environment for all pheasants used in this study.

Rearing

Eggs were collected daily and were cleaned and placed in a cooler until they were ready to be set. Eggs were set each Friday during the breeding season to synchronize hatching dates. Incubation occurred until hatching on the 24th day, after which chicks were moved into brooder rooms where they remained for one week. For the next 5 weeks chicks were allowed to move back and forth from the brooder room to a set of outdoor acclimation pens. Pheasants were then moved into large flight pens where they remained throughout the winter until spring (Bruce Warren, Mich. Dep. Nat. Resour., pers. commun.).

Release

Necklace style radio telemeters (Lotek Engineering, Inc., Newmarket, Ontario, Canada) weighing approximately 15 grams and equipped with 15" antennas and 9 hour mortality sensors were affixed to the hens in mid-March of both 1993 and 1994. Pheasants were held in pens for 1 week after the transmitters were attached to allow the birds to become accustomed to them. Each of the four sites received 12 Sichuan, 10 ring-necked, and 7 hybrid hens in 1993 and 12 Sichuan, 12 ring-necked and 12 F1 hybrid hens in 1994. No hens from 1993 survived long enough to nest in 1994. This provided a total of 96 Sichuan, 88 ring-necked, and 76 hybrid radio-collared hens for the 2 years of this study. In addition, 10 non-radioed Sichuan cocks were released at each site on both years.

The release schedule was similar for both 1993 and 1994. On 1 April, hen pheasants were released on Oneida/Benton and Kalamo/Maple Grove sites. Two days later, releases were made on the Baltimore and Thornapple sites. Specific release sites were chosen on the basis of providing adequate escape cover and were located as nearly as possible to the center of the study areas. Releases were made before sunrise using brush covered poultry crates. Crates were positioned adjacent to protective cover and observed from a distance to ensure that predators did not interfere with release. Pheasants were allowed to exit the crates by walking into the surrounding

vegetative cover. This was done to minimize the stress of handling and to facilitate a more natural and safe dispersal.

Dispersal

Dispersal distances were measured at 4 weeks and again at 8 weeks after release. Distances were measured as the Euclidean distance from the release site to the center of the grid cell (100 m X 100 m) in which the hen was located at the end of each of the 2 time periods. Dispersal distance was compared between the 3 pheasant lines using the Kruskal-Wallis test. When significant differences were found, the Mann-Whitney U test was used to determine pairwise differences.

Survival

All birds were located at least 3 times per week until mid May when birds were then monitored 4 to 6 times per week. Pheasants were monitored from early April through October by technicians equipped with radio receivers, and hand-held, 3-element directional antennas.

Survival was estimated over a 214 day period (1 April - 31 October). In addition, since pheasant survival is likely to be different during various times of the year, survival was estimated over 3 periods: the first month following release (1 April - 30 April), the peak nesting period (1 May - 31 July), and the postbreeding period (1 August - 31 October).

Nine hour mortality sensors allowed early detection of

dead pheasants. When 1 or more days elapsed between locations and mortality had occurred, pheasants were considered dead on the day after they were last found to be alive. Days between locations rarely exceeded 2 days surrounding a mortality.

Survival was estimated using the Kaplan-Meier method (Kaplan and Meier 1958). This method calculates a survival probability estimate at the time of death for each radio-tagged animal being monitored. Kaplan-Meier allows staggered entries of individuals and the ability to censor individuals. Individuals or observations may be censored because of radio failure, radio loss, emigration from the study area, or because the animal survives past the end of the study period. The Kaplan-Meier method requires 3 assumptions: 1) the censoring mechanism is random, 2) survival times are independent among individuals, and 3) a random sample of animals is obtained. Problems with the first assumption may have caused us to overestimate actual survival. On several occasions, damaged radios were found on dead hen pheasants. It appears that automobiles, farming equipment and some predators are capable of damaging transmitters when killing pheasants. Generally when this happens, radios are not found and individuals become censored when they should have been considered dead. This problem may have also contributed to the relatively high number of censored individuals in this study. I believe that, due to the nature of pheasant behavior and the source of pheasants used in this study, assumptions 2 and 3

did not present problems in this study. Differences in survival functions were determined using a log-rank test (Pollock et al. 1989).

Mortality

The mortality sensors on the transmitters allowed us to retrieve carcasses quickly following mortality. Several observations could be made in the field which indicated cause of death. Tooth marks on transmitter or antenna, chewed bones, sheared feathers, presence of mammalian tracks, scat, and odor, buried remains and proximity of active dens indicated mammalian predation. Straight or triangular beak marks on transmitter or antenna, intact skeleton with muscle tissue missing, plucked feathers, and presence of raptor whitewash or pellets were clues indicating avian predators (Rabe et al. 1988).

Remains were frozen and later taken to Rose Lake Wildlife Research Center for necropsy. Observations made in the field and results of the necropsy usually allowed us to determine cause of death.

Nesting

Incubating females and their nest sites were located with the aid of radio-telemetry. Locations of nests were determined and flags were placed in the general area of the nest. Direction and distance of the nest in relation to the flags

were recorded. Care was taken not to disturb the birds or to influence their behavior in any way.

Nest initiation dates were estimated by multiplying the number of eggs by 1.3 (number of days required to lay 1 egg (Campa et. al. 1987)) and backdating from the first day of incubation. Initiation dates of first nests were then converted to Julian days and compared using the nonparametric Kruskal-Wallis test.

Clutch size was determined by visiting the nest while the hen was off feeding or after eggs hatched or were abandoned. Clutch size was compared between the 3 lines using the nonparametric Kruskal-Wallis test.

Nest success was estimated by the computer program Micromort (Heisey and Fuller 1985) which uses the modified Mayfield model (Mayfield 1961, 1975). This model estimates a daily survival rate from the number of days that each nest was known to be at risk and the number of nests that were destroyed during that particular time period. This rate can then be applied to the total number of days that each nest was at risk including both the laying and incubation periods (Miller and Johnson 1978). Daily survival probabilities may differ between the egg laying and incubation stages, however, we were unable to estimate survival during incubation. By backdating, we can estimate nest success without ignoring nests that were not detected because they were destroyed at an early stage. If nests that are destroyed before they are

detected are not accounted for, nest success will tend to be overestimated. Nest success rates of the 3 lines were compared using a z test (Hensler and Nichols 1981). Nests were considered successful if 1 or more eggs hatched. Destroyed nests were considered unsuccessful on the day after they were last observed. In all cases, nests were visited nearly every day during incubation.

Multiple study areas, a large initial number of radio tagged pheasants, and random sampling were used in this study. This was done to achieve power and type I error rates that would help ensure correct conclusions and completion of a sound study. P values of ≤ 0.10 were considered significant for results in this study. Nonparametric statistics were applied for dispersal distance, date of nest initiation for first nests, and clutch size analysis as I was unable to assume normal distributions for these comparisons.

RESULTS

Land use/habitat

Most of the land on the study areas is privately owned. Farms, farm fields and woodlots are relatively small with a high degree of fragmentation, creating a mosaic landscape consisting of large amounts of linear shaped habitats. The areas consisted of relatively small amounts of land enrolled in the Conservation Reserve Program (CRP). CRP land often provides quality nesting habitat and winter cover for pheasants. The Oneida/Benton site contained just 57 ha (<1 % of the area) of CRP land, the Kalamo/Maple Grove site had 796 ha(8.5% of the area), the Baltimore site had 392 ha (4.3%), and the Thornapple site contained just 183 ha (2.4%). In spite of the lack of CRP land in these areas (< 5% of total area on all sites), there existed varying amounts of idle land that was not enrolled in the CRP program.

Land use and available habitat varied among release sites. Most noticeably, the Oneida/Benton site had the highest percentage of land in agricultural use (58%) while the Baltimore site had the lowest (21%). Conversely, the Baltimore site had the greatest area covered by woody plant species (shrub areas, woodlots, and woody fence rows) at 55% while the Oneida/Benton site had woody cover over just 25% of its area.

The Kalamo/Maple Grove and Thornapple sites consisted of similar amounts of cropland and woody cover and were intermediate between Oneida/Benton and Baltimore (Table 1).

Table 1. Land use for the 4 study sites during the 1993 field season.

Landuse	<u>Onei/Bent</u>		<u>Kal/M.G.</u>		<u>Baltimore</u>		<u>Thornapple</u>	
	ha	%	ha	%	ha	%	ha	%
Corn	2592	29	1086	12	771	9	1481	19
Soybeans	1512	17	784	8	189	2	454	6
Wheat	702	8	126	1	48	1	175	2
Hay	345	4	1084	12	839	9	802	10
Herbaceous	594	7	1675	18	1289	14	1165	15
Shrubs	442	5	732	7	1479	16	581	8
Forest	1774	20	2792	30	3511	39	2050	27
Em.Wetland	5	<1	107	1	178	2	67	1
Other	992	10	1022	11	730	8	956	12
Total	8958		9408		9034		7741	

Dispersal

Dispersal of hen pheasants from release sites was immediate and most birds appeared to move independently of each other. Several birds did remain in groups of 2 or 3 for a short time following release. Combining data from the 1993 and 1994 field seasons, pheasants moved an average of 1.4 ± 0.1 km ($n = 105$) from the release sites after 4 weeks. Sichuan, ring-necked, and hybrid dispersal distances were different (Kruskal-Wallis, $P = 0.017$) during this time. Pairwise analysis revealed that ring-necked and hybrid dispersal distances were similar (Mann-Whitney U, $P = 0.661$), while Sichuans tended to disperse shorter distances than both ring-necks (Mann-Whitney U, $P = 0.066$) and hybrids (Mann-Whitney U, $P = 0.010$). After 8 weeks, hens had moved an average of 1.7 ± 0.1 km ($n = 77$) from the release sites. For this time period, dispersal distances were similar (Kruskal-Wallis, $P = 0.857$) between the 3 lines (Table 2).

Table 2. Mean dispersal distances (km) $\pm$ SE of Sichuan, ring-necked, and Sichuan x ring-necked hybrid hen pheasants, combined over all 4 study sites, during the 1993 and 1994 field seasons.

Pheasant line	Time since release			
	n	4 weeks	n	8 weeks
Sichuan	35	1.1 $\pm$ 0.1	24	1.3 $\pm$ 0.2
Ring-necked	29	1.8 $\pm$ 0.3	20	1.8 $\pm$ 0.3
Hybrid	41	1.5 $\pm$ 0.2	33	1.8 $\pm$ 0.3
Combined		1.4 $\pm$ 0.1		1.7 $\pm$ 0.1

Survival

Survival probabilities were similar between years for each of the 3 lines (log-rank test, largest $x^2 = 1.08$, 1 df, $P = 0.305$). Combined over the 1993 and 1994 field seasons, survival for the entire 214 day period was higher for hybrids than for both ring-necks (log-rank test, $x^2 = 7.67$, 1 df, $P = 0.006$) and Sichuans (log-rank test, $x^2 = 12.42$, 1 df, $P = 0.0004$). Ring-neck and Sichuan survival was similar over this time period (log-rank test, $x^2 = 0.33$, 1 df, $P = 0.57$) (Table 3, Figure 2). Of the 260 hen pheasants released, 182 died and were found during the study, 48 were censored, and 30 were still alive at the end of the study period.

Table 3. Survival probabilities ($\pm$ SE) of Sichuan, ring-necked and F1 hybrid hen pheasants for the 214 day study period (1 April - 31 October).

Pheasant line	1993	1994	Combined
Sichuan	0.11($\pm$0.06)	0.10($\pm$0.07)	0.11($\pm$0.05)
Ring-necked	0.17($\pm$0.08)	0.16($\pm$0.07)	0.16($\pm$0.05)
Hybrid	0.31($\pm$0.11)	0.37($\pm$0.08)	0.35($\pm$0.07)

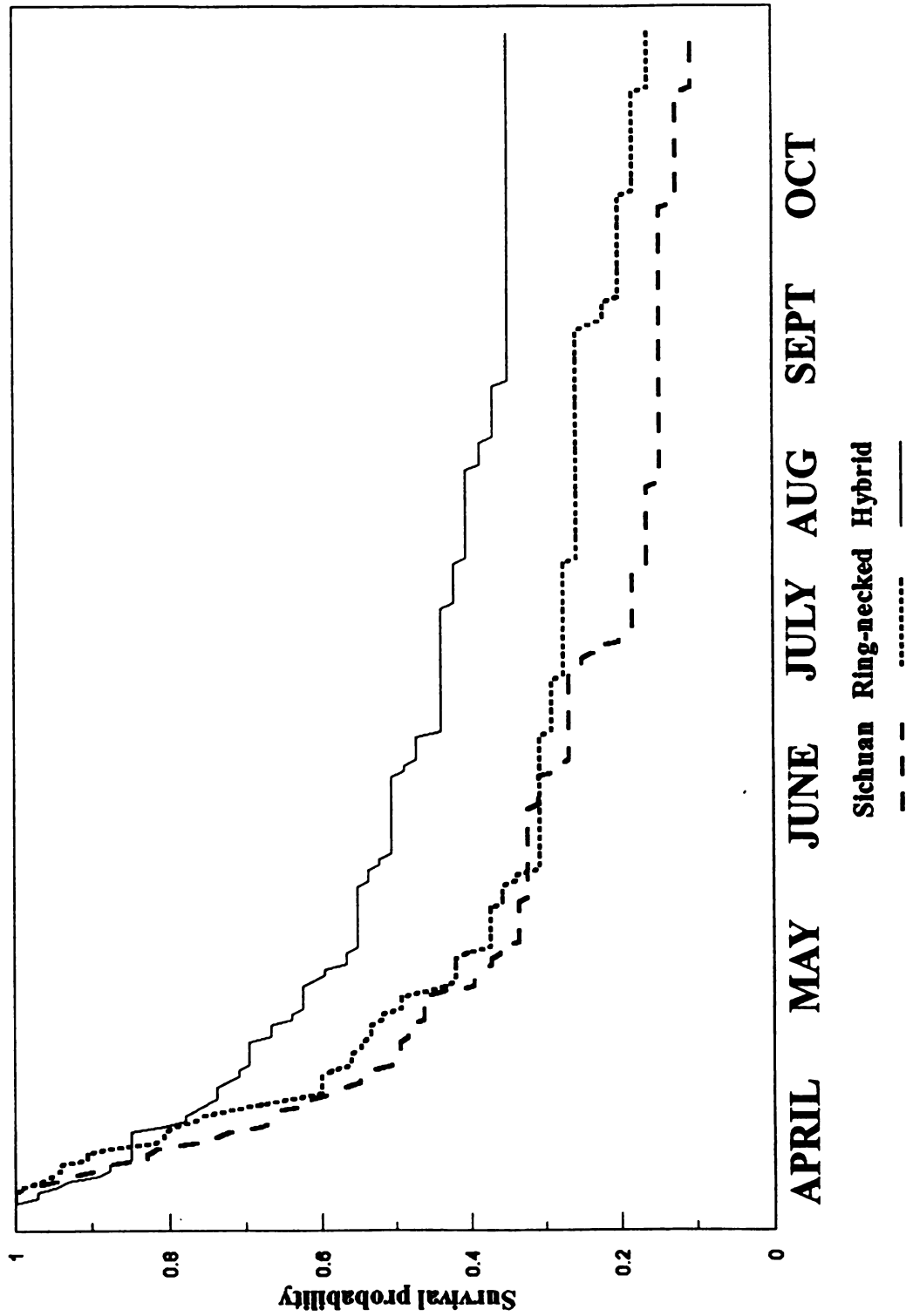


Fig. 2. Sichuan, ring-necked and F1 hybrid hen survival(1 April - 31 October) during the 1993 and 1994 field seasons.

Although low sample sizes prevented analysis of survival on each of the 4 study sites, pheasant survival curves appeared to differ somewhat between the sites. Ring-neck survival was higher on the Oneida/Benton site, which was the most intensively farmed and lower on the Baltimore site which has the most woody cover. Sichuan survival, while relatively low on all 4 sites was higher on the Baltimore site. Hybrid pheasants, with relatively high survival on all study sites, exhibited their highest survival on the Baltimore site as well. For all 3 lines of pheasant, the Thornapple site appeared to have the lowest survival of all sites.

Combining 1993 and 1994, survival for the first 30 days after release was higher for hybrids (70%) than for ring-necks (55%) (log-rank test, $x^2 = 2.93$, 1 df, $P = 0.087$) and for Sichuans (50%) (log-rank test, $x^2 = 5.98$, 1 df, $P = 0.014$) which were similar (log-rank test, $x^2 = 0.58$, 1 df, $P = 0.450$). During the peak nesting season (1 May - 30 July), although not significantly different, hybrid survival (58%) appeared to be slightly higher than ring-neck survival (47%) (log-rank test, $x^2 = 1.24$, 1 df, $P = 0.266$) and Sichuan survival (39%) (log-rank test, $x^2 = 1.94$, 1 df, $P = 0.164$) which were again similar (log-rank test, $x^2 = 0.03$, 1 df, $P = 0.86$). During the post-breeding period (1 August - 31 October), hybrid, ring-neck and Sichuan survival was not significantly different (76%, 58%, and 60%, respectively) (log-rank test, highest $x^2 = 0.33$, 1 df, $P = 0.57$).

Since the 3 periods are of different lengths of time, the survival differential during these 3 time periods is more clearly represented by daily survival rates. Daily survival probability was lowest for all pheasants during the initial 30 days. Also, note that the greatest advantage for hybrids occurred during the first 30 days following release (Table 4).

Table 4. Daily survival probabilities $\pm$ SE of Sichuan, ring-necked, and F1 hybrid hen pheasants during specific time periods.

Pheasant line	Initial 30 days ^a	Peak nesting ^b	Post breeding ^c	Total
Sichuan	0.977 $\pm$ 0.004	0.990 $\pm$ 0.006	0.994 $\pm$ 0.007	0.990 $\pm$ 0.003
Ring-neck	0.980 $\pm$ 0.005	0.992 $\pm$ 0.007	0.994 $\pm$ 0.007	0.991 $\pm$ 0.002
Hybrid	0.988 $\pm$ 0.005	0.994 $\pm$ 0.006	0.997 $\pm$ 0.006	0.995 $\pm$ 0.001
Total	0.981 $\pm$ 0.002	0.992 $\pm$ 0.003	0.995 $\pm$ 0.004	0.992 $\pm$ 0.001

^a 1 April - 30 April.

^b 1 May - 31 July.

^c 1 August - 31 October.

Mortality

Cause of death was due mainly to predation from avian and mammalian predators (Figure 3). Causes of mortality did not appear to be different between the 3 lines. The primary avian predators identified by direct observation and location and condition of the carcass were the red-tailed hawk (*Buteo jamaicensis*) and the great horned owl (*Bubo virginianus*). The

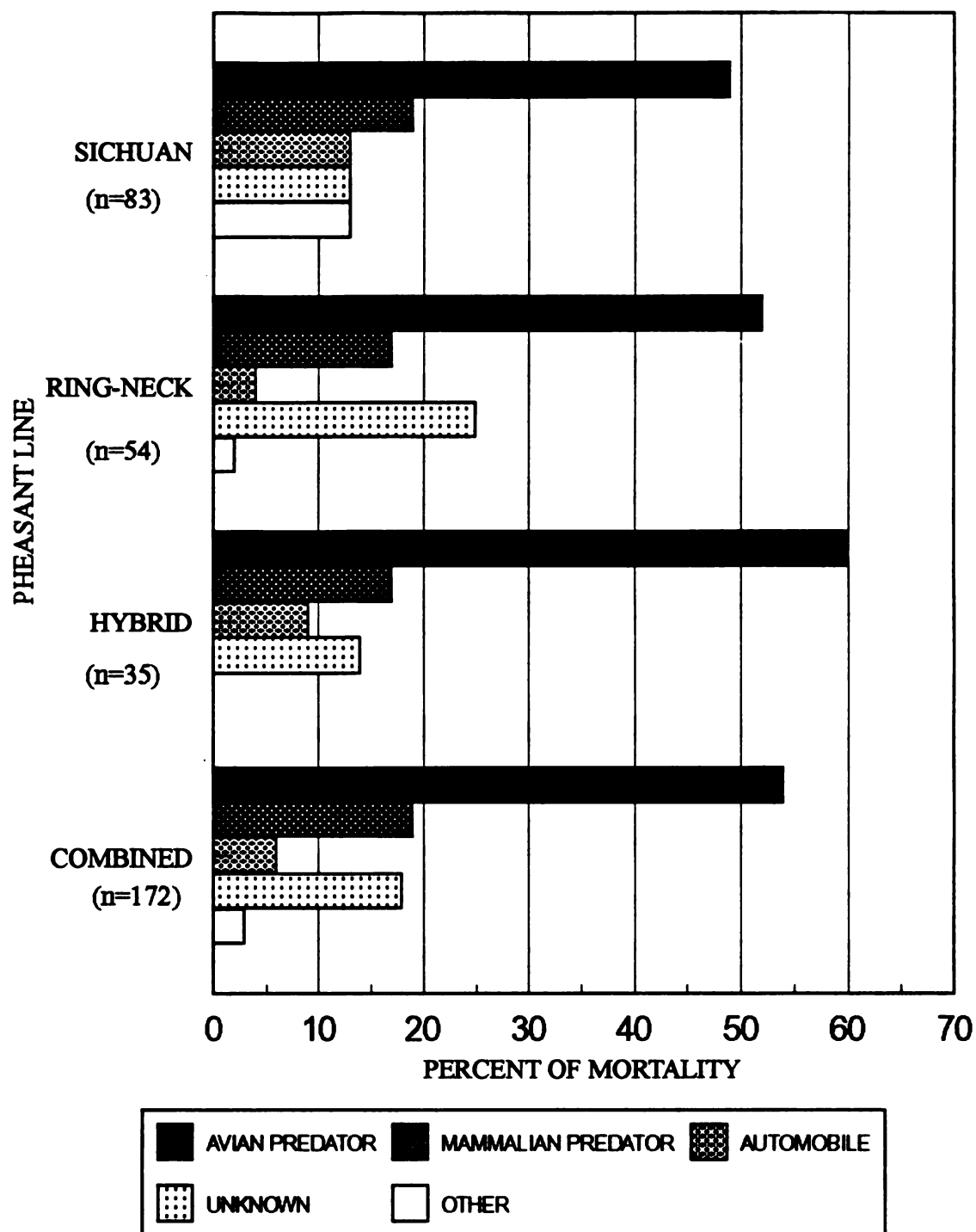


Fig. 3. Causes of mortality for uncensored Sichuan, ring-necked and F1 hybrid hen pheasants during the 1993 and 1994 field seasons. Other category included farm equipment, exposure, and malnutrition.

red fox (*Vulpes vulpes*) was identified as the most common mammalian predator. Other factors, including farming activity, road kills, exposure and malnutrition also contributed to pheasant mortalities. For several birds, the information was not sufficient to determine cause of death.

Nesting

Initiation dates of all nest attempts ranged from 11 April to 27 July. The peak of first or initial nests occurred in late April and early May (Figure 4). Comparison of first nest initiation dates by female type, indicate that Sichuan hens may tend to start their first nests slightly earlier than both ring-necks and hybrids. Mean nest initiation date was 4 May (± 6 days) for Sichuan hens, 6 May (± 7 days) for hybrid hens and 11 May (± 7 days) for ring-necked hens. These dates were not significantly different (Kruskal-Wallis, $P = 0.738$).

One hundred-twenty nests were attempted during 1993 and 1994. Eighty-nine (74%) of these were first nests. Although the 75 hybrid females represented only 29% of hens released in this study, they accounted for 50 (42%) of all nest attempts.

We were able to determine clutch size for 86 of the 120 nests attempted. Although there was not a significant difference (Kruskal-Wallis, $P = 0.115$) between clutch sizes of first nests for the 3 pheasant lines, it appeared that ring-necks may have slightly larger initial clutch sizes than both

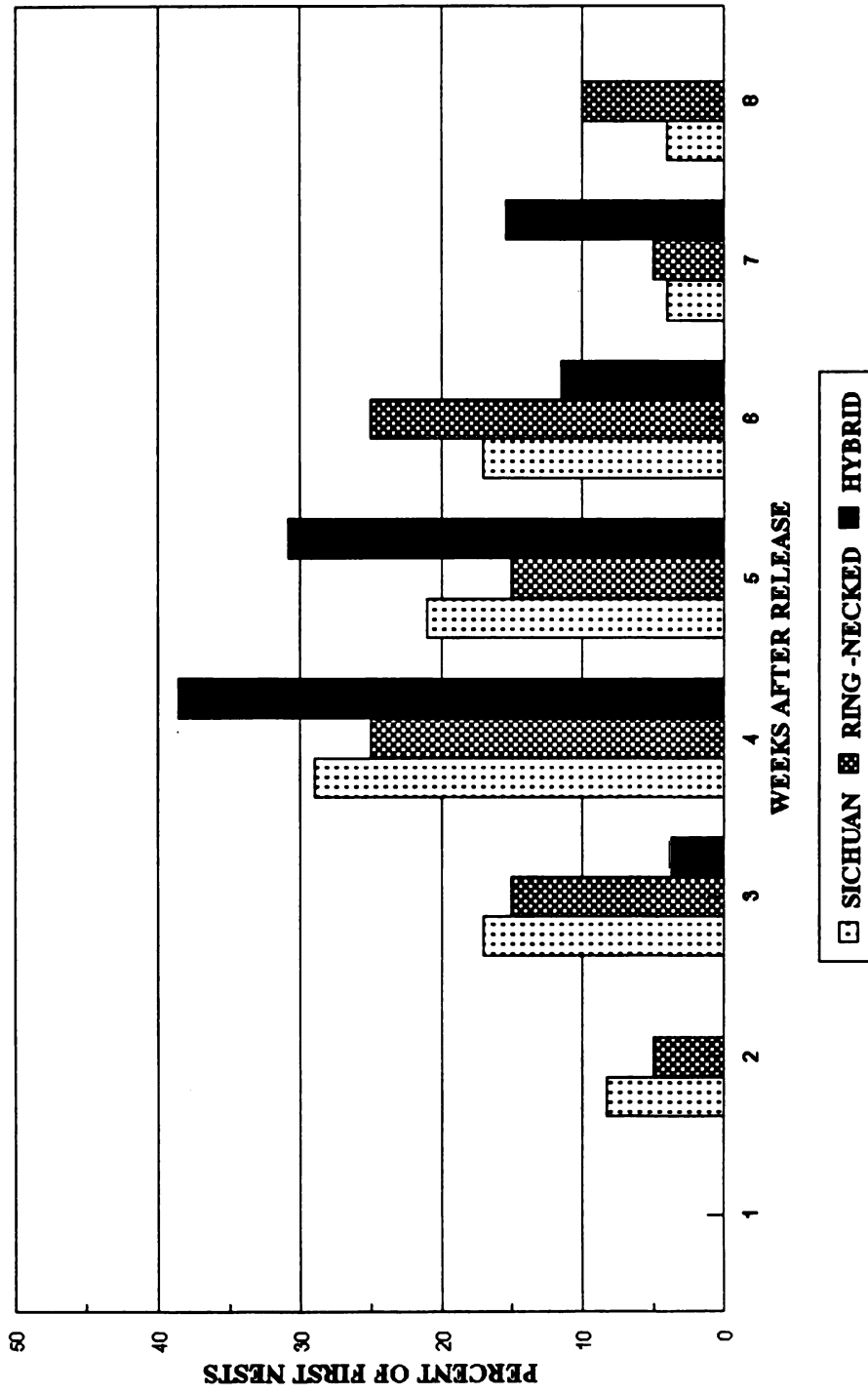


Fig. 4. Percentage of first nest initiations for all hen pheasants, combined over all study areas, during the 1993 and 1994 field seasons.

hybrids and Sichuans (Table 5). Combining all nesting attempts, no statistical difference was detected between the 3 lines (Kruskal-Wallis, $P = 0.46$).

Table 5. Average clutch size ($\pm$ SE) of first and second nests of Sichuan, ring-necked, and Sichuan x ring-necked hybrid hen pheasants, combined over all 4 study sites, during the 1993 and 1994 field seasons.

Female	First nests		Second nests		Third nests		All nests	
	n	Mean($\pm$ SE)	n	Mean($\pm$ SE)	n	Mean($\pm$ SE)	n	Mean($\pm$ SE)
Sichuan	21	8.3($\pm$ 0.7)	4	8.8($\pm$ 0.5)	1	9.0($\pm$ 0.0)	26	8.7($\pm$ 0.5)
Ring-necked	19	10.6($\pm$ 0.4)	5	7.4($\pm$ 1.0)	1	7.0($\pm$ 0.0)	25	9.8($\pm$ 0.7)
Hybrid	26	9.2($\pm$ 0.5)	11	9.5($\pm$ 0.8)	2	9.0($\pm$ 0.0)	39	9.2($\pm$ 0.4)
Total	66	9.3($\pm$ 0.4)	20	8.6($\pm$ 0.5)	4	8.5($\pm$ 0.5)	90	9.3($\pm$ 0.3)

Nest success, calculated using the Mayfield model, was 37.1% for all nests during the 1993 field season. Sichuans were less successful than both ring-necked hens ($z = 1.774$, $P = 0.077$) and hybrid hens ($z = 2.032$, $P = 0.042$) which were similar ($z = 0.210$, $P = 0.834$) in 1993. In 1994, overall nest success was 30.6%. That year, nests of all races were equally successful (highest $z = 0.637$, $P = 0.522$). Combined over both years, 32.3% of all nests were successful. Sichuan hens were less successful at nesting than ring-necked hens ($z = 1.652$, $P = 0.099$) and equally successful as hybrid hens ($z = 1.428$, $P = 0.153$). Ring-neck hens and hybrid hens exhibited similar success rates ($z = 0.412$, $P = 0.682$) (Table 6).

Table 6. Nest success rates for all nests for Sichuan, ring-necked, and Sichuan x ring-necked hybrid hen pheasants, combined over all 4 study sites, during the 1993 and 1994 field seasons.

Race	1993		1994		Total
	n	Success	n	Success	Success
Sichuan	20	0.19	20	0.26	0.22
Ring-necked	16	0.46	14	0.36	0.40
Hybrid	17	0.50	33	0.31	0.36

Specific nest predators were difficult to identify. Potential nest predators in this area include red fox, gray fox (*Urocyon cinereoargenteus*), coyotes (*Canis latrans*), raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), opossums (*Didelphis virginianus*), mink (*Mustela vison*), thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) and American crows (*Corvus brachyrhynchos*). Nest predators destroyed 49 of 120 nests attempted. Farming activity destroyed 9 nests, 5 hens were killed away from their nests, and 4 hens abandoned their nests for unknown reasons.

Ninety-one percent (n=11) of Sichuan hens, 87.5% (n=8) of ring-neck hens, and 100% (n=13) of hybrid hens that were still living 1 month after their first nest was destroyed attempted a second nest. No Sichuan hens (n=1), 50% (n=2) of ring-necked hens, and 60% (n=5) of hybrid hens that lived at least 1 month after loss of their second nest attempted a third nest. Renesting accounted for 25% of Sichuan broods, 18% of ring-necked broods and 38% of hybrid broods. In addition, 1 Sichuan, 1 ring-necked, and 1 hybrid hen attempted to renest after a successful nest had hatched earlier in the breeding season.

Production

Combining all 3 lines, an estimated 225 chicks were produced in 1993 and 212 chicks in 1994. Of these 437 chicks,

288 (65.9%) were from first nesting attempts. Second and third nesting attempts contributed 133 chicks (30.4%) and 16 chicks (3.7%) respectively. Combining data from both years, the 96 Sichuan hens produced 76 chicks (0.79 chicks per hen released), the 87 ring-necked hens produced 131 chicks (1.51 chicks per hen released) and the 75 hybrid hens hatched 230 chicks (3.07 chicks per hen released) (Table 7).

Table 7. Number of chicks hatched by race and nesting attempt during the 1993 and 1994 field seasons.

	Sichuan	Ring-necked	Hybrid	Total
1993				
First nest	22	79	42	143
Second nest	8	12	53	73
Third nest	9	0	0	9
1994				
First nest	22	24	99	145
Second nest	15	16	29	60
Third nest	0	0	7	7
Combined				
First nest	44	103	141	288
Second nest	23	28	82	133
Third nest	9	0	7	16
All nests	76	131	230	437
Chicks/hen	0.79	1.51	3.07	1.69

DISCUSSION

The habitat present on the 4 study areas is a diverse mixture of row crops, hay fields, idle fields, woodlots, and scrub-shrub zones. The high degree of fragmentation that occurs in these areas may result in habitat that provides for year around needs of pheasants without requiring large movements in order to survive and reproduce. However, the nature of this mosaic landscape pattern also provides large amounts of linear shaped habitats. These types of habitats may provide predators with an advantage for capturing prey and locating nests that they may not have in other parts of North America's pheasant range.

While ring-neck and hybrid dispersal distances were slightly greater than Sichuan hen dispersal, distances traveled from release sites by all 3 lines were comparable to dispersal distances of pheasants found in the literature. Warner(1988) reported that dispersal of released pheasants ranged from 1.5 to 3 km. Wilson et al. (1992) and Rabe et al. (1988) measured dispersal distances of 0.8 to 2.1 km.

Survival for all 3 lines in this study fell within or below the ranges reported in the literature for wild trapped hen pheasants and near or above survival rates of pen raised

pheasants. Survival rates of wild trapped hen pheasants ranged from 20% to 55% (Dumke and Pils 1973, Snyder 1985, Penrod et al. 1986, Wilson et al. 1992, and Lief 1994). For pen raised birds, spring to fall survival rates ranged from 2-26% (Ellis and Anderson 1963, Jarvis and Engbring 1976, Haensly et al. 1985, and Lief 1994).

Hybrid hen pheasant spring to fall survival rates were considerably greater than the < 10% survival rates reported for Sichuan x ring-necked hybrids in Pennsylvania (Johnson 1992) and were near the annual survival rate of wild hens of 30 - 35% suggested by Peterson et al. (1988) as the minimum long term rate of a self-sustaining population. Sichuan and ring-necked hen pheasant survival rates, however, were well below this level. Populations with survival rates lower than 30% were assumed to be declining, while those with rates greater than 35% were considered to be increasing (Peterson et al. 1988).

Low survival rates occurring in this study can be partially explained by the fact that hand-reared pheasants were studied. Hill and Robertson (1988) stated that hand-reared pheasants tend to suffer heavy losses immediately after being released and that these losses can reach a magnitude of 65% within 1 week and 80% during the first month. Hill and Robertson (1988) also stated that hand-reared birds consistently demonstrated a higher mortality rate than wild birds, due to a greater vulnerability to predation. As a

consequence, fewer females survive the breeding season to raise chicks than for their wild counterparts. Without the benefits provided by the natural rearing of the hen, unfamiliarity with wild food sources and natural predators result in low survival rates. Inbreeding depression, genetic defects and lack of competitive ability in the offspring may also contribute to low survival and productivity of hand reared pheasants (Woodward et al. 1983). Sixty-one percent of all deaths in this study occurred during the first month following release.

Although hybrid daily survival was higher during the first month following release, the peak nesting season and the post-breeding season, the greatest difference between hybrid daily survival probability and daily survival probability of Sichuan and ring-necked hens occurred during the first month following release. It is not clearly understood why hybrid survival is so much higher for the initial month following release, however, it appears that this time period is the most crucial for hand-reared pheasants. Increasing survival during the first month following release may be the key to improving success of future hand-reared pheasant releases.

Cause of death was attributed mainly to avian predators especially red-tailed hawks and great horned owls. Mammalian predators, mainly red fox, played a substantial but lesser role. Road kill, death by farm implement, exposure, and malnutrition were the cause of only a small fraction of total

deaths.

Pheasants seldom make up a major portion of an individual predator's diet, however they are frequently eaten by a variety of predators. In Wisconsin, 11 mammals and 9 raptors are recorded as preying on pheasants (Wagner et al. 1965). Hessler et al. (1970) reported that red-tailed hawks, great horned owls, red fox and mink (*Mustela vison*) commonly preyed on pheasants with avian predators presenting the most serious threat. Rabe et al. (1988) found that mammalian predators killed 28%, avian predators 12%, other, including motor vehicle and farm related 7% and unknown 53% of pen reared Sichuan hens in a study done in Michigan. In England and Ireland, where avian predators capable of killing ring-necked pheasants are rare, foxes are reported to be the predominant predators. Hill and Robertson (1988) found in Ireland that foxes accounted for 64% of all mortalities and 93% of all predator related mortalities of pen raised pheasants.

Although several studies (Boag 1972, Herzog 1979, Johnson and Berner 1980, Hines and Zwickel 1985) have commented on the effects that radio transmitters have on bird behavior and survival, this problem has become less of a concern as technology has allowed reduction of transmitter weight. Transmitter weight was less than the 2% of hen body weight above which Warner and Etter (1983) reported an effect on survival. Marcstrom et al. (1989) stated that necklace radio transmitters, at 2 to 3% of body weight, are the most suitable

option for studies of pheasant survival. Birds observed in pens for a short time following radio tagging did not appear to have difficulty adjusting to the transmitters.

Comparison of first nest initiation dates by female type indicate that although no statistical differences were detected, Sichuan hens may tend to start their first nests slightly earlier than both ring-necks and hybrids. These dates were slightly later than the mean initiation date of 1 May for first nests of ring-neck hens that Dumke and Pils (1979) found in Wisconsin.

Mean clutch sizes for first nests (Sichuan= 8.3, ring-necked= 10.6, hybrid= 9.2) demonstrate the genetic differences between the 3 lines, which appear to be based on additive genetic variance. Clutch sizes were equal to or slightly less than clutch sizes commonly reported in the literature. For ring-necks, Dumke and Pils (1979) reported a mean clutch size of 11.8 eggs for first nests and 11.5 for second nests in Wisconsin. Anderson (1964) found a mean of 10.2 eggs in Illinois. In Michigan, Luukkonen (1993) reported mean clutch sizes of first nests of 11.9 for wild trapped ring-necked hens.

Gates and Hale (1975) reported a range of 13- 46% nest success, with an average of 24.6% for 18 studies of ring-necked pheasants. This was lower than the 40% nest success rate found for ring-necks in this study. In Michigan, Luukkonen (1993) reported a higher nest success rate of 50%

for wild trapped ring-necks over a 3 year period. For Sichuan hens, the 22% success rate that we found was lower than the 40 % rate reported for Sichuans in Michigan by Padding (1988). Hybrid nest success (36%) was similar to the 31% and 33% success reported for Sichuan x ring-neck hybrids in Pennsylvania (Johnson 1992).

Occurrence of renesting following predation of first nests was higher for all 3 races than was found in the literature. Dumke and Pils (1979) found that 68% of ring-necked hens renested after their first nest was destroyed or abandoned. However, the 41% that renested after the second nest was destroyed in that study was much higher than was found in this study. They also found that, similar to this study, renesting efforts produced 40% of all broods in a breeding season.

Perhaps the best measure of the fitness of an introduced animal to its new habitat is the number of young produced plus the survival and reproductive capacities of these young. Spring releases of adult hens in Oregon (Jarvis and Engbring 1976) resulted in production of just 0.05 poults fledged per female released. Ellis and Anderson (1963) also reported 0.05 young per hen in Illinois. Haensly et al. (1985) reported production of 0.18- 0.28 young per female in Oregon. Brittas et al. (1992) reported production of 1.0- 1.7 chicks fledged per hen in a growing pheasant population on an island in Sweden. We were unable to measure chick survival to fledge or

the subsequent reproductive abilities of these offspring but did obtain information on number of chicks hatched by race during the first breeding season following release. Sichuan hens hatched 0.79, ring-necked hens 1.51, and hybrid hens 3.07 chicks per hen released during this study. The lower production exhibited by the Sichuan hens can be attributed to a combination of low adult survival, small clutch sizes, and low nest success rates. The greater production achieved by the hybrid hens can be attributed mainly to the high adult survival which allowed more hens to survive until the nesting period.

In southern Michigan habitats, Sichuan hens survived at a lower rate, had smaller clutch sizes and had lower nest success probabilities than ring-necked and hybrid hens. The low adult survival and nest success of Sichuan hens may be due to habitat preferences that increase susceptibility of hens to predators and nests to predation.

Hybrid hen reproductive parameters (clutch size and nest success) were intermediate between ring-necked hens and Sichuan hens, which seems to indicate additive genetic expression. Hybrid adult hen survival, meanwhile was much higher than both ring-necked and Sichuan hen survival in both 1993 and 1994. This heterotic response of reduced vulnerability to predators with correspondingly higher survival requires additional analysis for clarification and may be the result of habitat selection. Sichuan and ring-

necked pheasants interbreed readily and the hybrid condition should make up a significant segment of pheasant populations where Sichuans have been released. Information on how long the heterotic effects persist in a natural population is very important in determining future pheasant release strategies.

The survival probabilities and reproductive success of known Sichuan x ring-necked hybrid hen pheasants relative to pure Sichuan and Michigan ring-necks shed light on factors affecting success of releases of Sichuan pheasants in Michigan. The release of F1 hybrid pheasants may also provide managers with another tool to enhance the recreational benefits from local pheasant populations.

LITERATURE CITED

- Anderson, W. L. 1964. Survival and reproduction of pheasants released in southern Illinois. *J. Wildl. Manage.* 28: 254-264.
- Boag, D. A. 1972. Effect of radio packages on behavior of captive red grouse. *J. Wildl. Manage.* 36:511-518.
- Brittas, R., V. Marcstrom, R. E. Kenward, and M. Karlbom. 1992. Survival and breeding success of reared and wild ring-necked pheasants in Sweden. *J. Wildl. Manage.* 56:368-376.
- Campa, H., III, M. L. Rabe, P. I. Padding, E. J. Flegler, Jr., G. Y. Belyea, and H. H. Prince. 1987. An evaluation of the release of Sichuan pheasants in Livingston County, Michigan, 1987. *Mich. Dep. Nat. Resour., Fed. Aid Wildl. Restor. Proj. W-127-r-5, Study 71, Job 3.* 71 pp.
- Delacour, J. 1977. *The pheasants of the world.* Second ed. World Pheasant Assoc. and Spur Publ., Hindhead, England.
- Dumke, R. T., and C. M. Pils. 1973. Mortality of radio-tagged pheasants on the Waterloo wildlife area. *Wis. Dep. Nat. Resour. Tech. Bull.* 72. 52 pp.
- _____ and _____. 1979. Renesting and dynamics of nest site selection by Wisconsin pheasants. *J. Wildl. Manage.* 43 (3): 705- 716.
- Ellis, J. A. and W. L. Anderson. 1963. Attempts to establish pheasants in southern Illinois. *J. Wildl. Manage.* 27: 225-239.
- Gates, J. M., and J. B. Hale. 1975. Reproduction of an east-central Wisconsin pheasant population. *Wisconsin Dept. Nat. Res. Tech. Bull.* 85. 70 pp.
- Gatti, R. C., Dumke, R. T. and C. M. Pils. 1989. Habitat use and movements of female ring-necked pheasants during fall and winter. *J. Wildl. Manage.* 53 (2): 462-475.

- Haensly, T.F., S.M. Meyers, J.A. Crawford and W.J. Castillo. 1985. Treatments affecting post-release survival and productivity of pen reared ring-necked pheasants. Wildlife Society Bulletin 13: 521-528.
- Hanson, L. E. and D. R. Progulske. 1973. Movements and cover preferences of pheasants in South Dakota. J. Wildl. Manage. 37 (4): 454-461.
- Heisey, D. M. and T. K. Fuller. 1985. Evaluation of survival and cause-specific mortality rates using telemetry data. J. Wildl. Manage. 49 (3): 668- 674.
- Hensler, G. L., and J. S. Nichols. 1981. The Mayfield method of estimating nesting success: a model, estimators and simulation results. Wilson Bull. 93: 42-43.
- Herzog, P. W. 1979. Effects of radio-marking on behavior, movements, and survival of spruce grouse. J. Wildl. Manage. 43: 316-323.
- Hessler, E., J. R. Tester, D. B. Siniff, and M. M. Nelson. 1970. A biotelemetry study of survival of pen-reared pheasants released in selected habitats. J. Wildl. Manage. 34(2): 267- 273.
- Hill, D.A., and P.A. Robertson. 1988. The pheasant: ecology, management and conservation. Blackwell Scientific Publ., Oxford. 296 pp.
- Hines, J. E. and F. C. Zwickel. 1985. Influence of radio packages on young blue grouse. J. Wildl. Manage. 49 (4): 1050-1054.
- Jarvis, R. L. and J. Engbring. 1976. Survival and reproduction of wild and game farm pheasants in western Oregon. NW Sci. 50: 222-230.
- Johnsgard, P. A. 1986. The Pheasants of the World. Oxford Univ. Press, New York. 300 pp.
- Johnson, P. L. 1992. Survival, habitat use, and nest sites of Sichuan hybrid pheasants in Pennsylvania. M. S. Thesis. Penn. State Univ. 79 pp.
- Johnson, R. N., and A. H. Berner. 1980. Effects of radio-transmitters on released cock pheasants. J. Wildl. Manage. 44: 686-689.
- Kaplan, E. L., and P. Meier. 1958. Nonparametric estimation from incomplete observations. J. Am. Stat Assoc. 53: 457-481.

- Leptich, D.J. 1992. Winter habitat use by hen pheasants in southern Idaho. *J. Wildl. Manage.* 56 (2): 376-380.
- Lief, A. P. 1994. Survival and reproduction of wild and pen-reared ring-necked pheasant hens. *J. Wildl. Manage.* 58 (3): 501-506.
- Luukkonen, D. R. 1993. Population characteristics of wild Sichuan and ring-necked pheasants in southern Michigan. *Mich. Dep. Nat. Resour., Fed. Aid Wildl. Restor. Proj. W-127-R-11, Study 71, Job 19.* 27 pp.
- Marcstom, V., R. E. Kenward, and M. Karlbom. 1989. Survival of ring-necked pheasants with backpacks, necklaces, and leg bands. *J. Wildl. Manage.* 53 (3): 808-810.
- Mayfield, H. F. 1961. Nesting success calculated from exposure. *Wilson Bulletin.* 73: 255-261.
- _____. 1975. Suggestions for calculating nest success. *Wilson Bulletin.* 87: 456-466.
- Miller, H. W. and D. H. Johnson. 1978. Interpreting the results of nesting studies. *J. Wildl. Manage.* 42 (3): 471-476.
- Myers, S. M., Crawford, J. A., Haensly T. F. and W. J. Castillo. 1988. Use of cover types and survival of ring-necked pheasant broods. *Northwest Science*, Vol. 62, No. 1.
- Padding, P. I. 1988. Habitat selection and reproductive success of Sichuan pheasants in Michigan. M.S. Thesis, Michigan State Univ., East Lansing. 66 pp.
- Penrod, B. D., D. E. Austin, and J. W. Hill. 1986. Mortality, productivity, and habitat use of hen pheasants in western New York Fish and Game J. 33: 67-123.
- Peterson, L. R., R. T. Dumke, and J. M. Gates. 1988. Pheasant survival and the role of predation. Pages 165-196 in D. L. Hallett, W. R. Edwards, G. V. Burger, eds. *Pheasants: Symptoms of wildlife problems on agricultural lands.* North Central Section of the Wildl. Soc., Bloomington, IN.
- Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. *J. Wildl. Manage.* 53 (1): 7-15.

- Prince, H. H., P. Squibb, and G. Y. Belyea. 1988. Sichuans, pheasants of the future?-Learning from past release programs. Pages 291-305 in D. L. Hallett, W. R. Edwards, G. V. Burger, eds. Pheasants: Symptoms of wildlife problems on agricultural lands. North Central Section of the Wildl. Soc., Bloomington, IN.
- Rabe, M. L., H. Campa, III, E. J. Flegler, Jr., G. Y. Belyea, and G. M. Bragdon. 1988. An evaluation of 1988 Sichuan pheasant releases in Michigan. Mich. Dep. Nat. Resour., Fed. Aid Wildl. Restor. Proj. W-127-R-6, Study 71, Job 3. 97 pp.
- Snyder, W. D. 1985. Survival of radio-marked hen ring-necked pheasants in Colorado. J. Wildl. Manage. 49 (4): 1044-1050.
- Squibb, P. 1985. The Sichuan pheasant. Michigan Nat. Resour. Mag. 54 (5): 4-11.
- Wagner, F. H., C. D. Besadny, and C. Kabat. 1965. Population ecology and management of Wisconsin pheasants. Wisconsin Conserv. Dep. Tech. Bull. 34-168 pp.
- Warner, R. E. 1988. Habitat management: how well do we recognize the pheasant facts of life. Pages 129-148 In D. L. Hallett, W. R. Edwards, G. V. Burger, eds. Pheasants: Symptoms of Wildlife Problems on Agricultural Lands. North Central Section of the Wildl. Soc., Bloomington, IN.
- _____ and S. L. Etter. 1983. Reproduction and survival of radio-marked hen ring-necked pheasants in Illinois. J. Wildl. Manage. 47: 369-375.
- Whiteside, R. W. and F. S. Guthery. 1983. Ring-necked pheasant movements, home ranges, and habitat use in west Texas. J. Wildl. Manage. 47 (4): 1097-1104.
- Wilson, R. J., R. D. Drobney, and D. L. Hallett. 1992. Survival, dispersal, and site fidelity of wild female ring-necked pheasants following translocation. J. Wildl. Manage. 56 (1): 79-85.
- Woodward, A.E., H. Abplanalp, J.M. Pisenti and L.R. Snyder. 1983. Inbreeding effects on reproductive traits in the ring-necked pheasant. Poultry Science. 62: 1725- 1730.

MICHIGAN STATE UNIV. LIBRARIES



31293013992197