Survival and Nesting Habitat use by Sichuan and Ring-necked Pheasants Released in Ohio[1]

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Abstract. Ring-necked pheasant (*Phasianus colchicus*) populations in the Midwestern United States have declined drastically since World War II. Population numbers in Ohio have leveled off since the establishment of the Conservation Reserve Program (CRP); however, a return to historically abundant ring-necked pheasant populations is unlikely with current land-use practices. Studies by the Michigan Department of Natural Resources (DNR) of released Sichuan pheasants (*P. c. strauchi*), a subspecies of the ring-necked pheasant, suggested that Sichuans may nest in woody cover, a trait that could reduce agriculture-related nest losses common to ring-necked pheasants and potentially increase pheasant populations. We released over 2,000 Sichuan pheasants (962 females, 1,116 males) and 208 ring-necked pheasants (24 females, 84 males) in central Ohio, United States, in early April 1993-96. Survival and habitat use before, during, and after the nesting season were evaluated for a sample of hens from each subspecies through the use of radio-telemetry. Survival rates (range = 0.05-0.15) and apparent nest success (38% and 50% for Sichuan and ring-necked nests, respectively) were not different between the subspecies. The largest source of mortality for both subspecies was predation (71-84% and 65-88%, for Sichuan and ring-necked hens, respectively). Most nests, 85% of Sichuan and 81% of ring-necked, were located in upland herbaceous, upland shrub/scrub, and hay macro-habitat types. Nests of both subspecies were within 16 m of an edge, surrounded by few woody stems (median = 0.25/m^2) and dense herbaceous cover (1,450 and 1,130 stems/m^2, Sichuan and ring-necked nests, respectively). Sichuan hens selected a higher proportion of forbs (37.5% and 15.0%, Sichuan and ring-necked, respectively) and ring-necked hens selected a higher proportion of grass (17.5% and 37.5%, Sichuan and ring-necked, respectively) within 1.0 m^2 of the nest ($P \leq 0.010$). Population survey indices suggested that a self-sustaining Sichuan pheasant population was not established.

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INTRODUCTION

Changes in agricultural practices since World War II have led to dramatic declines in ring-necked pheasant (*Phasianus colchicus*) populations throughout the Midwestern United States (Etter and others 1988). Pheasant populations in Ohio have decreased since the late 1950s to an all-time low in the 1980s (Ohio Division of Wildlife, unpublished report, 2003). The Conservation Reserve Program (CRP) provision of the 1985 Food Securities Act has had a positive impact on numbers of grassland-associated birds, including pheasants, in several states (King and Savidge 1995; Patterson and Best 1996). Although Ohio pheasant survey indices and harvest have leveled off somewhat since 1985 with the establishment of over 120,000 ha of grassland enrolled in the CRP, the outlook for substantially increasing pheasant numbers in the state's traditional pheasant range is bleak. Intensive row-crop agriculture and urban sprawl account for over 6.7 million ha of land cover in the state (63.2%, Ohio Department of Natural Resources, unpublished data). Despite habitat loss and declining populations, pheasants are a popular game bird throughout the corn belt of the US. State Wildlife agencies, charged with conservation and management of wildlife resources, are often pressured by their constituents to stock or transplant pheasants to increase populations.

Biologists with the Michigan Department of Natural Resources (DNR) released and monitored the "Sichuan" pheasant (*P. c. strauchi*) from 1987 through the mid-1990s. The Sichuan, a subspecies of the ring-necked pheasant, was imported from Sichuan Province, Peoples' Republic of China in 1985 (Squibb 1985). Sichuans inhabit mountainous oak and pine forests and brushy habitat adjacent to agricultural fields in their native land. Michigan DNR's early research suggested that Sichuans might nest in woody cover, habitat usually considered marginal for ring-necked pheasants (Prince and Padding 1988; Rabe and others 1988; Luukkonen 1990); however, limited habitat use comparisons between the subspecies were completed before our study was initiated. Michigan researchers had acknowledged the need for further research before clear comparisons could be made (Campa 1989; Luukkonen 1990).

Sichuan pheasants may be more productive than ring-necked pheasants if their nesting habitat selection in woody cover reduced agriculture-related nest losses. Unlike grasslands, brushland habitat has increased in Ohio from 4,485 ha in the early 1970s to 170,000 ha in 1994 (Ohio Department of Natural Resources, unpublished data). Establishment of Sichuan pheasants along the glaciated-unglaciated border counties in Ohio would also expand pheasant populations into non-traditional pheasant range. Objectives of this study were

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to determine and compare post-release survival rates and habitat use of Sichuan and ring-necked pheasant hens, before, during, and after the nesting period. Establishment of a Sichuan pheasant population in the release area was evaluated by pre- and post-release pheasant population surveys.

MATERIALS AND METHODS

Selection of the study area and release sites followed guidelines developed by the Michigan DNR for Sichuan pheasant evaluations (Michigan DNR, unpublished report, 1991). Counties that met habitat criteria for this study (n = 9) were located along Ohio's glacial border from east-central to south-central Ohio. Two township-sized areas, 1 experimental and 1 control, were selected in Licking County, in central Ohio, because they met the habitat criteria and were within a reasonable driving distance of research headquarters. Mary Ann Township, in the northeastern section of the county, was selected as the experimental site. Land use was characterized by 38.9% active agriculture, 55.8% woody cover, 4.9% urban development, and 0.3% surface water (source: Ohio Capabilities Analysis Program database, Division of Soil and Water Conservation, 1985). Fallsbury Township, located northeast of Mary Ann Township, was selected as the control site. Land use in Fallsbury Township consisted of 28.2% active agriculture, 70.1% woody cover, 1.6% urban development, and 0.2% surface water (source: Ohio Capabilities Analysis Program database, Division of Soil and Water Conservation, 1985).

Paired sites were selected in each of 3 habitat types for release of radioed Sichuan and ring-necked pheasant hens. Sites were selected based upon size (≥16 ha), habitat (woody cover), and their distribution throughout the experimental township. Two release sites, 76 ha and 44 ha in size, were evergreen tree farms. Trees ranged from seedlings to 4.5 m in height. Ground cover was a mixture of grasses, forbs, and low-growing brambles (see Table 1 for scientific names and description of macro-habitat types). Vegetation between tree rows was mowed 1-3 times during the growing season. Two release sites, 32 ha and 30 ha, were selected in emergent and shrub/scrub wetlands. The last 2 release sites, approximately 16 ha and 65 ha, were in upland shrub/scrub habitats with a grass and forb understory. These sites were undisturbed during the growing season.

Pheasants were raised at the Ohio Division of Wildlife's propagation facility near Urbana in Champaign County, and were nearly 1-year-old adults at the time of release. Releases were in the experimental township only; the control township did not receive any released pheasants.

Radio transmitters were acquired from Telonics, Inc. (Mesa, AZ) and attached backpack-style with 0.5-cm Teflon ribbon. New and refurbished transmitters weighed an average of 21.3 g and 24.4 g, respectively (2.3 and 2.6% mean body weight), and each was equipped with a mortality switch. Pheasants were fitted with backpacks 10-12 days prior to release for an acclimation period. This research was conducted in accordance with The Ohio State University Institutional Laboratory Animal Care and Use Committee Protocol (#657001).

TABLE 1

Macro-habitat type descriptions of vegetation used by Sichuan and ring-necked pheasant hens in Licking County, OH, 1994-96.

Macro-habitat type	Description
Active agriculture	Grain crops (for example, oats, wheat, soybeans, corn), including those recently planted
Idle agriculture	1-3 years out of active production with <50% herbaceous canopy cover
Hay field	Alfalfa (*Medicago sativa*)/grass (for example, *Bromus* spp., *Dactylis glomerata*, *Phleum pratense*)/clover (for example, *Melilotus* spp., *Trifolium* spp.) grown for hay, cut during growing season
Upland herbaceous	Grass (for example, *Bromus* spp., *Festuca* spp., *Phleum pratense*, *Poa pratensis*) and forbs (for example, *Aster* spp., *Daucus carota*, *Solidago* spp.), <30% woody canopy (for example, *Rubus* spp., *Rosa multiflora*)
Upland shrub/scrub	Woody plant (for example, *Crataegus* spp., *Malus* spp., *Picea* spp., *Pinus* spp., *Prunus* spp., *Rubus* spp., *Rosa multiflora*), crown closure >30%, <10.2 cm dbh
Emergent wetland	Erect, rooted, herbaceous hydrophytes (for example, *Typha* spp., *Scirpus* spp., *Carex* spp.), <50% open water
Scrub/shrub wetland	Contains hydrophytes or is saturated with water at some time during the growing season *and* contains shrubs and/or small trees <6.0 m (20 ft) high and/or trees >6.0 m but with ≤50% crown closure
Woody strip cover	Linear habitat ≤30 m wide, for example, fencerows, ditches, roadsides, hedgerows, with ≥50% woody canopy cover (for example, *Crataegus* spp., *Malus* spp., *Picea* spp., *Pinus* spp., *Prunus* spp., *Rubus* spp., *Rosa multiflora*)
Herbaceous strip cover	Linear habitat ≤30 m wide, for example, fencerows, ditches, roadsides, hedgerows, with grass and forbs, <50% woody canopy cover

Pheasants were located 5 days per week with hand-held receiving antennas. Compass bearings were taken from a minimum of 3 receiving locations and plotted on study area cover maps (1.0 cm = 49 m). Hens were located during 1 of 3 time periods each day: sunrise to 1000 hours, 1000-1600 hours, and 1600 hours to sunset.

Daily tracking times were rotated so that locations for each hen were obtained equally across time periods.

Survival and Mortality

Transmitters on mortality mode were located after surviving birds were tracked. Remains were usually recovered within 24 hours of death by experienced observers. Cause of death was determined from evidence at the kill site when possible. Criteria developed by Michigan wildlife personnel (Rabe and others 1988, p 87-88), as well as information from Darrow (1938), Einarsen (1956), and Dumke and Pils (1973), were used to identify predator species and cause of death. Predators were combined into mammalian and avian categories to reduce uncertainty about specific predator species. Hens on mortality mode during the nesting season were not approached until the second consecutive day unless their location was away from a known nest. Survival was estimated using the Kaplan-Meier procedure (Kaplan and Meier 1958) as described by Pollack and others (1989). Survival was compared between subspecies and years with a Z-test. Cause-specific mortality rates were compared between subspecies by a Chi-square test.

Nest Success

Hens that were found at the same location for 3 consecutive days were considered to be incubating (Dumke and Pils 1979). Compass bearings were taken to the nest from 3 sites ≥10 m from the nest. Nests were located and status determined when incubating hens were away from the nest for 2 consecutive days during different time periods. Mayfield (1961, 1975) nest success estimates were calculated and 95% confidence limits (Johnson 1979) were compared between subspecies. Apparent nest success also was calculated and compared between subspecies by a Chi-square test.

Chicks were counted once per week from ages 3 to 9 weeks. Attempts were made to flush all young near the hen. Observation time was limited to 15 minutes and was conducted in good weather, before 1600 hours, to minimize negative impacts on chick survival. Broods with at least 1 young surviving to 9 weeks were considered successful. Brood success was compared between subspecies by a Fisher exact probability test (Siegel 1956). Habitat used by hens with broods was summarized but no statistical tests were run because of small sample sizes.

Nest Site Characteristics

Vegetative characteristics of nest sites were measured at the macro- and micro-habitat scales upon nest termination. Macro-habitat around the nest was assigned to a major cover type (Table 1). Woody stems >7.6 cm diameter at breast height (dbh) were counted in 10.0 × 10.0-m plots, stems 2.5-7.6 cm dbh were counted in 5.0 × 5.0-m plots, and stems <2.5 cm dbh were counted in 2 × 2-m plots centered on the nest. Distances were measured from the nest to the nearest woody stem ≤2.5 cm dbh and >2.5 cm dbh, and to the nearest edge, defined as a change in macro-habitat type. Percent cover was approximated within a 1.0-m^2 Daubenmire frame (Daubenmire 1959) centered on the nest with corners oriented in the cardinal directions. Herbaceous stems were counted in 0.1 × 0.1-m corners of the frame and a mean was calculated. Horizontal cover was estimated with a vertical obstruction board (Nudds 1977) at 0.25-m height intervals from 0.0 to 2.0 m at a point 5.0 m from the nest. Estimates were taken from the cardinal directions and a mean was calculated. Overhead cover, quantified as percent canopy, was measured at the nest bowl and 1.0 m above the nest bowl with a spherical densiometer (Lemmon 1956; Prince and Padding 1988). Micro-habitat measurements were repeated at a randomly selected site within 50 m of the nest in the same macro-habitat type. Measurements were compared between subspecies and between subspecies and random sites by Mann-Whitney U-tests. Individual macro-habitat comparisons between subspecies could not be made because of small sample sizes. Macro-habitats were combined into woody and non-woody categories and comparisons between subspecies were made by a Fisher exact probability test (Siegel 1956).

Surveys

Pheasant populations were monitored on a township-wide basis through crowing cock surveys. Survey conditions were standardized similarly to Michigan DNR surveys and guidelines suggested by the Midwest Pheasant Council (unpublished report 1974). Direction of travel was alternated each time a route was repeated. Weather criteria were as follows: skies clear to party cloudy, wind ≤8.0 km/hr, and no precipitation during and immediately before surveys.

Crowing cock survey routes were designed with 27 listening stations uniformly distributed across the experimental and control townships. Stations were further grouped into 9 listening stations per survey route (17.1-23.8 km). Survey procedures were designed to mirror those of Michigan DNR's Sichuan pheasant evaluation when possible (Campa and others 1987). Routes were run 4 times from late April through May 1992-97. Additional surveys were run only in Mary Ann Township in 1998 and 1999. Total calls and number of pheasants heard were recorded for 3-minute intervals. Surveys began 50 minutes before sunrise and were completed in approximately 1 hour. Crowing cock survey indices were compared by township for the period 1992-97 by paired Student's t-tests.

RESULTS

Mary Ann Township received 1,747 Sichuan pheasants (836 females, 911 males) in early April 1993-96. Ten hens and 10 cocks were released at most sites throughout the township (19-22 sites per year). Forty to 45 Sichuan hens equipped with backpack-mounted transmitters were released at 3 sites (13-15 per site) each year, 1994-96. Sixty-five to 70 cocks were released at the same sites a few days previously. Forty to 43 similarly equipped ring-necked pheasant hens and 24-30 cocks were released at 3 additional sites annually.

Survival and Mortality

Sichuan hen survival varied early in the study period each year, however, by week 21 survival was not significantly different among years (range = 0.05-0.14, $P \geq 0.066$, Fig. 1). Ring-necked hen survival differed significantly for only 4 weeks between 1994 and 1996 ($P \leq 0.044$). Otherwise, survival was fairly uniform among the 3 years varying from 0.06 to 0.15 at 21 weeks post-release ($P \geq 0.075$, Fig. 2). The most dramatic difference in survival between subspecies was in the first 12 weeks of 1994 when ring-necked hens survived significantly better than Sichuans ($P \leq 0.039$), but survival was nearly identical by 21 weeks post-release for the 3 years of study ($P \geq 0.295$).

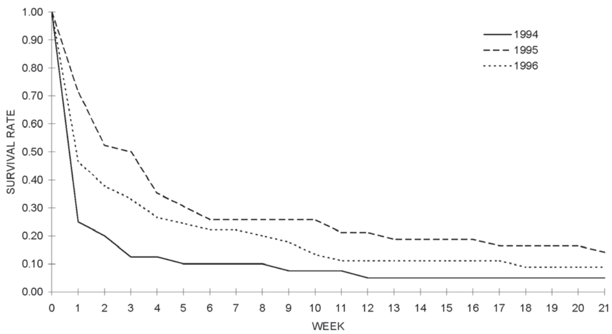

FIGURE 1. Survival of radioed Sichuan pheasant hens released in Mary Ann Township, Licking County, OH, 1994-96.

Predation was the largest source of mortality for released hens of both subspecies. Ring-necked hens (n = 110) were killed by avian and mammalian predators with similar frequency (28%), but Sichuan hens (n = 113) were taken more often by mammalian (44%) than avian predators (18%, P = 0.012). Other causes of death included road kills, mowing, drowning, and poaching. Mortality of 3 severely emaciated Sichuan hens was attributed to transmitter-related causes in 1994.

Nest Success

Forty-three clutches laid by 37 hens (19 Sichuan, 18 ring-necked) reached incubation. Predators were the principle cause of nest failure, consuming eggs of 9 Sichuan nests and 7 ring-necked nests across 6 different habitat types. Hay mowing was the second most common cause of nest failure, destroying nests of 2 Sichuan hens and 5 ring-necked hens. One Sichuan nest in a hayfield was trampled by cattle and 1 was washed away

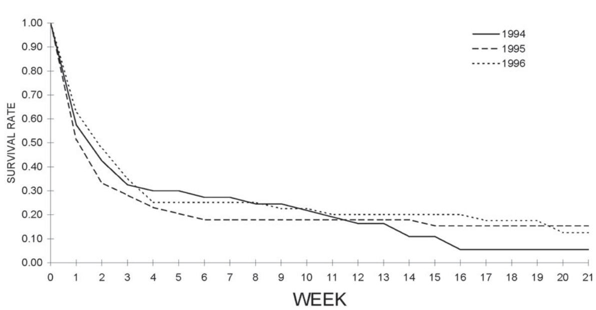

FIGURE 2. Survival of radioed ring-necked pheasant hens released in Mary Ann Township, Licking County, OH, 1994-96.

in torrential rain. Known renesting attempts were limited to 2 Sichuan hens and 4 ring-necked hens. Eight Sichuan and 10 ring-necked clutches survived to hatch. Nest success estimates were not different between subspecies. Apparent nest success was 38% for Sichuan hens and 50% for ring-necked hens (P = 0.443). Similarly, Mayfield (1961, 1975) nest success estimates were 46% for Sichuan hens and 54% for ring-necked hens. Daily survival rates were 0.97 (95% CI = 0.94-0.98) for Sichuan nests and 0.97 (95% CI = 0.96-0.99) for ring-necked nests. Sichuan nests were most successful in upland shrub/scrub (n = 4) and hay (n = 3), whereas ring-necked nests were equally as successful in upland shrub/scrub (n = 4) and upland herbaceous (n = 4). One Sichuan nest was successful in upland herbaceous, and 2 ring-necked nests were successful in herbaceous strip cover and hay.

Brood Success and Habitat Use

Brood success was not different between Sichuans and ring-necks (P = 0.479). Only 3 Sichuan broods (38%) survived to 9 weeks post-hatch. Five ring-necked broods (50%) are believed to have survived to 9 weeks post-hatch, although transmitters on 2 hens failed at 6 and 8 weeks. Five broods of both subspecies disappeared before the first flush count at 3 weeks post-hatch. Predators killed 5 hens (2 Sichuan, 3 ring-necked) within 2 weeks after hatch and their broods were assumed dead. Most locations (n = 119) of ring-necked hens with broods were in upland shrub/scrub (33%), hay (22%), upland herbaceous (20%), and active agriculture (10%) for the first 9 weeks post-hatch. Sichuan hens were also located (n = 69) in upland herbaceous (40%), upland shrub/scrub (37%), and active agriculture (12%) during 9 weeks of brood rearing.

Nest Site Characteristics

Eighty-five percent of Sichuan nests were found in 3 macro-habitat types: upland herbaceous, upland shrub/scrub, and hay. Other Sichuan nests were in idle agriculture and woody strip cover. Similarly, 81% of ring-necked nests were also located in upland herbaceous, upland shrub/scrub, and hay. Less frequently, ring-necked nests were placed in active agriculture and woody and herbaceous strip cover. Combining macro-habitat types into woody and non-woody categories resulted in similar proportions of nests for both subspecies in each type (P = 0.455). Most nests, 62% of Sichuan and 68% of ring-necked, were placed in non-woody habitat.

Daubenmire frame measurements indicated that Sichuan hens selected a higher proportion of forbs and ring-necked hens selected a higher proportion of grass within 1.0 m^2 of the nest ($P \leq 0.010$, Table 2). Canopy cover over the nest bowl was 95-97%, and no differences were detected between subspecies or random sites ($P \geq 0.247$). There was very little canopy cover at 1.0 m above nests of either subspecies. Even so, cover was greater at ring-necked nests (0.7%) than at random sites (0.2%, P = 0.039), but no difference was found between the subspecies (P = 0.406).

TABLE 2

Median % cover at nests and random sites within 50 m of nests for Sichuan and ring-necked pheasant hens released in Mary Ann Township, Licking County, OH, 1994-96.

	Sichuan		Ring-necked	
Category	Nests	Random	Nests	Random
Litter	1.5	1.5	4.0	5.0
Grass	17.5 [a]	40.0	37.5 [a]	75.0
Forbs	37.5 [b]	40.0	15.0 [b]	20.0
Woody	5.5	4.0	17.5	1.0

[a] Mann-Whitney *U*-test, $P = 0.010$.
[b] Mann-Whitney *U*-test, $P = 0.009$.

The percentages of horizontal cover at nest sites were similar between subspecies at all height intervals ($P \geq 0.159$). Vegetation was dense from ground level to 0.5 m for both nests and random sites (median range = 73.9-100.0%). Median cover values from 1.0 to 2.0 m above the nest were at least twice as dense for ring-necked sites (range = 8.8-36.9%) than for Sichuan sites (range = 1.5-17.8%) although the difference was not significant ($P \geq 0.159$). Horizontal cover was denser at Sichuan nest sites than at random sites in the same field for all height intervals above 0.25 m, although only significantly different from 0.5 to 1.0 m ($P \leq 0.049$). Measurements at ring-necked sites did not differ from those at random sites ($P \geq 0.093$).

Median density and maximum height of herbaceous stems at nest sites and random sites were not different ($P \geq 0.083$). Median stem density values ranged 1,130-1,450/m^2. Median height of herbaceous stems ranged 84-93 cm within 1.0 m^2 of the nest and random points. Both subspecies and random sites had median woody stem densities <2.5 cm dbh of 0.25/m^2. Ring-necked nests were closer to small woody stems (1.4 m), ≤2.5 cm dbh, than were Sichuan nests (4.7 m) although the difference was not significant ($P = 0.348$). Median values for woody stem density >2.5 cm dbh were 0.0 for both subspecies and random sites. Distance to woody stems >2.5 cm dbh (range = 14.8-20.9 m) and distance to edge (range = 13.8-16.7 m) were not significantly different between subspecies or between subspecies and random sites ($P \geq 0.173$).

Surveys

The mean number of calls heard per stop on crowing count surveys for Mary Ann Township increased steadily from pre-release in 1992 through 1996, the last year of pheasant release. The index dropped 12-48% each year post-release, 1997-99. The mean number of cocks heard per stop also increased 1992-94, fell slightly in 1995, then reached its peak in 1996 before declining 6-49% in years 1997-99 (Fig. 3). Fallsbury Township indices

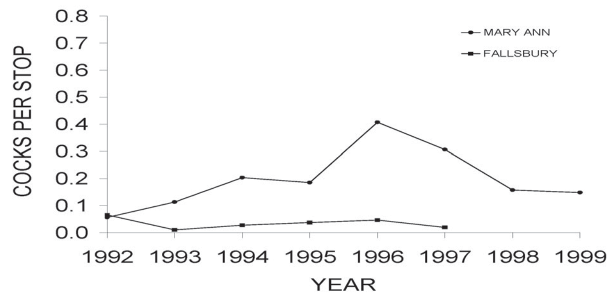

FIGURE 3. Pheasant crowing count indices, Mary Ann (experimental) and Fallsbury (control) townships, Licking County, OH, May 1992-99. Pheasants were released in Mary Ann Township in early April 1993-96.

began at their highest level in 1992, dropped in 1993, then increased slightly each year through 1996. The index fell again in 1997, the last year surveys were conducted. Crowing count indices were significantly higher in Mary Ann Township than in the control township over the project period 1992-97 ($P \leq 0.023$).

DISCUSSION

Survival rates for Sichuan and ring-necked hens released in Ohio were similar to rates reported in several other studies for pen-reared and released pheasants. Michigan biologists reported that ring-necked hens survived longer than Sichuan hens in 2 study years (Luukkonen 1990; Prince and others 1993). Ring-necked hen survival rates ($n = 80$) in 1990 were 0.20 at 10 weeks and 0.07 at 20 weeks. Sichuan hen survival ($n = 30$) was 0.10 and 0.0 at 10 and 20 weeks, respectively. Survival in 1993 was 0.35 and 0.28 for ring-necked hens ($n = 29$), and 0.23 and 0.13 for Sichuan hens ($n = 36$) at 10 and 20 weeks post-release, respectively. A subsequent Michigan study by Niewoonder and others (1998) reported a mean survival rate of 0.11 for Sichuan hens ($n = 144$) and 0.12 for ring-necked hens ($n = 134$) for 30 weeks over a 3-year study period, 1993-95. Johnson (1992) found survival rates at 21 weeks post-release of hen Sichuan hybrids to be 0.0 and 0.008 on 2 Pennsylvania release sites in 1990, and 0.001 and 0.04 on the same release sites in 1991. Pooled survival data from 2 years (1984-85) of early-May ring-necked hen releases in Sweden resulted in a survival rate of 0.21 ($n = 40$) at 13 weeks (Brittas and others 1992), similar to our ring-necked survival rate of 0.16-0.20 at 13 weeks. Survival of ring-necked hens released as adults in South Dakota, 1990-92, was 0.08 at approximately 25 weeks, from early April through early October (Leif 1994). Survival rates in our study were poorer than those reported in a similar 2-year Pennsylvania study (Casalena and Wallingford 1996) for fall-released Sichuan and ring-necked hens (0.48 and 0.50-0.62 at 10 weeks, 0.18-0.27 and 0.22-0.29 at 20 weeks for Sichuan and ring-necked hens, respectively). Petersen and others (1988) reported that annual pheasant hen survival of <30% is insufficient to maintain a pheasant population. Survival rates of 30-35% are necessary for a self-sustaining population, and rates >40% are indicative of a growing population. These figures, and those reported here for released pheasants, demonstrate that releasing pen-raised pheasants is not an efficient nor economical way to establish new populations in areas devoid of pheasants.

Stress from handling and crating may have had an adverse impact on pheasant survival immediately after release. Sichuan hens often flew the length of the production pen and collided with wire fencing during the crating process in 1994. Canvas baffles were hung from overhead wire in the pens to prevent birds from flying while they were crated in 1995-96. Hens with obvious injuries were not included in the study. Transmitter impacts were not evaluated in our study, but we recognize that they may have reduced survival of pheasant hens. Abnormal behavior of pheasant hens carrying transmitters was not observed in the field, although on a few occasions radioed hens flapped louder than non-radioed hens when they flushed.

Predation was the primary cause of mortality in pheasant studies by Hessler and others (1970), Krauss and others (1987), Wilson and others (1992), Riley and others (1994), and Schmitz and Clark (1999). All but 1 of these studies found mammalian predation to be more common than avian predation of ring-necked pheasants. Our study found mammalian and avian predation of ring-necked hens to be similar, but Sichuan hens were killed more often by mammals. Sichuan hens seemed to "sit tight" then flush long distances just before being stepped on when approached in the production pens and in the field. One Sichuan hen was crushed by a front-end loader at a tree farm. This behavior may explain the higher percentage of Sichuan hens killed by mammalian predators. Michigan studies (Campa and others 1987; Rabe and others 1988) found 33.4% and 11.9% avian mortality, and 25.3% and 28.2% mammalian mortality of Sichuan hens in 1987 (n = 87) and 1988 (n = 117), respectively. Niewoonder and others (1998) reported no difference in cause of death between Sichuan, ring-necked, and Sichuan-ring-necked hybrids. Pennsylvania biologists reported avian and mammalian predation rates were similar between subspecies. Avian predators killed 16.3-20.5% and 14.0-22.2%, and mammals killed 20.9-21.3% and 13.1-14.0%, of ring-necked and Sichuan hens, respectively, 1993-95 (Casalena and Wallingford 1996).

Pheasant predation rates have increased considerably in the US since the 1940s, and especially since the 1960s (Petersen and others 1988). Declining survival due to predation has resulted from loss of quality habitat combined with stable or increasing predator populations, particularly important during severe winter weather, and spring dispersal and nesting periods. Most of the predation in this study occurred in April while hens were dispersing from release sites.

Nest success rates were similar for the 2 subspecies and similar to those reported in other studies of pen-raised pheasants. Michigan biologists reported nest success from 30 to 57% for Sichuan nests and 36% for ring-necked nests (Campa and others 1987; Rabe and others 1988; Luukkonen 1990). Casalena and Wallingford (1996) observed that success rates were not different between Sichuan and ring-necked nests and reported an average combined nest success rate of 31%. Daily nest survival rates in our study were nearly equal to those found by Niewoonder and others (1998). They reported that rates did not differ between subspecies (0.961 and 0.976 for Sichuans and ring-necks, respectively, P = 0.090). Mayfield nest success rates were 0.26 for Sichuan nests and 0.41 for ring-necked nests (P = 0.136).

We observed no differences in macro-habitat type selection between the subspecies for nesting. Most nests were located in upland herbaceous, upland shrub/scrub, and hay macro-habitat types. Nests were most successful in upland shrub/scrub habitat, although ring-necked hens were equally as successful in upland herbaceous. Michigan studies (Campa and others 1987; Rabe and others 1988) also reported Sichuan hens nested most frequently in upland herbaceous, active and idle cropland, and upland shrub cover types. The percentage of nests in herbaceous cover ranged from 52.8 to 85.6%, and in upland shrub cover from 4.8 to 15.2%. Casalena and Wallingford (1996) found 24% of Sichuan nests in woodland and in rangeland, and 20% in hayfields. They observed a larger proportion, 34%, of ring-necked nests located in woodland and only 21% in hay. Most successful Sichuan clutches were located in hay and rangeland (29%) and 23% were in woodland. However, most successful ring-necked clutches were located in woodland (46%) and 31% were in hay. Sichuan hybrid hens in Pennsylvania placed 26% of their nests (n = 10) in herbaceous rangeland, and in shrub/brush and mixed rangeland over 2 nesting seasons (Johnson 1992). Nests were most successful in herbaceous rangeland on 1 study site (n = 3) and in cropland on the other (n = 3).

Sichuan hens spent most of their time in upland herbaceous and shrub/scrub habitat during brood rearing. Ring-necked hens with broods were also located in those habitats and in hay. These findings are not surprising since most nests were found in the same habitats. Kuck and others (1970) reported that wild ring-necked broods used all available habitat within 2.0-4.0 ha of nest sites for the first 3 weeks post-hatch. Riley and others (1998) found hens with broods selected grassland habitat in much higher proportions than its availability in their Iowa study area. Hay and oats were preferred by wild pheasant broods in Illinois up to 6 weeks of age for feeding and roosting (Warner 1979). Sichuan hens with broods preferred agricultural fields (including idle fields) and upland scrub-shrub habitat in the first 21 days post-hatch in Michigan (Prince and Padding 1988); later in brood rearing (days 22-42) hens primarily selected upland herbaceous and agricultural habitats.

Micro-habitat measurements indicated little difference in vegetational composition between Sichuan and ring-necked nest sites and between each subspecies and random sites. Both subspecies selected sites with few woody stems, dense herbaceous cover up to 1.0 m in height, and within 16 m of an edge. Forbs were denser around Sichuan nests, which may suggest that they were in habitat that was in a later successional stage than ring-necked nest sites. Canopy cover at the nest bowl was within the range of values reported by Michigan for Sichuan nests, but was slightly greater than those reported for ring-necked nests. Both subspecies in our study selected nest sites in dense vegetation from ground level to 0.5 m (percent cover range = 94.3-100%). Similarly, Rabe and others (1988) reported that Sichuans nested in areas with dense vegetation <0.5 m in height over and around the nest bowl, but vegetation >0.5 m was relatively sparse. They reported percent cover values of 84.0 and 96.3% for a 0.0-0.5 m height interval, estimated by line intercept method. Luukkonen (1990) also found dense vegetation up to 0.5 m at Sichuan nests using Robel pole measurements (0.56 m for first nests, 0.53 m for second nests). Herbaceous stem densities were greater at Ohio nests than those reported for Sichuan and ring-necked nests in Michigan (Luukkonen 1990). Mean woody stem density <2.5 cm dbh was 3.3 stems/m^2 for Sichuan nests and 2.6 stems/m^2 for ring-necked nests in our study. Rabe and others (1988) reported means for Sichuan nests at 2 sites were 0.75 and 1.2 stems/m^2; however, their measurements included only stems 0.5-1.0 m in height. Luukkonen (1990) reported woody stem density of stems <2.5 cm dbh at Sichuan nests in 2 height categories. Densities were 1.1 stems/m^2 for vegetation ≥1.0 m in height and 14.2 stems/m^2 for vegetation <1.0 m in height. Mean values for stems 2.5-7.6 cm dbh were 0.02 stems/m^2 for both Ohio Sichuan and ring-necked nests, within the range of 0.01-0.03 stems/m^2 found by Rabe and others (1988) and 0.03 stems/m^2 reported by Luukkonen (1990) for Sichuan hens. The mean for ring-necked nests was greater than the 0.004 stems/m^2 found by Luukkonen (1990).

Survey indices indicated that pheasant populations were very low before the study began, increased during 4 years of spring releases, and declined substantially in the 3 years post-release. Similar results have been reported in Illinois (Ellis and Anderson 1963), Iowa (Farris and others 1977), and Oregon (Jarvis and Engbring 1976) for released pheasants. It should be noted that annual crowing count indices 1993-96 were run 1 month after the release of cock pheasants throughout the study township. An increase in survey observations could be indicative of better short-term survival of released cocks from 1 year to the next rather than growth of a newly established population.

CONCLUSIONS

Released Sichuan hens had no survival advantage over released ring-necked hens. Survival was similar to that reported in other studies of released pheasants and lower than necessary to establish a stable pheasant population. This finding was supported by the continuing decline in pheasant numbers in Mary Ann Township after annual releases were discontinued, suggesting that a viable population was not established. Not surprisingly, predation was the primary cause of mortality as in most pheasant studies. Sichuan hens succumbed more readily to mammalian predation than ring-necked hens, possibly because of a behavioral tendency to sit tight when in perceived danger.

Similar conclusions were reached by researchers in Michigan and Pennsylvania. The Michigan DNR concluded in 1997 that experimental releases of Sichuan pheasants failed to demonstrate increases in pheasant abundance in their study area (Luukkonen and others 1997). Casalena and Wallingford (1996) also concluded that according to survival and nest success rates determined in their study and current habitat conditions, pheasant populations would continue to decline in their Pennsylvania study area.

Micro-habitat measurements differed only in the proportions of grass and forbs within 1.0-m^2 of the nests. Both subspecies placed most of their nests in upland herbaceous, upland shrub/scrub, and hay habitats. These findings were also consistent with those of Sichuan and ring-necked pheasant studies in Michigan and Pennsylvania. Ohio nests were within 16 m of an edge, surrounded by few woody stems and dense herbaceous cover up to 1.0 m in height. Although nest success by hens that survived to reproduce was similar to that found in other studies, recruitment by both subspecies was poor. Production from 126 Sichuan hens and 124 ring-necked hens released was limited to only 3 and 5 broods, respectively. Brood-rearing habitat consisted mainly of brush, upland herbaceous, hay, and active agricultural habitats.

Ring-necked pheasants are dependent upon the diversity of the agricultural landscape. Habitats preferred by both subspecies in this study are consistent with those found in typical Midwest farmland of 30-40 years ago. However, land use has changed considerably in the last few decades. Intensive agriculture, use of pesticides, removal of fencerows and odd areas, suburban sprawl, and commercial development have had detrimental effects upon pheasant populations. It is doubtful that the answer to declining pheasant numbers lies in finding a new and better bird to release into declining and increasingly fragmented habitat. Rather, future research should concentrate on how intensive land use affects pheasant populations on a landscape scale and how land managers can positively impact those populations.

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