

PRODUCTIVITY AND SURVIVAL OF THE LOGGERHEAD SHRIKE IN INDIANA¹

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Abstract. We estimated productivity and adult survival of the Loggerhead Shrike (*Lanius ludovicianus*) in Indiana during 1988 and 1989. Productivity averaged 3.82 fledglings/pair and adult survival was 52% based on observed band-return and site-fidelity rates. These numbers predict a mean lifetime reproductive output of 4.08 young per breeding individual, requiring a juvenile survival rate of 24% for replacement. Although the number of breeding pairs in our core study area remained constant, Breeding Bird Survey data and recent surveys indicate that the population is declining.

Key words: Loggerhead Shrike, *Lanius ludovicianus*, Indiana, productivity, survival probability.

PRODUCTIVIDAD Y SOBREVIVENCIA DEL ALCAUDÓN AMERICANO (*LANIUS LUDOVICIANUS*) EN INDIANA.

Resumen. Estimamos la productividad y sobrevivencia adulta del alcaudón americano en Indiana en 1988 y 1989. La productividad promedio fue de 3.82 pollos/pareja y la sobrevivencia adulta fue del 52% según recuperaciones de anillos y tasas de fidelidad de sitio. Estos números predicen una capacidad reproductiva vitalicia de 4.08 pollos por individuo reproductor, lo cual requiere una tasa de sobrevivencia juvenil de 24% para alcanzar el remplazo. Aunque el número de parejas nidificantes en nuestra área de estudio permaneció constante, datos del Breeding Bird Survey y conteos recientes indican que la población está en declive.

Palabras clave: Alcaudón americano, *Lanius ludovicianus*, Indiana, productividad, probabilidad de sobrevivencia.

PRODUCTIVITE ET SURVIE DE LA PIE-GRIECHE MIGRATRICE DANS L'INDIANA

Résumé. Nous avons estimé la productivité et la survie adulte de la Pie-grièche migratrice (*Lanius ludovicianus*) dans l'Indiana en 1988 et 1989. La productivité moyenne était de 3.82 poussins à l'envol par couple, et la survie adulte était de 52% sur la base des retours de bagues observés et des taux de fidélité au site. D'après ces chiffres on prédit la production de 4.08 jeunes en moyenne par chaque adulte reproducteur au cours de sa vie, avec un taux de survie juvénile de 24% pour assurer le remplacement. Bien que le nombre de couples reproducteurs reste constant au cœur de notre site d'étude, les données du Breeding Bird Survey et les derniers recensements indiquent que la population est en déclin.

Mots-clés: Pie-grièche migratrice, *Lanius ludovicianus*, Indiana, productivité, probabilité de survie.

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PRODUKTIVITÄT UND ÜBERLEBENSRATE
VON LOUISIANAWÜRGERN IN INDIANA

Zusammenfassung. Wir berechneten Produktivität und Adult-Überlebensrate beim Louisianawürger (*Lanius ludovicianus*) in Indiana für 1988 und 1989. Produktivität war im Mittel 3.82 flügge Junge/BP und Adult-Überlebensrate auf Basis von Wiederfunden und Rückkehraten entsprach 52%. Aus den Zahlen ergibt sich eine mittlere Lebens-Reproduktion von 4.08 Jungvögeln pro brütendem Individuum, was wiederum eine Überlebensrate von 24 % bei den Jungvögeln voraussetzt, um den Verlust der Altvögel zu kompensieren. Obwohl die Zahl der Brutpaare in unserem Hauptuntersuchungsgebiet unverändert blieb, legen Monitoringdaten aus dem BBS und jüngste Bestanderfassungen nahe, dass die Population abnimmt.

Schlüsselwörter: Louisianawürger, *Lanius ludovicianus*, Indiana, Produktivität, Überlebenswahrscheinlichkeit.

INTRODUCTION

The Loggerhead Shrike (*Lanius ludovicianus*) has exhibited a well-documented but poorly-understood decline over much of its range during this century (Morrison 1981, Peterjohn and Sauer 1995, Cade and Woods 1997). The Breeding Bird Survey (BBS) shows a 3.69% annual decline, one of the strongest of any species, survey-wide from 1966 to 1998 (Sauer et al. 1999). Suggested causes of declines most commonly include loss of nesting habitat (Graber et al. 1973, Smith and Kruse 1992), high pesticide loads (Busbee 1977, Anderson and Duzan 1978, Blumton et al. 1990) and high winter mortality due to habitat loss in turn producing increased intraspecific competition (Brooks and Temple 1990a, Lymn and Temple 1991, Telfer 1993). Other potential factors include road mortality (Bull 1974, Novak 1986, Flickinger 1995), disease (LeGrand 1985), interspecific competition (Novak 1986), predation (Scott and Morrison 1990), and reduced productivity (Yosef 1994). However, no single factor satisfactorily accounts for these declines (Bystrak 1983, Hanrahan 1987).

Declines in populations are evident among shrike species world-wide. Recent and drastic declines and range contractions have been documented for every well-studied shrike species (Yosef and Lohrer 1995). These trends prompted the First International Shrike Symposium in 1993; this symposium highlighted the consistency of population trends, the scarcity of good demographic data, and the need for further study.

It is generally recognized that critical data on

productivity and survivorship are essential for identifying not only causes of population declines but also effective management and conservation strategies (DeSante et al. 1993, Martin et al. 1995). Unfortunately, demographic data on shrikes are scarce. Mostly predatory birds of open country, shrikes do not lend themselves well to standardized mark-recapture studies such as the Monitoring Avian Productivity and Survivorship (MAPS) Program. In fact, no systematic study of survivorship in the Loggerhead Shrike, perhaps the most intensively-studied shrike species, has been done. The few existing estimates of survivorship, based on band returns or site reoccupancy, are confounded by unknown degrees of dispersal and philopatry (Yosef 1996).

In this paper we present data on the demographics of Indiana's remnant Loggerhead Shrike population on the basis of an intensive two-year study, 1988-1989. We estimated productivity in each year. We also estimated adult survival probability as a function of band-return rate and site fidelity. We used these results to estimate lifetime reproductive output and the juvenile survival probability necessary for population maintenance. We examine potential sources of error for consideration in future studies.

STUDY AREA

The 151 active Loggerhead Shrike territories found in Indiana during 1988 and 1989 were clustered in 12 southern counties and concen-

trated in the southwest (Figure 1). All sites fell within the Highland Rim and Lexington Plain physiographic regions (Bystrak 1981). The area is primarily open farmland interspersed with woodlots of various sizes. The terrain ranges from relatively flat bottomlands in the west to hilly, more heavily wooded country in the east. Many of the territories were in Amish settlements, which appear to provide habitat conditions especially attractive to shrikes (Burton 1989, 1990).

METHODS

PER-PAIR PRODUCTIVITY

To measure productivity, we included only territories found early in the season (before first broods fledged). In 1988, we visited all active shrike territories weekly from time of discovery through August or until we sighted no birds during two consecutive visits. We checked nest contents on every visit until fledging or failure and collected data on fledging rates. In 1989, we visited territories every four days and checked nests as in 1988.

ADULT SURVIVAL PROBABILITY

We caught 37 adult shrikes (22 males and 19 females) from breeding pairs in 1988 and banded them with unique combinations of one aluminum band on one leg and two coiled, plastic color bands on the other. In 1989, we revisited all sites active in 1988 to determine site re-occupancy (the proportion of 1988 territories active in 1989) and site fidelity (the proportion of returning adults using the same territory in both years). We searched the study area for additional territories not found in 1988. We calculated band-return rates as the proportion of banded birds of each sex found in 1989. From these data we estimated adult survival probability from 1988-1989 as

$$ASP = BR/SF,$$

where *ASP* = adult survival probability, *BR* = band-return rate, and *SF* = site fidelity. This model is based on the assumptions that we found all the returning birds and that surviving birds were as likely to switch territories as they were to leave the study area.

POPULATION CHANGE

In both years we counted the number of shrike pairs within our intensively monitored core

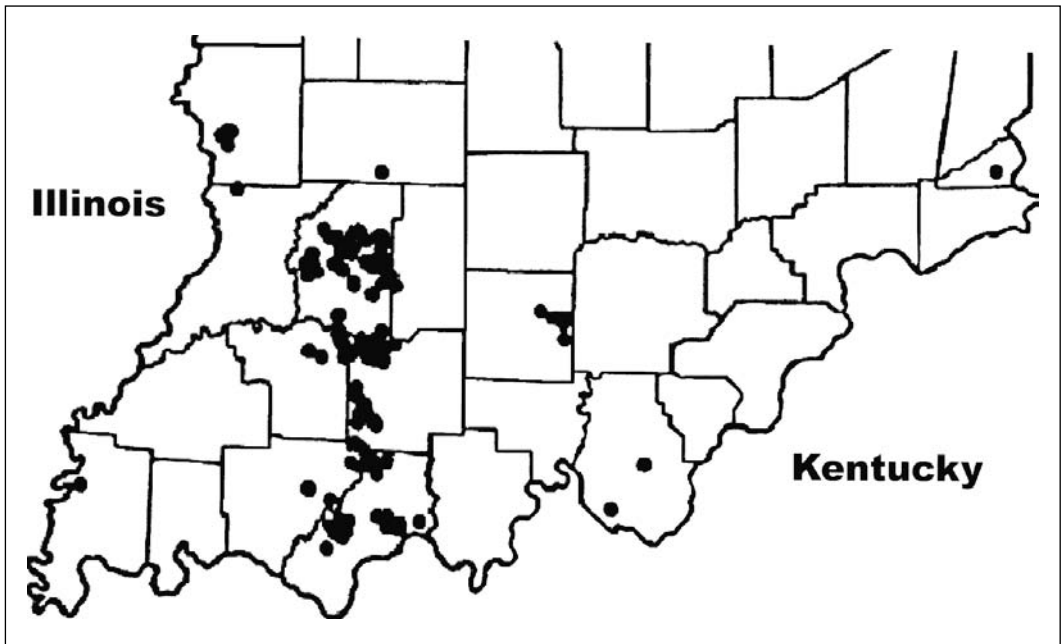


FIGURE 1. Known Loggerhead Shrike nest sites in Indiana, 1988-89.

study area to estimate the two-year local population change. At the beginning of the 1989 breeding season, we checked all known 1988 territories in this area at least twice. Intervening areas were traversed and scanned every week in 1988 and every four days in 1989.

Results are expressed as mean \pm SE. Statistical significance was set at $\alpha = 0.05$.

RESULTS

PRODUCTIVITY

Nesting pairs ($n = 55$) produced an average of 3.82 ± 2.76 fledglings during the two years of study [3.12 ± 2.50 ($n = 17$) in 1988 and 4.13 ± 2.87 ($n = 38$) in 1989; Table 1].

ADULT SURVIVAL

During 1989, 38 of 54 nesting territories found in 1988 were active again; thus, site re-occupancy was 0.704 (Table 1). Eleven of 12 returning banded males and 3 of 5 returning banded females used the same territories in both years; thus, *BR* was 0.545 for males and 0.263 for females and *SF* was 0.917 for males and 0.600 for females (Table 1). This resulted in *ASP* values of 0.594 for males and 0.438 for females ($\bar{x} = 0.516$).

POPULATION CHANGE

The number of breeding pairs in our core study area remained constant at 17 from 1988 to 1989, indicating no change in the size of the population. Site re-occupancy in this area was identical to that for the entire study area, indicating that the core was representative of the whole.

DISCUSSION

PRODUCTIVITY

We probably underestimated productivity slightly because our 1988 sample was biased heavily towards a subset of the population (birds in Amish areas) that had lower productivity than the remainder (Burton 1990). Nonetheless, our estimate of 3.82 ± 2.76 is similar to the mean value of 3.46 ± 0.69 reported in studies of Loggerhead Shrikes summarized by Luukkonen (1987) and is probably above average for open-nesting, temperate-zone passerines (Nolan 1978, Kridelbaugh 1983, Brooks and Temple 1990b).

Other authors (Kridelbaugh 1983, Gawlik and Bildstein 1990) have concluded that productivity of Loggerhead Shrikes remains relatively high,

Table 1. Demographic parameters of the Loggerhead Shrike in Indiana. Sample sizes in parentheses.

Parameter	1988	1989	Both years
Per-pair productivity ¹	3.12 \pm 2.50 (17)	4.13 \pm 2.87 (38)	3.82 \pm 2.76 (55)
Site re-occupancy		0.704 (54)	
Adult band returns		0.415 (41)	
Adult band returns (δ)		0.545 (22)	
Adult band returns (φ)		0.263 (19)	
Adult philopatry		0.824 (17)	
Adult philopatry (δ)		0.917 (12)	
Adult philopatry (φ)		0.600 (5)	
Adult survival		0.516	
Adult survival (δ)		0.594	
Adult survival (φ)		0.438	
Breeding seasons			2.14
Breeding seasons (δ)			2.39
Breeding seasons (φ)			1.89
Lifetime productivity			4.08
Lifetime productivity (δ)			4.56
Lifetime productivity (φ)			3.61

¹Expressed as mean \pm SE.

even in declining populations. None of 18 studies summarized by Cade and Woods (1997) suggested reduced productivity as a cause of population declines in this species, although Novak (1989) and Yosef (1994) suggest that it may be premature to discount productivity. Unfortunately, too little information is available on productivity in the few increasing Loggerhead Shrike populations to allow comparison with decreasing populations. The fact that shrike productivity is higher than that of some other species does not mean that it has not declined, nor that a reduction is not contributing to population declines.

ADULT SURVIVAL

Previous estimates of survivorship in Loggerhead Shrikes have been confounded by unknown degrees of philopatry (Yosef 1996). Brooks and Temple (1990b) used site re-occupancy (0.47) as a direct measure of adult survival based on the assumptions of 100% male site fidelity, equal survival rates of males and females, an unskewed sex ratio, and unlimited breeding opportunities for all survivors. However, neither males nor females in Indiana exhibited 100% philopatry. Moreover, we found evidence of a sizeable number of male floaters, suggesting a skewed sex ratio, perhaps resulting from unequal survival rates. Furthermore, site re-occupancy is affected by other factors such as habitat quality and availability as well as recruitment. Thus, we feel that the degree of site re-occupancy is not a valid direct measure of adult survival.

Band-return rates, particularly of females, may underestimate adult survival. Haas and Sloane (1989) suggested that low band-return rates for shrikes may indicate low site fidelity rather than winter mortality. Our site-reoccupancy rate of 70% was substantially higher than our band-return rates of 55% for males and 26% for females. Kridelbaugh (1983) recorded a site-reoccupancy rate of 54% and a male return rate of 47%, while Brooks and Temple (1990b) recorded rates of 47% and 43%, respectively. None of Kridelbaugh's (1983) banded females returned to his study area, and Haas and Sloane (1989) reported a five-fold bias towards male band returns in North Dakota. Our data indicate that these wide disparities between male and female return rates are due in part to a greater degree of philopatry by

males.

Other than the estimate of adult survival by Brooks and Temple (1990b), based purely on site reoccupancy, we know of no direct estimates of adult survival in shrikes. Ricklefs (1973) reported adult survival rates ranging from 0.29-0.63 for other passerines, depending on body size. DeSante et al. (1998) reported survival probabilities of 0.47-0.66 for Wood Thrush (*Hylocichla mustelina*), 0.49-0.61 for Gray Catbird (*Dumetella carolinensis*), and 0.55-0.74 for Northern Cardinal (*Cardinalis cardinalis*), depending on region, based on MAPS data. DeSante et al. (1999) found that adult survival probability of about 0.55 or greater predicted a population increase in a passerine community in the Pacific Northwest. In the context of these data, we suggest that the little evidence available on Loggerhead Shrikes indicates low adult survival as contributing to population declines.

The apparent discrepancy we observed between male and female survival could be an indicator of intraspecific competition on the wintering grounds resulting from habitat loss (see also Brooks and Temple 1990a, Lymn and Temple 1991, Telfer 1993). Such competition likely would favor adult males over other age and sex classes. Alternatively, our assumption that birds were as likely to switch territories within the study area as they were to leave the study area may not be valid for females, which may have lower philopatry and higher survival than we estimated.

LIFETIME REPRODUCTIVE OUTPUT AND JUVENILE SURVIVAL

With a mean annual reproductive output of 3.82 young per pair and a mean annual survival probability of 0.516, the mean reproductive lifespan of shrikes in Indiana is 2.14 breeding seasons and the mean lifetime reproductive output is 4.08 young per individual. The survival rate to breeding age of these offspring would need to be 0.245 (47% that of their parents) to maintain a stable population in the absence of net migration. This juvenal survival rate seems reasonable. Dhondt (1979) recorded a juvenal survival rate of 0.1 for a population of Great Tit (*Parus major*), a small, sedentary species. Brooks and Temple (1990b) arrived at an estimate of 0.19 for a strongly declining

Loggerhead Shrike population. Ash (1970) calculated a rate of 0.32 for Red-backed Shrike (*Lanius collurio*). Ricklefs (1973) states that theoretical juvenal passerine survival is about 0.3 and that the ratio of juvenal:adult survival is typically about 0.25 for passerines. Other recent studies indicate that this ratio probably ranges from 0.25-0.50 (DeSante et al. 1999).

Recent studies also have shown that most juvenile passerines do not survive the period between fledging and dispersal (Sullivan 1989, Zann and Runciman 1994, Anders et al. 1997). Our observations suggest that fledgling mortality in our study population during the first two weeks was quite high, perhaps exceeding 40%, and the period of post-fledging dependency extends well beyond that time. In fact, this period of vulnerability may be longer in shrikes than in other passerines, perhaps even approaching that of some raptors, because shrikes must acquire relatively complex hunting skills. It may be lengthened even further by mental retardation caused by contaminant loads (Busbee 1977).

POPULATION CHANGE

The shrike population in our core study area did not decline from 1988 to 1989. However, intensive surveys in two portions of our study area (including the core) in 1999 and 2000 indicated that the shrike breeding population had declined by 41% since our study (Castrale and Ferchak 2001). The decline was only 13% (from 39 territories to 34) in the portion including our core area but 60% (from 58 territories to 23) in the other, suggesting that the shrike population in Indiana may be a heterogeneous assemblage of independent clusters and that conclusions drawn from one may not be applicable to others. The Breeding Bird Survey shows a highly significant, 15% annual decline in the combined Highland Rim and Lexington Plain strata from 1988 to 1998 (Sauer et al. 1999). Thus, the shrike population in the middle Ohio Valley appears to be declining sharply, and the apparent stability we observed during 1988-1989 may have been a spatial and/or temporal anomaly. We suspect that survival during the 1988-89 winter may have been unusually high due to mild, dry weather to the south (Muth 1989, Peterjohn 1989) and that the population in our core study area is declining less precipitously than

elsewhere in the state.

Evidence available from Indiana supports the conclusions of other researchers that Loggerhead Shrike declines may be due more to low survival rates of adults and young, especially away from the breeding grounds, than to poor productivity or breeding habitat loss. To confirm or refute this hypothesis, rigorous comparative demographic studies of increasing, stable, and decreasing shrike populations on the breeding grounds are desperately needed, coupled with studies of over-winter survival of young and adult shrikes. Such studies are complicated by the difficulty of identifying and defining populations and by the considerable mixing of populations and subspecies that occurs on the wintering grounds. Demographic studies (of all species) need to be combined with standardized censuses to assess population trend within the study area itself rather than relying on BBS data, which often show considerable heterogeneity within physiographic regions and trends that are seldom associated with physiographic boundaries (Sauer et al. 1995).

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