

Nesting Success of Ruffed Grouse in West Virginia

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Abstract: Ruffed grouse densities are lower in the southern portion of its range than in the more northern reaches. It has been suggested that the lower productivity of ruffed grouse in southern latitudes may account for lower population densities. We examined nesting success of ruffed grouse *Bonasa umbellus* at 2 sites in West Virginia during 1998 and 1999. We located nests of radio-collared female grouse and determined proportion of females that nested, nest success (proportion of hens successful in hatching ≥ 1 chick), clutch size, hatching success, and hatch dates. Proportion of hens that attempted to nest, nesting success, and average clutch size and hatching success was similar between age classes, sites, and years. Depredation was the major cause of nest failure, with 30% of nests monitored over the two-year period being disturbed or destroyed. Nests monitored via video cameras revealed raccoons (*Procyon lotor*) and black rat snakes (*Elaphe o. obsoleta*) were common nest predators. Nesting success and nest depredation rates of ruffed grouse in West Virginia were found comparable to those in other portions of the range, however, re-nest rates were considerably lower.

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Ruffed grouse densities are lower in the southern portion of its range than in more northern reaches (Bump et al. 1947), potentially because of lower productivity at southern latitudes (Bergerud 1988). However, little is known about grouse productivity in southern portions of their range (Bump et al. 1947, Stafford and Dimmick 1979, Norman and Kirkpatrick 1984, Small et al. 1991).

Bergerud (1988) suggested that nest depredation for gallinaceous birds is greater in southern latitudes, and indicated that greater rates of nest depredation might account for lower productivity. However, Hewitt and Kirkpatrick (1993) measured nest depredation rates in Virginia via artificial nests and found weak evidence to support this hypothesis. Ortega et al. (1998) reported that predators responded differently to artificial versus natural nests, and that results from artificial nest experi-

ments should be carefully scrutinized. Beckerton and Middleton (1982) suggested that ruffed grouse females on a protein deficient diet may have lower quality eggs, which may negatively influence hatching and survival. They indicated that females entering the breeding season in poor condition may have lower hatching success and chick survival. Draycott (1998) reported that pheasants (*Phasianus colchicus*) in poor condition show decreased productivity in Great Britain.

Examining breeding ecology and productivity of ruffed grouse in southern latitudes would provide a better understanding of potential regional variation. Consequently, our objective was to examine nesting success in ruffed grouse in West Virginia.

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Methods

Study Area

Our study was conducted on the Westvaco Wildlife and Ecosystem Research Forest (WERF) located in the Allegheny Mountain Physiographic Province (Fenneman 1938) in Randolph County, West Virginia, and the Westvaco Dutch Run Tract (DRT) located in the Ridge and Valley Physiographic Province (Fenneman 1938) in Greenbrier County, West Virginia.

The WERF was a 3,413-ha area established by Westvaco Corporation in 1994 to study industrial forestry impacts on ecosystems and ecological processes. Forests were managed on a 60- to 70-year harvest rotation. Elevations ranged from 740 to 1200 m, and topography was characterized by plateau-like ridgetops with steep slopes and narrow valleys (Fenneman 1938, Ford and Rodrigue 2001). The WERF was characterized by a cool, moist climate, and average annual precipitation exceeded 198 cm (<http://www.nndc.noaa.gov>). The WERF contained Allegheny hardwood-northern-hardwoods forest type, cove-hardwoods, and a xeric mixed oak type (Eyre 1980). The Allegheny hardwood type covered approximately 90% of the site.

The DRT was a 2,036-ha area managed on an even-aged forest rotation length of 40–70 years. Approximately 94% of this area was dominated by oak-hickory associations typical of the Ridge and Valley Physiographic Province. Elevations ranged from 520 to 1100 m. Topography was steep and rugged, with ephemeral seeps and streams running throughout. Well drained soils, combined with a lower annual average precipitation of approximately 107 cm (<http://www.nndc.noaa.gov>) that resulted from a rain shadow from the Allegheny mountains immediately to the west, and resulted in more xeric conditions than on the WERF (Hicks 1998).

Trapping and Monitoring Females

We trapped female ruffed grouse during fall 1997 until ≥ 10 females were captured on both sites. Trapping resumed in early spring to replace females lost to mortality and radio-failures and continued until the second week of April. We captured grouse using modified lily-pad traps (Gullion 1965). Ten- to 16-m leads consisting of 46-cm tall poultry wire were used to guide grouse into the funnel and body of the lily-pad trap. There was 1 trap body at each end of the wire lead. Once captured, birds were weighed, aged based on feather molt and wear (after Kalla and Dimmick 1995), and leg banded with an aluminum identification tag (No. 12 butt-end tags, Natl. Band and Tag, Newport, Ky). We equipped each female with a necklace-type radio transmitter (Advanced Telemetry Systems, Isanti, Minn.). Transmitters weighed 10–11 g, had a 2-year life expectancy, and were equipped with a mortality sensor.

We monitored females twice weekly in 1998 using a 2-element yagi antennae and portable receiver (Wildl. Materials, Carbondale, Ill., and Advanced Telemetry Systems, Isanti, Minn.). Beginning 1 March 1999, we monitored females 3 times weekly to accurately document nest initiation. We obtained a minimum of 3 azimuths from permanently located, geo-referenced stations, and determined locations via triangulation (Mech 1983). We recorded and plotted all locations on topographic maps of the area. As the breeding season progressed, we used these telemetry azimuths to aid in locating nests.

Johnsgard (1983) found that the female's time on the nest increased proportionately to clutch size. Similarly, Maxson (1977, 1978) noted a marked decrease in both activity and movement once females started nesting, laying eggs, and incubating. These behaviors helped to determine the onset of egg laying and incubation. Once observed, we used telemetry to locate nests by homing (Mech 1983).

In 1999, we placed infrared cameras (Fuhrman Industries, Seabrook, Texas) on 10 nests on the WERF. When possible, cameras were placed on the nests when females were absent. However, 6 of 10 females were flushed to allow for camera placement. We only placed the actual camera lens and attachment arm near the nest. A cable ran from the camera lens to the video recording unit and power source 20 m away from the nest. Therefore, subsequent daily visits to the VCR unit of the camera to change tapes and batteries did not disturb the female. We used camera footage to determine the onset of incubation, which occurred when the female remained on her nest throughout the night. We used onset of incubation to predict hatch dates. On nests without cameras, we obtained an egg count during egg laying and incubation. We used this information to predict hatch dates by backdating to when the last egg was laid. We were able to use the camera footage to determine exact hatch dates and times for 3 of the 10 nests that had cameras. These were nests on which we were able to maintain cameras throughout incubation. The remaining 7 cameras were removed prior to hatching for use on another study. We determined hatching dates on nests without cameras by visual inspection towards the end of incubation.

We determined nesting rate (proportion of females attempting to nest) by dividing the number of females under observation by the number of females that at-

tempted to nest. We determined apparent nest success (Johnson and Shaffer 1990) as the percentage of observed nests that successfully hatched ≥ 1 chick (i.e., number of nests under observation divided into the number that hatched ≥ 1 chick $\times 100$). We compared nest success between years, study sites, and age classes using Fisher's Exact Test. We chose this test because of small expected values (< 5) per cell (Dowdy and Wearden 1985). Age class was defined as adult (entering second or higher breeding season) or juvenile (entering first breeding season). We determined percentage of renests from the proportion of females that lost their first nest to those that attempted a second nest. Mean clutch size was compared between years, study sites, and age class using the non-parametric Mann-Whitney test. We determined hatching success of successful nests in females that successfully hatched ≥ 1 chick by dividing the number of eggs laid by the number that hatched. Hatching success was compared between years, study sites, and age class using Fisher's Exact test. We performed statistical analyses using Statistical Analysis Systems software (SAS 1996).

Results

We collected data from 41 females (23 on WERF, 18 on DRT). Forty (98%) of 41 females attempted to nest and the proportion of nesting females was similar between age classes ($P \geq 0.26$), sites ($P \geq 1.00$), and years ($P \geq 0.42$). Proportion of females successful in hatching ≥ 1 chick was similar between age classes, within sites ($P \geq 0.11$), between sites (Table 1) and between years ($P \geq 0.64$).

We obtained clutch size from 31 first nest attempts (18 from WERF, 13 from DRT). Clutch size ranged from 9 to 12 in 1998. Mean clutch size in 1998 did not differ between age classes, within sites ($P \geq 0.25$) or between sites (Table 2). Clutch size in 1999 ranged from 7 to 14 on DRT and 9 to 12 on WERF. Average clutch size was similar between age classes, within sites ($P \geq 0.19$), between sites (Table 2), and between years ($P \geq 0.61$).

Of 290 eggs laid, 264 (91.0%) hatched. One hundred seventy-nine (98.4%) of 182 hatched at WERF, and 85 (78.7%) of 108 at DRT. Three partially depredated

Table 1. Between-site comparison of the proportion (p) of ruffed grouse (age classes pooled) hatching ≥ 1 chick on the Westvaco Ecosystem Research Forest (WERF) in Randolph County, West Virginia, and the Westvaco Dutch Run Tract (DRT) in Greenbrier County, West Virginia, 1998–1999.

Year	WERF		DRT		P^a
	N	p	N	p	
1998	9	0.78	7	0.71	1.000
1999	13	0.77	11	0.55	0.390

a. Fisher's Exact Test

Table 2. Between-site comparison of average \bar{x} clutch size for ruffed grouse (age classes pooled) on the Westvaco Ecosystem Research Forest (WERF) in Randolph County, West Virginia, and the Westvaco Dutch Run Tract (DRT) in Greenbrier County, West Virginia, 1998–1999.

Year	WERF			DRT			P^a
	\bar{x}	SE	N	\bar{x}	SE	N	
1998	10.6	0.37	7	10.5	0.65	4	1.000
1999	10.8	0.35	11	10.4	0.75	9	0.754

a. Mann Whitney test.

nests at DRT adversely affected this number, however, and if removed from the analysis, 253 (97.7%) of 259 eggs hatched successfully, 74 (96.1%) of 77 at DRT. Juvenile and adult females in 1998 had a hatch rate of >96% in first nest attempts, and no differences were found between age classes, within sites ($P = 1.00$) or between sites ($P = 1.00$). Analysis between age classes was not performed in 1999 because only adult females were successful in first nest attempts. Hatching success of adult females on both sites was >95%, and no differences were found between sites ($P \geq 0.13$) or years ($P \geq 0.38$).

Mean hatch dates were 22–24 May for adult and juvenile females on both sites in 1998. The range in hatch dates was 21–29 May on WERF and 17–28 May on DRT. Mean hatch dates were 21–23 May for adult females in 1999, and the range in hatch dates was 18–23 May on WERF and 20–26 May on DRT. The re-nest on WERF hatched on 29 May 1999.

Causes of Nest Failure

Depredation was the primary cause of nest failure. Predators disturbed or destroyed 29.3% of monitored nests, 5 on WERF and 7 on DRT. Four nests in 1998 (2 at each site) had the entire clutch removed, while 1 nest on DRT was only partially depredated. Two females were killed while incubating. A raccoon and a black rat snake were identified by video cameras as nest predators at 2 of 3 nest depredations on WERF in 1999. Hair analyses from samples gathered at the remaining depredated nest suggested black bear (*Ursus americanus*) and/or bobcat (*Lynx rufus*) as possible predators. A long-tailed weasel (*Mustela frenata*) also was recorded on video entering the nest. A lack of disturbance around nests at DRT in 1999 suggests that snakes depredated 2 of 4 nests. No re-nesting occurred after depredation events; however, 1 female on WERF did re-nest after abandoning her first nest.

Discussion

Average clutch sizes reported here (~10 eggs) are similar to those reported elsewhere for ruffed grouse. Porath and Vohs (1972) and Maxson (1978) found nests

with clutch sizes up to 13 eggs in Iowa and Minnesota, respectively. Bump et al. (1947) noted that clutch sizes ranged from 9–14 eggs in New York, and Larson (1998) reported an average clutch size of 12.7 for first nests in Michigan. In the central Appalachian region, Haulton (1999) found an average clutch size of 9.5. Average clutch size for ruffed grouse in West Virginia and the central Appalachian region may be slightly lower than in the northern portion of the range. However, clutch size also may be influenced by partial depredation events as reported here or misclassification of renests as first nests.

Younger grouse are reported to have smaller clutches (Bump et al.). We found no differences in nest success between age classes, suggesting that juveniles were contributing equally to recruitment. Our findings are supported by those of Maxson (1978) and Larson (1998). We suggest that juvenile females make an important contribution toward annual recruitment and that their survival and reproduction could play a role in sustaining huntable populations in the region.

Hatching success typically is high in ruffed grouse, usually >90% (Bump et al. 1947, Rusch and Keith 1971). Our hatching success was consistent over 2 years (>95%) and comparable to other portions of the ruffed grouse range. Larson (1998) reported a first nest hatching success of 96% and a second nest hatching success of 83% in Michigan. Bump et al. (1947) suggested that lower second nest success may result from increased egg infertility.

Hatching dates in ruffed grouse often depend on geographical conditions and prevailing weather conditions (Johnsgard et al. 1989). Peak hatch occurred during the last week of May, indicating that West Virginia falls within the range of hatch dates reported for ruffed grouse. Regionally, Haulton (1999) also found that peak hatch for ruffed grouse occurred during the last week of May and reported no differences among sites in the central Appalachians. In Wisconsin, Kubisiak (1978) found that hatching began in the last week of May and continued through July, but that over 74% of the eggs were hatched before 15 June. In Michigan, Larson (1998) reported a mean hatch date of 10 June, with approximately 40% of the nests hatching prior to this date. Later hatch dates may result from unseasonable cold, delayed green-up, or represent the inclusion of renests in first-nest reports.

We found nest depredation to be the primary factor influencing ruffed grouse nest success. Thirty percent of nests monitored over the 2-year period were destroyed, with 92% of those attributed to depredation. Other studies have shown that nest depredation is an important nest loss and nest abandonment mechanism in grouse (Bergerud 1988, Johnsgard and Maxson 1989). Depredation rates from 23% to 41% are reported throughout the range of ruffed grouse (Bump et al. 1947, Johnsgard and Maxson 1989, Rusch 1989, Larson 1998, Haulton 1999). Similarly, other gallinaceous species show high incidence of nest depredation leading to lowered nest success (Miller et al. 1998, Paisley et al. 1998, Fies 1999). Because of the lower densities of grouse in the southern range, nest depredation may have a greater impact on lowering recruitment.

We found raccoons and black rat snakes responsible for the complete or partial depredation of several grouse nests. Both species have been identified as common

nest predators on a variety of species (Best and Stauffer 1980, Hernandez et al. 1997, Neal et al. 1998). Raccoons caused substantial disturbance at the nest site, whereas snakes left no disturbance. Hernandez et al. (1997) suggested that depredation events are often erroneously attributed to snakes because no evidence is left at the site. Raccoons, however, are capable of leaving few egg shells or other evidence behind. Indirect evidence also suggested that black bear, bobcat, and weasel also may represent potential nest predators in West Virginia.

Although renesting can act to compensate for nest loss, we observed no renest attempts of nest loss to depredation. Haulton (1999) reported a renest rate of only 6% over a 2-year period in the central Appalachians. Renesting in ruffed grouse is reported as uncommon (Bump et al. 1947, Johnsgard and Maxson 1989). However, Small et al. (1996) in Wisconsin and Larson (1998) in Michigan observed >50% renesting rates for females that had lost or abandoned their first nests. The stage in the nesting period at which depredation occurs is critical in determining the likelihood of the female attempting a renest (Johnsgard and Maxson 1989). Even though a female has the biological potential to immediately renest after depredation or disturbance, this ability diminishes over time. As egg laying ends and incubation begins, the female's ova are reabsorbed, which limits additional egg production (Maxson 1977). Bump et al. (1947) reported that the average clutch size in New York was much lower on renesting attempts, averaging 7.5 eggs. In Michigan, the average second nest clutch size was 7.3 (Larson 1998). The only female attempting to renest in our study produced a clutch of 10 eggs. Because of lower renest rates observed in the southern region, nest depredation could have substantial impact on hatching success and potential recruitment.

Management Implications

Although public support exists for certain types of predator management (Messmer et al. 1999), and some studies have found positive relations with intensive predator removal and nesting success on a localized scale (Balser et al. 1968, Trautman et al. 1974, Duebbert and Lokemon 1980, Livezey 1981, Sargeant and Arnold 1984, Greenwood 1986), others report that predator removal or control was ineffective, inefficient, and expensive (Chesness et al. 1968, Rusch and Keith 1971). From a management perspective, predator control has limited potential to enhance grouse nesting success, and it would be more cost effective to focus on improving habitat (e.g., breeding, nesting, brood) for grouse. Moreover, changes in forest management practices and increased timber harvesting across West Virginia have increased forest fragmentation and edge, and possibly enhanced the predatory efficiency of mesomammals (Heske 1995, Marini et al. 1995). Habitat management practices such as creating feathered edges could deter predators from using certain areas (Gates and Geysel 1978, Yahner and Wright 1985, Yahner et al. 1989, Pedlar et al. 1997).

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