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DAILY ACTIVITY TIMES OF RUFFED GROUSE IN SOUTHWESTERN VIRGINIA

DAVID G. HEWITT[1]

Department of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061 USA

ROY L. KIRKPATRICK

Department of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061 USA

Abstract.—Densities of Ruffed Grouse (*Bonasa umbellus*) in the southern Appalachians are lower than in more northerly portions of the species' range. One explanation is that highly dispersed winter food resources in the southern Appalachians cause southern Ruffed Grouse to spend a larger portion of each day active. More activity could increase mortality by increasing predation risks and energy expenditure. Radio-tagged Ruffed Grouse in Virginia were active an average of ≥5 h/d during the winter. This level of activity is greater than that reported for Ruffed Grouse and other grouse species during winter. Ruffed Grouse in more northerly portions of the range may be able to meet their energy requirements in less than half the time required for grouse in the southern Appalachians. Ruffed Grouse in Virginia were not strongly crepuscular as are most other grouse species. The high activity levels of Ruffed Grouse observed during the winter in Virginia are consistant with the hypothesis that low food availability in the Southeast results in increased time spent foraging.

PRESUPUESTO DE ACTIVIDADES DE *BONASA UMBELLUS* EN LA PARTE SUROESTE DE VIRGINIA

Sinopsis.—La densidad de *Bonasa umbellus* en la parte sur de los Apalaches es menor que en la porción mas al norte de las áreas en donde se encuentra esta especie. Una posible explicación es la dispersión de los recursos alimentarios durante el invierno en la parte sur de los Apalaches, causando que el ave tenga que estar activo por un periodo mayor de tiempo. Este periodo de mayor actividad puede incrementar la mortalidad de la especie, al incrementar el gasto de energía y el riezgo de ser depredado. Las aves que se estudiaron con radiotransmisores en Virginia, estuvieron activos un promedio >a 5 h/d durante el invierno. Este nivel de actividad fué mayor que el informado para esta especie y otros Tetraonidae durante el invierno. Las poblaciones más al norte muy bien pudieran cubrir sus requisitos energéticos en menos de la mitad del tiempo que sus congéneres sureños. Las aves estudiadas no fueron tan crepusculares como otros Tetraonidae estudiados. Los altos niveles de actividad de *Bonasa umbellus* durante el invierno en Virginia es consistente con la hipótesis de poca disponibilidad de alimento en el sureste, produciendo como resultado un aumento en el periodo de forrajeo.

Densities of Ruffed Grouse are lower in the southern Appalachians than in the central portion of the species' range, specifically the north-central and northeastern United States and eastern Canada (Bump et al. 1947). Servello and Kirkpatrick (1987) hypothesized that densities were lower in part because the biomass of high-quality forage (e.g., herbaceous leaves, buds, catkins, and fruits) was insufficient in late winter for grouse

[1] *Current address: Caesar Kleberg Wildlife Research Institute, Campus Box 218, Texas A&M University-Kingsville, Kingsville, Texas 78363 USA.*

to harvest efficiently. Furthermore, abundant evergreen forage (e.g., mountain laurel, *Kalmia latifolia*) and ferns are toxic to grouse when eaten in large quantities (Hewitt and Kirkpatrick 1997). Thus, Ruffed Grouse in the southern Appalachians may have to eat as much evergreen material as they can detoxify, then search for herbaceous leaves and fruits to meet the remainder of their nutrient requirements. A consequence of this hypothesis is that Ruffed Grouse in the southern Appalachians should spend more time active than grouse in central portions of the range where quaking aspen (*Populus tremuloides*) buds are abundant and easily harvested (Svoboda and Gullion 1972). More activity increases predation risk, energy expenditure, and potentially, mortality rates. The objective of this study was to determine activity times of Ruffed Grouse in southwestern Virginia during winter.

STUDY AREA

This study was conducted on two areas in Montgomery and Giles counties in southwest Virginia (elevation 650–900 m, 37°10′N, 80°30′W). The Buckeye study area was second growth, mixed hardwoods, interspersed with pasture that in some areas was reverting to eastern red cedar (*Juniperus virginiana*) and black locust (*Robinia pseudoacacia*): Hardwood areas had an open understory, whereas reverting pasture had a thick growth of honeysuckle (*Lonicera* spp.), greenbriar (*Smilax* spp.), coral berry (*Symphoricarpus* sp.), multiflora rose (*Rosa* spp.), and blackberry (*Rubus* sp.). The Norris Run study area was oak (*Quercus* spp.)-hickory (*Carya* spp.) forest with yellow popular (*Liriodendron tulipifera*) and red maple (*Acer rubrum*) also common in the overstory. A majority of the Norris Run site had burned 20 yr earlier. The burned areas had high densities of small (<10-cm DBH) trees and an open understory with scattered vaccinium (*Vaccinium* sp.), greenbriar, and grape (*Vitis* sp.). The unburned portions had a well-developed understory of mountain laurel, vaccinium, and rhododendron (*Rhododendron* sp.).

METHODS

Activity Monitoring.—Ruffed Grouse were trapped from December 1991–February 1992 and from November 1992–January 1993. Grouse were captured using lily-pad traps (Gullion 1965) and fitted with 15-g radio transmitters (Advanced Telemetry Systems, Isanti, Minnesota), which were held on the crop region of the bird by harness straps around the neck and body. The transmitters were battery-powered and contained real-time tip switches that changed the pulse rate from 45 to 75 pulses/min when the plane of the radio against the bird's breast tipped past 25° (1992) or 45° (1993) from horizontal. The angle of the tip switch was altered after 1992 because very few pulse rate changes were recorded with the original design. All birds were released within 10 min after being removed from the trap and within 50 m of their capture site. Grouse were flushed within 5 d of being trapped to ensure their flight was normal, and then located an average of three times a week by triangulation or homing using a Telonics (Mesa, Arizona) radio receiver and H-antennae.

During January–March 1992, two systematically chosen grouse on each study area were monitored for activity on two predetermined days every other week. Radio signals (signal strength and pulse rate) were monitored in 2-min time blocks, alternating between birds, from 15 min before sunrise to 15 min after sunset. The same person (DGH) monitored all grouse and was within 500 m of the birds while doing so. A grouse was classified active during a 2-min block if any change in pulse rate or signal strength was noted. The percent time active was calculated as the percent of 2-min blocks classified active. Two minute time periods were chosen because they allowed ample time to determine if pulse rate or signal strength were fluctuating yet were short enough to minimize bias from classifying an entire period active when the bird was only active a few seconds. Captive grouse fitted with similar radio transmitters and monitored using the same techniques were correctly classified as active or inactive in 158 of 180 (88%) 1-min periods (Hewitt 1994). Misclassifications were equally divided between active and inactive grouse.

During January–March 1993, radio signals were monitored using an omnidirectional antennae, radio receiver, data processor (Telonics, Mesa, AZ), and a two-channel data recorder (Rustrak RangerII, model RR2-1200, East Greenwich, RI), which recorded both signal strength and pulse rate every 0.5 s. This system was set up within 250 m of the grouse and the antenna was secured to prevent signal changes from movement of the receiving antenna. Each radio-tagged grouse was monitored from 30 min before sunrise to 30 min after sunset on one predetermined day each week. Data files were transferred to a micro-computer and PRONTO software (Rustrak, East Greenwich, Rhode Island) was used to plot signal strength and pulse rate against time of day.

Periods of activity and inactivity at least 2 min in duration were delineated based on the frequency of changes in signal strength or pulse rate. A period was classified as inactive if neither signal strength nor pulse rate varied, and as active if both signal strength and pulse rate varied. Periods in which only signal strength or pulse rate varied were classified as active or inactive according to one of two methods. The "single criterion method" required changes in either signal strength or pulse rate to classify a period as active. The "dual criteria method" required changes in both signal strength and pulse rate to classify a period as active. Time active was calculated using both of these methods. In validation tests with captive grouse, a significant relationship was found between estimated and observed activity in 11 trials using both the single criteria (linear regression, $P < 0.001$, $r^2 = 0.87$) and the dual criteria ($P = 0.006$, $r^2 = 0.59$) methods (Hewitt 1994).

Percent activity for both years was the percent of the monitoring period (before sunrise to after sunset) that a grouse was classified as active. Data from a day were not used if the radio signal was lost for >10% of the potential monitoring time of that day. Daily activity patterns were deter-

TABLE 1. Mean percent time (±SE) free-ranging Ruffed Grouse were active from 15 min before sunrise to 15 min after sunset in southwestern Virginia during January–March 1992. Each row is data from one bird. On a given day, radio signals from two grouse were monitored in alternating 2-min periods. If any signal strength change was noted, that 2-min period was considered active.

Study Area	*n* (days)	Monitoring period	Percent time active	Percent time signal lost
Buckeye	4	20 January–6 March	48.9 (2.28)	5.3 (1.87)
	5	20 January–17 February	44.1 (3.67)	3.8 (1.75)
Norris Run	5	31 January–13 March	53.3 (5.52)	0.9 (0.56)
	5	31 January–13 March	33.9 (3.69)	0.6 (0.46)
	2	2 March–6 March	70.8 (9.95)	0.3 (0.30)
	1	2 March	52.2	0.0

mined using the percent time active for each successive 60-min period during the monitoring period. Any 60-min period in which the signal was lost >20% of the period was discarded from this analysis. Means are reported ± 1 standard error. All statistical tests were conducted using SAS (SAS Institute, Inc. 1988) software.

RESULTS

During the winter of 1991–92, six grouse were captured in 424 trap days; during 1992–93, six grouse were captured in 844 trap days. Three birds in 1992–93 were killed by predators or lost their radios before usable data were gathered. Twenty-two days of activity estimates (using only signal strength changes to determine activity because the angle of the tip switch did not result in frequent pulse-rate changes) were obtained on six grouse in 1992 (Table 1). Four grouse had ≥4 d of monitoring each and were active an average of 45 ± 4.2% (n = 4) of the day (Table 1). Two grouse, with 1 and 2 d of monitoring, averaged 62% (n = 2) of the day active (Table 1). The amount of time active per day averaged 351 ± 38.0 min (n = 6).

Signal strength and pulse rate changes were used to determine activity for three grouse on 16 days in 1993. Mean percent activity was 53 ± 3.6% with the single criterion method of classifying activity and 43 ± 4.4% with the dual criteria method (Table 2). The difference in these two estimates of activity is the percent time that pulse rate and signal strength were in conflict as to the bird's activity status. On average, the two methods of determining activity were in agreement 90 ± 1.8% of the time. The amount of time active per day averaged 376 ± 26.5 min for the single criterion method and 300 ± 31.0 min for the dual criteria method.

Daily activity patterns in both years showed a moderate probability of grouse being active at any hour during the day (Fig. 1). Grouse tended to be less active in the final hour of daylight than during the preceding hour.

TABLE 2. Mean percent time (±SE) free-ranging Ruffed Grouse were active from half-hour before sunrise to half-hour after sunset in southwestern Virginia during January–March 1993. Each row is data from one bird. Active periods were determined when signals from radios varied in either strength or pulse rate (single criterion) or when both signal strength and pulse rate varied (dual criteria). The radio tags contained a mercury tip switch that altered the pulse rate of the radio signal between 45 and 75 pulses/minute as the radio tipped past 45 degrees from horizontal.

		Percent time active		
n (days)	Monitoring period	Single criterion	Dual criteria	Percent time signal lost
8	19 January–14 March	48.2 (5.10)	36.9 (6.53)	1.2 (0.74)
5	31 January–11 March	60.2 (6.15)	51.7 (5.78)	1.22 (0.82)
3	29 January–18 February	51.9 (6.24)	40.7 (9.43)	3.0 (3.0)

DISCUSSION

Using changes in radio signal strength to determine activity is controversial. The technique has been used with a variety of species (Cederlund and Lemnell 1980, Gjerde and Wegge 1987, Lancia et al. 1980), although none of these studies reported the accuracy of their methods. Gillingham and Bunnell (1985) reported that signal strength from captive black-tailed deer (*Odocoileus hemionus*) varied least when animals were inactive and most when animals were active. Beier and McCullough (1990), while testing their ability to estimate activity of white-tailed deer (*O. virgnianus*) using radio signals, reported 29 of 30 observations of deer bedded or standing alert had constant signal strength. However, 72 of 193 (37%) observations of deer active also had constant signal strength. These data suggest an underestimation of activity when using only changes in signal strength. In this study, not only did tests with captive grouse show a good relationship between changes in signal strength and activity, but field data from 1993 showed 90% agreement for activity classification between changes in signal strength and pulse rate of radios with activity sensors.

Average activity times for grouse in this study (5–6 h/d) were greater than those reported for other grouse species during winter. Capercaillie in Norway were active an average of 3 h/d (Gjerde and Wegge 1987), Black Grouse (*Tetrao tetrix*) in Finland, 90 min/d (Marjakangas 1992), Willow Ptarmigan (*Lagopus lagopus*) in British Columbia, 52 min/d (Mossop 1988), and White-tailed Ptarmigan (*Lagopus luecerus*) in Colorado, approximately 3 h/d (Braun and Schmidt 1971).

Activity times for Ruffed Grouse in the central part of the species' range have not been reported. Huempfner and Tester (1988) suggested that during periods of deep, powdery snow in Minnesota, Ruffed Grouse had peaks of activity at dawn, at dusk, and for 1–2 h around midday. Arboreal feeding was the primary activity during crepuscular periods. When snow

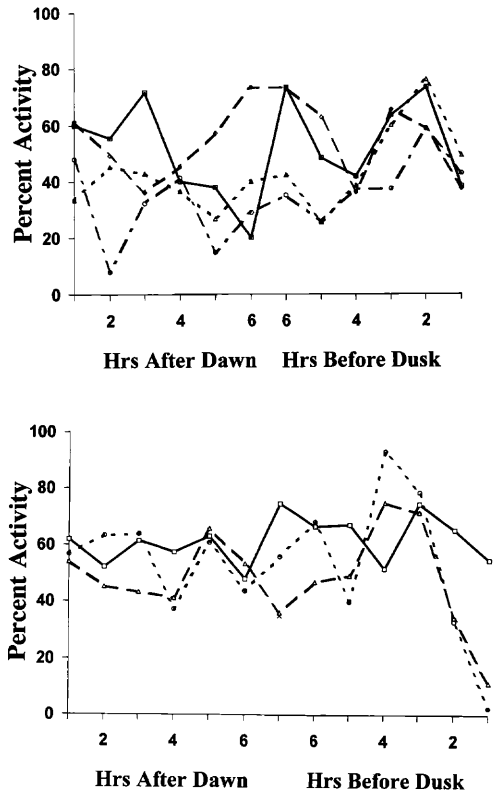

FIGURE 1. Mean percent time active during successive hours after dawn and before dusk for radio-tagged Ruffed Grouse in southwest Virginia during January–March 1992 (top) and January–March 1993 (bottom). Each line represents a different grouse.

crusted, midday activity increased as grouse searched for food at ground level. During winter, Ruffed Grouse in New York had feeding periods in the morning and evening, but tracks in the snow and flushing records indicated that grouse may feed at any time during the day (Bump et al. 1947).

Long periods of foraging are not necessary in areas where grouse feed extensively on buds and catkins. Ruffed Grouse foraging in quaking aspen trees can meet their daily energy requirements in 30–50 min (Hewitt and Kirkpatrick 1996). The duration of foraging bouts of wild Ruffed Grouse when feeding in male quaking aspen averaged 12.2–16.0 min in the morning and 17.6–24.0 min in the evening (Doerr et al. 1974, Huempfner and Tester 1988, Svoboda and Gullion 1972). In contrast, winter diets of Ruffed Grouse in the Southeast are dominated by leaves and fruits (Seehorn et al. 1981, Servello and Kirkpatrick 1987, Smith 1977, Stafford and Dimmick 1979). Studies with captive grouse (Hewitt and Kirkpatrick

1996) suggest that >100 min of foraging would be required to meet the daily energy requirements of a Ruffed Grouse consuming an average diet of leaves and fruits. This estimate is a minimum because it assumed ideal foraging conditions and excluded search time for food and vigilance for predators.

The longer foraging periods required of Ruffed Grouse in the Southeast could contribute to the high levels of daily activity recorded for these birds. Studies are needed of Ruffed Grouse activity levels in more northerly portions of the species' range where grouse feed on buds and catkins during winter and of the relationship between activity and predation risks. Ruffed Grouse in Missouri had lower survival rates when daily movements were greatest (Kurzejeski and Root 1988, Thompson and Fritzell 1989). Because predation is the greatest cause of mortality (excluding hunting) for full-grown Ruffed Grouse (Bergerud 1988, Small et al. 1991), an increase in predation risks may have consequences for population dynamics and densities.

Daily activity patterns of grouse in this study differ from the primarily crepuscular patterns of other grouse species during winter (Braun and Schmidt 1971, Gjerde and Wegge 1987, Marjakangas 1992, Mossop 1988). Not only did Ruffed Grouse in the present study have > 30% probability of being active during the middle of the day, but most birds were less active during the final hour before dusk than during the preceding 2 to 3 hours. Ruffed Grouse in the central part of their range have short periods of intense feeding at dawn and dusk, but can also be active periodically during the middle of the day (Bump et al. 1947, Doerr et al. 1974, Huempfner and Tester 1988).

This study supports the hypothesis that Ruffed Grouse in the Southeast are active during a large portion of each day and related studies suggest that this may be due to widely dispersed food resources (Hewitt et al. 1992, Hewitt and Kirkpatrick 1996, Servello and Kirkpatrick 1987). Management for increasing Ruffed Grouse populations in the Southeast should consider providing more fruits and herbaceous leaves near heavy cover during late winter to minimize foraging time.

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