Post-recruitment Survival of White-tailed Deer Fawns in Southern Illinois

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Abstract: Reliable estimates of survival for white-tailed deer (*Odocoileus virginianus*) fawns are needed for sound deer management. Several studies have estimated fawn survival prior to recruitment (i.e., before the onset of hunting season) but few have monitored fawns post-recruitment, especially in the lower Midwest or Southeast. We captured and radiocollared 166 neonatal fawns during 2002–2004 in southern Illinois. Ninety-one fawns survived to recruitment and were monitored for survival from 1 October until the end of the firearm hunting season (typically 8 December). Post-recruitment survival was 0.73 (95% CI = 0.63 – 0.83). Hunter harvest was the primary source of mortality (13%) followed by vehicle collisions (8%). Male and female harvest mortality was 14% and 12%, respectively, and did not differ ($P = 0.73$). By monitoring radiocollared fawns through the firearm hunting season, we were able to estimate proportion of fawns harvested in southern Illinois without biases associated with harvest data. We also suggest vehicle collisions are another important source of mortality for fawns and should be incorporated into population models and management decisions.

Key words: fawn, Illinois, harvest, mortality, *Odocoileus virginianus*, survival, vehicle collisions, white-tailed deer

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Biologists require reliable estimates of important demographic parameters for white-tailed deer (*Odocoileus virginianus*) population models and management programs (Caughley 1966, Eberhardt 1985, Campbell et al. 2005). Knowledge of fawn survival is particularly important because fawns are more susceptible to mortality than any other age class (Porath 1980, Nelson 1984, White and Lubow 2002).

Fawn survival has been studied in numerous habitats across the species' range (Huegel et al. 1985*a*, Linnell et al. 1995, Vreeland et al. 2004). Most researchers have monitored fawn survival during recruitment (Cook et al. 1971, Epstein et al. 1985, Nelson and Woolf 1987) defined here as the period from birth to the onset of the hunting season. Several researchers have monitored fawn survival after recruitment, but many of these studies were conducted outside of the lower Midwest or Southeast (Huegel et al. 1985*a*, Long et al. 1998, Ballard et al. 1999, Vreeland et al. 2004). To our knowledge only Wickham et al. (1993) and Bowman et al. (1998) have monitored fawn survival after recruitment in the lower Midwest or Southeast. Wickham et al. (1993) captured and monitored fawns in Maryland from birth until conclusion of hunting season. Hunter harvest was the only source of mortality for fawns during the post-recruitment period. Wickham et al. (1993) also reported male fawns were not more susceptible to harvest than female fawns, which was contrary to other studies (Roseberry and Klimstra 1974, Coe et al. 1980, Roseberry and Woolf 1988). Bowman et al. (1998) captured fawns on an island in the Mississippi River and monitored them from birth to six months of age and observed no fawn mortalities during the post-recruitment period.

Additional estimates of post-recruitment fawn survival in the lower Midwest and Southeast would provide useful insight into deer populations. Except for Wickham et al. (1993) and Bowman et al. (1998), much of the information about fawn mortality after recruitment in the region comes from harvest data such as fawn per doe kill ratios and age structure of harvest. However, estimates obtained from harvest data can be biased (Roseberry and Woolf 1988) and fail to identify non-harvest sources of mortality.

We studied post-recruitment survival of fawns in southern Illinois to provide information for deer management programs in

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the lower Midwest and Southeast. We previously estimated fawn survival to recruitment (i.e., from birth until 1 October) to be 0.59 (95% CI = 0.51 – 0.68; Rohm et al. 2007). Herein, our objectives were to estimate fawn survival during hunting season (October-December) and identify causes of mortality. We also examined differential harvest vulnerability between male and female fawns.

Study Area

We studied deer fawns at two sites in southern Illinois. These areas had a moderate topography ranging from 96–240 m. The region was typified by hot, humid summers and mild winters; mean monthly temperatures ranged from 32 C in July to -5 C in January. Annual precipitation averaged 120 cm with 29 cm occurring as snowfall (National Oceanic Atmospheric Administration 2000).

The Pope and Johnson counties study site encompassed 51 km^2 and was centered on the Pope-Johnson county line within the Shawnee National Forest. Land cover of this site was 39% forest, 35% grassland, 17% agricultural, and 9% wetland, open water, or developed (Luman et al. 1996). The predominant forest type was mixed hardwoods composed mainly of oak (*Quercus*) and hickory (*Carya*). Grasslands were dominated by fescue (*Festuca*) with blackberry (*Rubus*) and golden rod (*Solidago*) occurring in later successional grasslands. Corn and soybean were the primary crops grown throughout the region. Human population densities were 5/km^2 in Pope County and 14/km^2 in Johnson County (U. S. Census Bureau 2000).

The Jackson County study site was 20 km^2 in area and composed of 51% forest cover, 28% grassland cover, 11% agricultural cover, 10% wetland, open water, or developed (Luman et al. 1996). Plant species composition of the site was the same as that found on the Pope and Johnson counties site. Human population density in Jackson County was 39/km^2 (U. S. Census Bureau 2000).

Methods

Fawn Capture and Handling

We captured fawns during 21 May–30 June 2002–2004 (Rohm 2005) in accordance with methods approved by the Institutional Animal Care and Use Committee at Southern Illinois University Carbondale (03–003). We captured fawns by (1) conducting foot searches through likely fawning habitat (Steigers and Flinders 1980, Ballard et al. 1999, Vreeland 2002), (2) searching for does displaying postpartum behavior (Downing and McGinnes 1969, White et al. 1972), and (3) monitoring radiocollared does (Huegel et al. 1985*b*). We located fawns by two crews of four or five people on foot searching ≤50 m of edges of early-mid successional fields, pastures, small woodlots, and other suitable fawn rearing areas (Wickham et al. 1993). When a doe displaying postpartum behavior was sighted, we searched the area for fawns. We monitored does radiocollared as part of a concurrent study (Schauber et al. 2005) during April until the onset of parturition. When parturition occurred, we located fawns by homing to the doe and searching the area (Huegel et al. 1985*b*).

Once we located the fawns, we captured them by hand or with the assistance of a long-handled net and immediately blindfolded them. Capture measurements are detailed in Rohm (2005). We ear tagged each fawn with numbered plastic tags (National Band and Tag Co., Newport, Kentucky) and fitted them with a 70-g VHF radiocollar equipped with an inactivity sensor (Advanced Telemetry Systems, Inc., Isanti, Minnesota). We used radiotransmitters that were affixed to elastic collars that contained folds stitched together by cotton thread (Diefenbach et al. 2003). These collars were designed to detach within one year from deterioration of cotton stitches and the force exerted by the growing neck of fawns.

Survival Monitoring and Mortality Assessment

We monitored fawns for survival using ground-based radiotelemetry (White and Garrott 1990) at least once per week from capture to the end of the Illinois firearm deer season (typically by 8 December). Archery hunting was the only other season open during this period. When a mortality signal was detected, we immediately located the transmitter and cause of mortality was determined. We assessed cause of mortality by site and carcass evidence and classified it into human-induced (i.e., vehicle collisions and harvest), natural (i.e., predation), and unknown categories. We classified predator-related mortalities based on a key modified from Vreeland (2002:88). These mortalities were distinguished from scavenging incidents by presence of blood at the site and evidence of trauma, hemorrhaging, and bruising on the carcass. We were generally unable to determine the specific predator responsible for mortality because of monitoring frequency. If the mortality source could not be determined afield, we took the carcass to the laboratory and necropsied it according to Woolf (1978). Fawns captured at the two study areas were pooled for analysis because our previous research (Rohm et al. 2007) indicated no study area differences in survival.

Survival Rates

Following Rohm et al. (2007), we defined date of recruitment as 1 October. This represented a management-based definition of recruitment based on the beginning of archery season in Illinois and its utility in the Illinois Deer Harvest and Management Program used to model deer populations in Illinois (Roseberry 1995). For analysis of post-recruitment survival (i.e., during October-December), we calculated apparent survival as the number alive at the end of the post-recruitment period divided by number alive at the beginning of the period minus number of unknown fates (i.e., censored individuals). We used this relatively simple estimator as opposed to a more robust approach [i.e., using program MARK (White and Burnham 1999), the Kaplan-Meier product-limit estimator (Pollock et al. 1989) or the method of Heisey and Fuller (1985)] because we wished to compare our estimates to those we hand-calculated from other studies (Huegel et al. 1985*a*, Wickham et al. 1993, Bowman et al. 1998, Vreeland 2002). Although several of these studies used more robust approaches to estimate survival, they did so using different periods (e.g., survival until 1 year of age) than we did. Hence, to make our survival estimates comparable to others, we had to hand-calculate survival estimates from other studies based on their published data, which often comprised only of reports of animals available and animals died (and not radiodays). We expressed mortality rates as a simple proportion of number dead divided by total number of fawns. We used a chi-square test to examine annual and sex-specific differences in survival ($\alpha = 0.05$), and used the method of Clopper and Pearson (1934) to calculate exact confidence interval for the overall proportion surviving.

Results

During 2002–2004, we captured 166 fawns using 47 person-hours/fawn (Rohm 2005). Ninety-one fawns survived to recruitment (Rohm et al. 2007). Of these, 8 had unknown fates because of radiocollar loss or radiotransmitter failure and were censored (Table 1). Of the remaining 83 fawns with known fates, survival between recruitment and end of firearm season was 0.73 (95% CI = 0.63 – 0.83). We found no difference in post-recruitment survival among years ($\chi^2_2 = 2.04$, $P = 0.36$) or between males (0.70) and females (0.78; $\chi^2_1 = 0.12$, $P = 0.73$).

The primary source of mortality was hunter harvest (13% of recruited fawns) with almost all harvest occurring during the firearm hunting season (Table 1). One fawn was harvested via archery hunting. Proportion of males and females harvested were 14% and 12%, respectively. The second leading cause of mortality was vehicle collisions (8%) followed by predation (3%; Table 1).

Discussion

The fawn survival rate we obtained for the post-recruitment period was lower than that reported for most studies. Wickham et al. (1993) reported an 85% post-recruitment survival rate in Maryland and Bowman et al. (1998) observed 100% survival in Mississippi. Outside of the lower Midwest and Southeast, our post-recruitment survival estimate was lower than those from Pennsylvania (89% and 87%; Vreeland 2002), Iowa (92%; Heugel et al. 1985*a*), and New Brunswick (86%; Ballard et al. 1999). Although we attempted to make our results more comparable by using a relatively simple survival estimator, we recognize limitations of this approach, namely that (1) fawns were not all marked at the same time, and (2) we are not certain that survival rates were constant between seasonal intervals (Heisey and Fuller 1985). However, all fawns were marked during spring-summer seasons during our three capture years (72% were captured within a two-week period), and our previous analysis of pre-recruitment survival indicated no annual survival differences (Rohm et al. 2007). Furthermore, the relatively low number of animals with unknown fates helped minimize the bias associated with not utilizing a method that involved a competing risk framework.

Our relatively low estimate of post-recruitment fawn survival can be explained by elevated rates of harvest- and vehicle-caused mortalities. We believe our estimate of harvest mortality was reflective of the true harvest. We also believe any potential bias in hunter behavior caused by presence of radiocollars was minimal

Table 1. Fate of white-tailed deer fawns post-recruitment (1 October to first Monday after end of firearm deer season in December) in southern Illinois, 2002–2004.

	Year								
	2002		2003		2004		Total		
Fate	*N*	Proportion[a]	*N*	Proportion	*N*	Proportion	*N*	Proportion	95% CI
Recruits[b]	25	—	29	—	37	—	91	—	
Unknown fate[c]	3	—	4	—	1	—	8	—	
Unknown death[d]	1	0.045	0	0	0	0	1	0.012	0.000–0.065
Archery harvest	1	0.045	0	0	0	0	1	0.012	0.000–0.065
Firearm harvest	4	0.182	2	0.080	4	0.111	10	0.120	0.059–0.210
Vehicle collision	0	0	1	0.040	6	0.167	7	0.084	0.035–0.170
Predation	1	0.045	1	0.040	1	0.028	3	0.036	0.300–0.840
Post-recruitment survivors	15	0.682	21	0.840	25	0.694	61	0.735	0.630–0.830

a. Of recruits with known fate.
b. Fawns surviving to 1 October.
c. Fawns whose radio collars dropped off or signal was lost and subsequently censored.
d. There was evidence that death had occurred but not sufficient evidence to determine cause.

because hunters who harvested marked individuals indicated that they either did not see the collar or did not care that the fawn was wearing one. Furthermore, we instructed study area hunters and landowners to harvest fawns as they would otherwise, regardless of radiocollar presence. The harvest mortality rate we observed was twice as much as the 6% reported in Maryland (Wickham et al. 1993) and slightly higher than the 8% recorded in Pennsylvania (Vreeland 2002) both of which used similar methods. The monitoring period in Huegel et al. (1985*a*) included the archery season but did not include firearm seasons; no archery harvest was recorded during their study (Huegel et al. 1985*a*). However when the firearm season opened, they reported 21% of the available marked fawns were harvested which was much higher than the estimate we obtained (Huegel et al. 1985*a*). Differences in fawn mortality from harvest may reflect different harvest levels and hunter efficiencies and philosophies among study areas. Although mortality from vehicle collisions was the second leading source of mortality for post-recruitment fawns in southern Illinois, it was not important or not recorded in other studies (Huegel et al. 1985*a*, Wickham et al 1993, Bowman et al. 1998, Ballard et al. 1999, Vreeland 2002). It is possible the road density and traffic volume in southern Illinois contributed to higher mortality relative to other study areas.

Despite the impact predation has on fawns from birth to recruitment (Nelson and Woolf 1987, Ballard et al. 1999, Vreeland et al. 2004, Rohm et al. 2007), predation does not seem to be a primary source of mortality during the post-recruitment period in the lower Midwest or Southeast (Wickham et al. 1993, Bowman et al. 1998, this study). We observed only 3% of fawns succumbing to predators during the post-recruitment period. Potential predators of fawns in southern Illinois were bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and domestic dogs (*Canis familiaris*; Rohm et al, 2007). Although we were not able to determine specific predators, coyotes and bobcats were likely the most influential predators if late recruitment predation was indicative of post-recruitment predation (Rohm et al. 2007). Other studies in the Southeast also found post-recruitment predation to be minimal with neither Wickham et al. (1993) nor Bowman et al. (1998) recording any predation. Post-recruitment predation in the more northern latitudes also seems slight with an 8% rate occurring in Iowa (Heugel et al. 1985*a*), 5% in New Brunswick (Ballard et al. 1999), and no predation occurring in Pennsylvania (Vreeland 2002). Although predation could be important in late winter and early spring months for northern regions with severe winters (Nelson and Mech 1986, Patterson et al. 2002), this is not likely the case in the lower Midwest or Southeast.

Past research has indicated that male fawns are more susceptible to harvest than females (Roseberry and Klimstra 1974, Coe et al. 1980, Roseberry and Woolf 1988). Difference in harvest vulnerability is believed to be a result of male fawns being more active, a tendency to travel alone, and their general adventuresome nature (Coe et al. 1980, Roseberry and Woolf 1988). However, Dusek et al. (1989), Wickham et al. (1993), and our study found little or no evidence of male fawns being more susceptible than females to harvest. Previous research that reported a difference in fawn vulnerability analyzed harvest records and did not know the true number of fawns from each sex entering the hunting season. Monitoring a marked sample through the seasons does not have such a limitation. Several methods used to analyze harvest data incorporate proportion of yearling males to females in the harvest (Lang and Wood 1976, Creed et al. 1984, Roseberry and Woolf 1991). This method requires equal recruitment into the yearling class and this ratio is often corrected for an assumed preponderance of males in the harvest (Roseberry and Woolf 1988). Given we observed males were not more susceptible to harvest than females, this correction would not be necessary for deer population models on our study areas.

Management Implications

By monitoring radiocollared fawns through the firearm season in southern Illinois, we were able to estimate proportion of fawns that were harvested without biases associated with harvest data. In addition to determining extent of harvest mortality, we were able to identify other sources of mortality impacting fawns during the fall months. Predation during this time was minimal. However, vehicle collisions were an important source of mortality and should be incorporated into population models and management decisions, especially in areas with an extensive road network. It is often assumed that male fawns are more susceptible to mortality than females. We provide evidence that this may not be true. Deer managers should periodically revise and calibrate their population models based on updated and local fawn survival studies.

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