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Notes

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Abstract

Minimal information is available regarding the reproduction of coyotes (*Canis latrans)* in the Mid-Atlantic region, which includes the states of Delaware, Maryland, North Carolina, Pennsylvania, Virginia, and West Virginia. Since reproductive information is useful to assess populations and determine management strategies and because this information is unavailable for the Mid-Atlantic, we examined uterine tracts of 66 female coyotes collected from February to May 2010 for fetuses. We measured fetuses using a digital caliper and approximated dates of conception and parturition. Nine (13.6%) female coyotes were pregnant with visible fetuses; seven of these females were yearlings (1.5–2.5 y old). Average litter size of yearling coyotes was 5.4 (SE = 0.48). We estimated an average conception date of 2 February and an average parturition date of 6 April. Conception and parturition dates were within the reported range for coyotes, though one female successfully bred in early January, which is earlier than reported in the literature. The relatively high proportion (30.4%) of yearling females breeding in West Virginia may reflect abundant food resources, low density of coyotes, increasing human-caused mortality, or a combination of these factors. Reproductive information reported here will be helpful in monitoring coyote population trends and in the assessment of management strategies.

Keywords: coyote; *Canis latrans*; reproduction; West Virginia

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Introduction

Female coyotes (*Canis latrans*) are seasonally monestrous and usually breed between mid-January and March, giving birth approximately 63 d later (Bekoff and Gese 2003). Coyote reproduction records in the western United States are available from the mid-1910s (Hamlett 1938) and early reports show slight variation among whelping dates of pups. Most states report litters present in dens between March and May, with some reports as late as June (Hamlett 1938). Litter sizes and the age of females at breeding is affected by several factors. Areas more recently colonized by coyotes tend to have higher reproductive rates than those areas with more established populations (Chambers 1992). In populations of coyotes that are unexploited (where no lethal take occurs) the age structure tends to be older, adults have high survival rates and low reproductive rates, and few young survive to replace adults (Andelt 1985; Gese et al. 1989; Windberg 1995), whereas in heavily exploited

coyote populations age structure tends to be younger, adults have low survival rates and high reproductive rates, and younger animals are more likely to breed (Gier 1968; Knowlton 1972; Gese 2005). Although heavy exploitation may increase litter sizes and result in higher rates of yearling breeding, coyote population sizes remain constrained by the availability of food on the landscape (Gier 1968; Clark 1972; Knowlton et al. 1999).

Fecundity among coyote populations is generally high, with 60–90% of adult (>2.5 y old) females breeding (Knowlton 1972; Bekoff and Gese 2003; Nelson and Lloyd 2004). Yearling (1.5–2.5 y of age) coyotes may breed, and Knowlton (1972) reported that 35% of captive females may experience estrus in their first year. However, juveniles (<1.5 y of age) do not constitute a substantial proportion of the breeding population (Windberg 1995) and often have lower rates of implantation than adults (Chambers 1992). Kennelley (2001) suggested that most annual variation in the number of breeding females in a population is a result of the number of juveniles that become sexually mature. In a high-density coyote population in Texas, yearlings had lower and more variable natality than adults (Windberg 1995). Gipson et al. (1975) reported that among captured female coyotes in Arkansas, no juveniles had bred, but 74% of coyotes older than 2 y were pregnant or had produced pups. Nelson and Lloyd (2004) reported that 88% of adult females (>32 mo old), 56% of yearlings (20–23 mo old), and 44% of juveniles (8–11 mo old) bred in Illinois. In Maine, Hinton (1976) reported that no yearling females were pregnant or showed evidence of pregnancy (i.e., uterine scars). In Tennessee, Stephenson and Kennedy (1993) documented that 15 of 31 coyotes showed placental scars, with all female coyotes 2 y or older showing signs of having been bred, whereas no yearling females exhibited signs.

Estimates of litter size are based on counts of fetuses, embryos, placental scars, (e.g., Gier 1968; Chambers 1992) and pups present at den sites (e.g., Knowlton 1972; Hennessey 2007). Hamlett (1938) and Asdell (1964) suggested that fetus numbers can be higher than actual numbers found in dens, with 85–92% of embryos developing into pups. Average litter size varies between four and six pups depending on prey availability (Hamlett 1938; Golightly 1979; Bekoff and Gese 2003). Literature regarding eastern coyotes documents placental scars averaging between 3.9 and 5.9 (Moore and Millar 1984; Smith 1984; Stephenson and Kennedy 1993; Nelson and Lloyd 2004; Mahan and Mahan 2007), with Hinton (1976) reporting the highest average at seven. Documented litter sizes from radiotracked coyotes in the eastern United States ranged between 3 and 10 (Way et al. 2001; Hennessey 2007).

Few studies have been conducted on coyotes in the Mid-Atlantic region of the United States and little is known about their reproduction in this region (Mastro 2011). Coyotes were first identified in Pennsylvania in the 1940s (Hilton 1978; Hayden 2003), in Tucker County, West Virginia in 1950 (Taylor et al. 1976), and in Northern Virginia near the border with West Virginia in the mid-1960s (Carpenter 1971). Sightings became more frequent in Virginia (Carpenter 1971) and West Virginia (Taylor et al. 1976) in the 1970s, with coyotes becoming common in West Virginia by the 1990s (Wykle 1999). Reproductive information can be useful to assess harvest management strategies, manage damage issues, or for incorporation into population models (Knowlton 1972). Our objective was to collect fetuses from coyotes to estimate conception date, parturition date, and average litter size to advance our knowledge of reproductive ecology of coyotes in West Virginia.

Methods

We collected and froze coyote carcasses in cooperation with U.S. Department of Agriculture, Animal and Plant Health Inspection Agency Wildlife Services (hereafter Wildlife Services), hunters, and trappers throughout the state of West Virginia as part of a larger coyote diet study (Albers 2012). We recorded location collected, collector's name, and date trapped for each animal. We examined uterine tracts of coyotes trapped from February to May 2010 to determine presence of fetuses and litter size. We used digital calipers to record crown–rump measurements of fetuses. Fetus measurements were taken by the same observer to standardize measurement procedures. Small fetuses (<50 mm) were measured within the amniotic sac to avoid damage. We estimated date of conception and parturition date by determining fetus age, which we approximated following methods described by Kennelly et al. (1977) using a fetus ruler incorporating coyote fetus growth-curve rates. A lower canine tooth was removed from coyotes that were pregnant to age individuals. Radiographs of teeth showing root tip closure or lack thereof were used to separate juveniles from yearlings and adults (Linhart and Knowlton 1967). Adult and yearling teeth collected were sent to Matson's Laboratory (Milltown, Montana) for cementum annuli aging (Matson 1981).

Results

We examined the reproductive condition of 66 female coyotes (37 juveniles, 23 yearlings, 6 adults) collected in West Virginia from 20 January to 18 May 2010. Among them were nine females with visible fetuses; 1 of 37 (2.7%) juveniles (< 1.5 y of age), 7 of 23 (30.4%) yearlings (1.5–2.5 y of age), and 1 of 6 (16.7%) adults (2.5+ y of age). Because of the limited number of juveniles and adults with visible fetuses, we focused our analysis on yearling coyotes (Table 1). We recorded yearling females with fetuses from several geographic locations throughout the state, with 7 of 55 counties represented (Figure 1).

Average conception date among yearlings was 4 February, with conception ranging from 6 January to 26 February (Table 1). Fetus age ranged from 30–58 d (Table 1). Average litter size for yearling coyotes with fetuses was 5.4 (SE = 0.48). One in utero litter was old enough to determine fetus sex (i.e., fetus length >100 mm); this litter consisted of two males and five females.

Table 1. Reproductive parameters from seven yearling (1.5–2.5 y) female coyotes (*Canis latrans*) collected in West Virginia, February–May 2010.

Number of fetuses present	Average fetus crown–rump length (mm)	Approximate age of fetuses (d)	Estimated conception	Estimated parturition
4	40.8	35	6 January	10 February
5	14.2	30	25 January	29 March
6	31.1	33	26 January	30 April
7	68.1	41	11 February	15 April
4	52.9	38	8 February	12 April
7	160.4	58	3 January	7 April
5	59.4	39	11 February	15 April
Average dates			4 February	8 April

Estimated parturition dates averaged 8 April and ranged from 10 March to 30 April.

Discussion

Several factors may influence reproductive rates in coyotes, including food availability, population density, and harvest pressure (Gier 1968; Clark 1972; Knowlton 1972; Nellis and Keith 1976; Dumond and Villard 2000). Food resources vary among habitats throughout West Virginia. Although coyote population density is unknown, an average of 2,700 coyotes were harvested annually during the 2010–2011 and 2011–2012 seasons. Additionally, sightings from bowhunters, although varying slightly, were relatively consistent from 2007 to 2010 (0.55 sightings/100 h average; D'Amico et al. 2013). Harvest opportunity is liberal, with a 4-mo trapping season and year-round hunting season in West Virginia. Average litter size in West Virginia was consistent with other reports from throughout North America of four to six pups (Hamlett 1938; Knowlton 1972; Nellis and Keith 1976; Windberg 1995; Bekoff and Gese 2003; Sacks 2005), though on the upper end of that range. Large litter sizes reported here may reflect high resource availability, low density, high exploitation, or a combination of these factors acting on coyote populations in West Virginia. Regardless of the influence of the aforementioned factors, information regarding litter size, as it does not currently exist for West Virginia coyotes, will be an important parameter when examining coyote population dynamics.

Yearling pregnancy rates reported in the literature vary substantially, and range from 0 (Hinton 1976; Stephenson and Kennedy 1993) to 56% (Nelson and Lloyd 2004). Our pregnancy rate (30%) is similar to the 35% pregnancy rate reported by Knowlton (1972) in Texas. However, our estimate may be conservative because we were unable to detect embryos in the earliest stages of pregnancy, which is a limitation of sampling coyotes trapped before the end of the breeding season to estimate pregnancy rates. Ten of our 23 juvenile females (43.5%) were trapped before 3 March (~30 d beyond our average conception date), making it possible that they were pregnant but lacked visible fetuses, as most fetuses are visibly undetectable until 25–30 d. Evaluations of uterine horns for placental scars may have also provided additional information regarding yearling reproduction, but we did not collect uterine tracts.

Figure 1. Harvest locations (★) of yearling coyotes (*Canis latrans*) with fetuses present in West Virginia, January–May, 2010.

Albers (2012) reported that the average age of sampled coyotes in West Virginia during 2009–2011 was 0.89 y, which may suggest a rapidly growing coyote population in West Virginia. Yearling breeding and evidence of juvenile breeding suggest high resource availability relative to population density. Our prediction of high resource availability is moderately confounded by the relatively low level of adult reproduction recorded (16.7%). However, our limited sample size for adults ($n = 6$) may have affected our estimated pregnancy rate for this age class. In Colorado, Gese et al. (1989) found no yearling reproduction and small litter sizes in adult coyotes, which the authors speculated suggested that food was limiting. Our observed elevated rate of yearling breeding could suggest that resources are currently not limiting reproduction of coyotes in West Virginia. Though speculative, the habitats in West Virginia are generally productive eastern forests, mixed with cultivated agriculture fields and pastures that also support populations of many game and nongame species, including harvestable populations of other carnivores, including black bear (*Ursus americanus*), red and gray foxes (*Vulpes vulpes* and *Urocyon cinereoargenteus*), and bobcats (*Lynx rufus*). The productivity of these habitats would suggest that resources, especially for coyotes that are opportunistic in their diet, would support relatively high rates of reproduction. Increased trapping and hunting pressure in recent years (Rogers 2011) may also have contributed to higher rates of reproduction as shifting age structure associated with harvest pressure may influence litter sizes in coyotes (Knowlton 1972; Dumond and Villard 2000). Coyotes are thought to have become "common" in West Virginia in the 1990s, but it is uncertain when coyotes may have populated every county in West Virginia. Wildlife Services began selectively removing coyotes as part of the Farm Protection Program in 1996 (Houben et al. 2004) and lethal removal for nuisance or damage situations and regulated harvest of coyotes has been legal throughout the colonization of coyotes (R. Rogers, West Virginia Division of Natural Resources, personal communication). The level of estimated harvest based on harvest surveys was low in the late 1990s but began to increase in the mid-2000s (Rogers 2012; Reference S8) and observations by hunters increased over this same time period. Recent levels of exploitation (i.e., younger age structure) within productive habitats may have contributed to our observed rate of yearling reproduction.

Our average date of conception of 4 February among yearling coyotes is consistent with reports of coyotes breeding in January and February in the western United States (Gier 1968; Windberg 1995) and in the Northeast (Hinton 1976). We estimated that one female bred 6 January, which is earlier than the late-January to early-February breeding reported for other regions (Gier 1968; Parker 1995; Kennelly 2001), and in captive populations (Kennelly 2001; Carlson and Gese 2008). Our average parturition date of early April falls within the reported range for coyotes, though slightly earlier than the average peak of mid-April for coyotes in the Northeast (Chambers 1992). It should be acknowledged, however, that as discussed with proportion of breeding animals, our timing of collecting samples could have influenced our estimated parturition and conception dates, as we may not have detected some early or late breeders.

Conclusions

Our findings suggest that a moderate percentage of yearling coyotes are breeding and that the average litter size in West Virginia is on the upper end of the range reported in the literature. Our observations of reproductive yearlings and large litter sizes suggest that population densities remain low in some areas, which could support the premise of coyotes as a relatively recent colonizer of West Virginia. Alternatively, it could suggest that populations are responding to exploitation as a result of regulated harvest and lethal removal in response to damage and nuisance situations. Reproductive yearlings suggest that there may be high food resource availability and a functional response to increasing trapping and hunting pressure, allowing younger animals to breed. Although our overall pregnancy rate for yearlings was within the reported range, our observations of breeding yearlings adds to the limited knowledge of coyote reproduction in the Mid-Atlantic region and more specifically, in West Virginia.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

Reference S1. Bekoff M., Gese EM. 2003. Coyote (*Canis latrans*). Pages 467–481 in Feldhammer GA, Thompson C, Chapman JA, editors. Wild mammals of North America: biology, management, and conservation. 2nd edition. Baltimore, Maryland: Johns Hopkins University Press.

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Reference S2. Carlson DA, Gese EM. 2008. Reproductive biology of the coyote (*Canis latrans*): integration of mating behavior, reproductive hormones, and vaginal cytology. Journal of Mammalogy 89:654–664.

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Reference S3. Gese EM. 2005. Demographic and spatial responses of coyotes to changes in food and exploitation. Proceedings of the Wildlife Damage Management Conference 11:271–285.

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Reference S4. Hamlett GWD. 1938. The reproductive cycle of the coyote. U.S. Department of Agriculture Technical Bulletin 616.

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Found at DOI: http://dx.doi.org/10.3996/072015-JFWM-063.S5 (3.72 MB PDF); also available at http://naldc.nal.usda.gov/download/39881/PDF (March 2016).

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