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Situational and Driver Characteristics Associated With Deervehicle Collisions in Southeastern Michigan

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SITUATIONAL AND DRIVER CHARACTERISTICS ASSOCIATED WITH DEER-VEHICLE COLLISIONS IN SOUTHEASTERN MICHIGAN

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Abstract: Deer-vehicle collisions (DVCs) create societal impacts throughout the range of white-tailed deer (*Odocoileus virginanus*). In Michigan reported DVCs increased by nearly 60% between 1992-2003, with current estimates at more than 65,000 DVCs per year and a mean of $2,300 vehicle damage. To better understand where to direct education and information programs, we used Office of Highway Safety Planning (OHSP) data, 2001-2003, to profile driver characteristics and accident situations of DVCs in Washtenaw, Oakland, and Monroe Counties in Michigan. Each county varies in intensity of land use, human and deer densities, and available deer habitat. Deer density in Washtenaw, Oakland, and Monroe Counties was 49.5, 21.9 and 8.9 per mi^2, respectively, and the annual rate of DVCs in these counties was 5.3, 2.6 and 1.8 per 1,000 licensed drivers. Drivers are at particular risk of being involved in DVCs between 6pm-6am, which includes dawn and dusk commuting hours, and night. Single lane roads and roads with higher posted speed limits provided greater risk to drivers of involvement in a DVC. Middle-aged drivers, particularly males, were at increased risk deer-related collisions. Results from this study will be combined with survey research to determine how best to educate drivers about risk factors that make occurrence of a DVC more likely.

Key words: deer-vehicle collisions, driver characteristics, education, Michigan, *Odocoileus virginianus*, white-tailed deer

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INTRODUCTION

Annually, more than 1 million deer-vehicle collisions (DVCs) in the United States cause nearly 30,000 driver and passenger injuries, 200 human fatalities (Conover et al., 1995), and an estimated $2,300 in damage per vehicle (R. Miller, personal communication). The total societal costs of DVCs are unknown due to low reporting rates (< 50%; Allen and McCullough 1976, Decker et al. 1990) and the difficulty of estimating costs other than vehicle damage. For example, the social costs of DVCs, which may include human death and often include human injury, property damage, absence from work, and psychological trauma to victims of accidents and their families, are rarely factored into equations calculating expenses related to DVCs (Hansen 1983).

Michigan, like many other states, has seen a marked increase in white-tailed deer (*Odocoileus virginianus*) populations in recent years and an associated surge in the number of DVCs over that same period (Figure. 1). In 2003, the Michigan Department of Transportation (MDOT) received 67,790 reports of DVCs (Office of Highway Safety Planning (OHSP) 2004), which represented a 59.5% increase from the 42,494 DVCs reported in 1992 (OHSP 2002). Deer-vehicle collisions reported to MDOT in 2003 resulted in 11 fatalities and 1,913 injuries in Michigan.

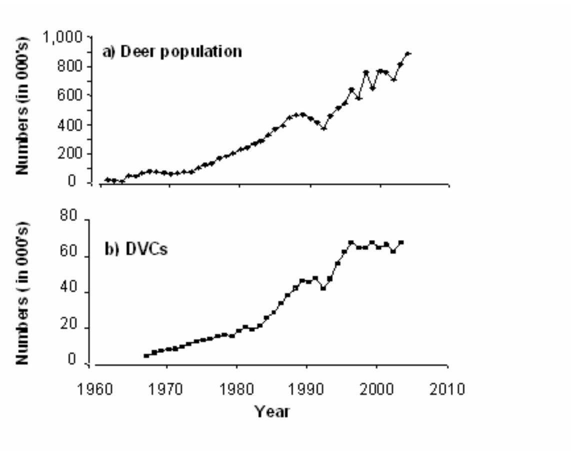

Figure 1. Trends in a) annual estimate of deer numbers from 1961 – 2004 in Michigan's Southern Lower Peninsula (unpublished MDNR data), and b) reported number of deer-vehicle collisions in Michigan, 1967 – 2003, (Langenau and Rabe 1987; OHSP 1997, OHSP 2003).

Wildlife damage management is principally about reducing negative impacts of wildlife to society (Riley et al. 2002). To better understand why DVCs are occurring, and to develop effective education, there is a need to better understand the types of drivers involved and the physical circumstances associated with DVCs. Most research on DVCs has assessed deer populations, habitat, and road design aspects of the problem (Jahn 1959, Pojar et al. 1972, Puglisi et al 1974, Groot Bruinderink and Hazebroek 1996, Putman 1997, Hubbard et al. 2000) or their economic implications (Reed et al. 1982, Hansen 1983, Decker et al. 1990, Conover et al. 1995). Engineering solutions alone, those directed at manipulation of the physical environment (Foster and Humphries 1995) or deer population, are not likely to be sufficient for reducing impacts of DVCs. Yet, no research has yet been done to profile drivers involved in DVCs and only limited research has been done to profile the characteristics of the accident scene and the timing of DVCs (Allen and McCullough 1976) or the interrelationship of theses variables.

We analyzed situational and driver characteristics associated with DVCs within 3 counties in southeastern Michigan that represent a gradient of human densities, land use characteristics, and traffic volumes. The aim of the study was to develop improved profiles that will assist wildlife managers and public safety officials to more effectively communicate with drivers about how to reduce their risk of experiencing a DVC. Information and education programs of this type may be a useful tool for supplementing decisions regarding management of deer populations or the design of roads, aimed at minimizing societal impacts of DVCs.

METHODS

Our analyses focused on vehicle crash data from Oakland, Washtenaw and Monroe Counties in southeastern Michigan (Figure. 2). These counties were selected because they encompass a variety of deer habitats, industrial, community, and residential development, and traffic conditions found in southern Michigan. Oakland is the most urban of the 3 counties, having experienced the greatest urban sprawl from the Detroit metropolitan area. Monroe County is the most rural, with large-scale farming still comprising a majority of the landscape. Washtenaw County is intermediate between the other 2 counties in terms of human settlement, transportation patterns, and deer habitat and abundance. Ann Arbor is situated near the middle of the county and over the past 30 years has transitioned to a center for high-tech jobs. Much of the rural landscape has been converted to small tract housing amid a mix of state land and farms.

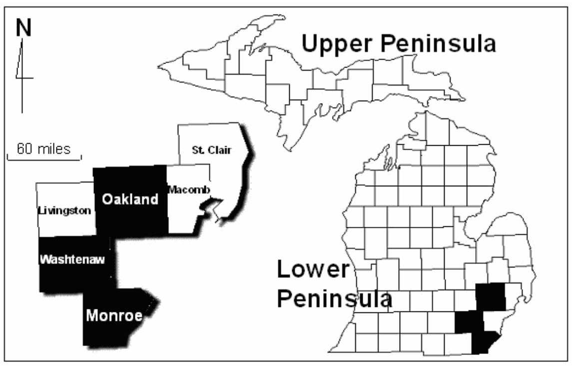

Figure 2. Location of Oakland, Washtenaw, and Monroe Counties in southeast Michigan.

Data Sources.

Data on all motor vehicle crashes for the years 2001 – 2003 were obtained from UD-10 Traffic Crash Reports, which were provided by the Michigan Office of Highway Safety Planning (OHSP). UD-10 Traffic Crash Reports are completed by law enforcement and traffic safety officers for all reported vehicle crashes that result in $\geq$ $400 in damage to a vehicle. Drivers involved in crashes were categorized by gender, age, and type of vehicle driven. For the purpose of this study we analyzed the following six vehicle categories: passenger and station wagon (any sedan type vehicle); van or motor home (any large van or motor home); pickup (any pickup truck); truck < 10,000 lbs.; motorcycles; and trucks or buses > 10,000lbs. Accident scene characteristics included: the county the accident occurred in; the number of traffic lanes; speed limit posted at the scene; timing (hour of day, day of week, and month); weather (clear, cloudy, fog, rain, snow); road condition (dry, wet, wintry); and light (daylight, dusk, dawn, dark with artificial lighting, dark with no lighting) conditions.

Human population data from the 3 counties for the period were obtained from the United States Census Bureau (USCB 2000) and the Southeast Michigan Council of Governments provided information about licensed drivers in the area (Tom Bruff, SEMCOG, unpublished data). Deer population estimates for the Southern Lower Peninsula were obtained from the Michigan Department of Natural Resources (B. Rudolph, MDNR, personal communication).

Data Analysis

The raw data provided by the UD-10 reports were counts of DVC and non-DVCs, with associated driver and situational data for each collision. Such counts reflect the risk of collision at a given place and time, together with the extent of exposure to that risk. Risk is determined by situational characteristics of the collision scene in addition to behavior of deer and drivers, whereas exposure is primarily determined by traffic volume. Thus a high number of recorded DVCs may reflect a risky situation, high traffic volumes (usually reported as vehicle miles traveled;), or both.

Vehicle miles traveled (VMT) data collected by the MDOT are available in aggregated form (i.e., per county per year). However, we did not attempt to correct for differences in VMTs associated with factors such as weather and road conditions. Rather, we used the background rate of non-DVCs as a proxy for overall traffic volumes and calculated the relative risk that collisions in a particular situation were DVCs rather than non-DVCs. High relative risk values indicated situations where many more DVCs are occurring than would be expected from the overall accident rate in that situation. Low relative risk values indicate situations where very few deer are involved among the collisions that are occurring. Our risk estimates were thus influenced by circumstances that changed the overall collision rate of drivers.

RESULTS

Location

In 2003, a total of 1,300,647 drivers were licensed in the 3-county study-area (72% in Oakland, 19% in Washtenaw, and 9% in Monroe). More than 95% of households in all 3 counties owned at least 1 vehicle (Southeast Michigan Council of Governments (SEMCOG) 2003 *a*, *b*, *c*). Workers in these counties commuted a mean of 25 minutes to and from work (USCB 2000).

From 2001 – 2003, throughout the study area 186,930 accidents were reported. Of those, 9,790 (5.2%) involved or were caused by deer. Oakland is the largest and most populated with the most roads, vehicle accidents and DVCs (Table 1). Washtenaw has more than twice as many deer as Oakland, a much higher annual DVC rate per 1,000 licensed drivers, and a much higher proportion of DVCs among the vehicle accidents occurring in that county. Monroe, the smallest and least populated county in terms of human and deer density, had the fewest DVCs. Nevertheless, the DVC rate per 1,000 drivers and the proportion of accidents that were DVCs were higher in this agricultural county than in the more urbanized Oakland County. The proportion of drivers involved in DVCs per 1,000 drivers in Washtenaw County was more than 2x greater than Monroe County and approximately 7x greater than as in Oakland County.

Table 1. Human development, traffic conditions, and estimates of deer abundance for Oakland, Washtenaw, and Monroe Counties, Michigan, USA, 2001-2003.

	Oakland	**Washtenaw**	**Monroe**
Type of community	Urban/Suburban	Suburban/Rural	Rural
Area (mi^2) [a]	907	723	561
People per mi^2 [a]	1,369	455	265
Total length of roads (mi) [b]	5,582	2,326	1,725
Average commute to work (min)	27	22	24
Percentage of agricultural land [c]	7	41	62
Estimated deer population [d]	19,846	35,815	4,968
Deer per mi^2	21.9	49.5	8.9
Number of licensed drivers	941,669	241,920	117,058
Annual number of DVCs [e] (2001-2003)	1,666	1,293	303
Annual DVC rate (per 1,000 drivers)	1.77	5.34	2.59
Average posted speed limit at location of DVC / Non-DVC accidents (MPH)	47.9 / 42.8	53.0 / 42.5	54.6 / 42.7
Percentage of all vehicle crashes that were DVCs [e]	3.6	9.2	6.5

[a] USCB (2000)

[b] OHSP (2002)

[c] SEMCOG (2003*a*,*b*,*c*)

[d] B. Rudolph (pers. comm.)

[e] SEMCOG (2003*d*); data for 2002 only

Accident Scene Characteristics

Vehicle Type.--A minimum of 9,837 vehicles were involved in DVCs reported from 2001-2003. There were more vehicles than DVCs (n = 9,790) because a single accident sometimes involved more than 1 vehicle. Of the total number of vehicles involved, 67% involved passenger vehicles or station wagons, and 20% involved pickup trucks. Of the 328,551 vehicles involved in non-DVCs, 73% were passenger vehicles or station wagons and 13% were pickup trucks. The difference between the number of non-DVCs (n=177,140) and the number of vehicles involved was much greater for non-DVCs because these accidents often involved more than 1 vehicle, whereas DVCs were mostly 1-vehicle collisions.

Pick-up truck collisions were more at risk than any other vehicle to involve deer (Table 2). Collisions involving pick-up trucks were almost twice as likely as passenger vehicles to involve a deer, whereas trucks and buses > 10,000 lbs. were the least likely vehicles to have collisions that involved deer.

Speed Limit.--Roads with speed limits between 45 and 70 mph posed the greatest risk to drivers that collisions would involve a deer (Table 2). For example, roads with posted limits of 55-60 mph had 13 times the risk of roads with a 35-50 mph speed limit. Roads with speed limits below 40 mph were the least risky in terms of DVCs.

Road Type.--Roads with 2 lanes held the greatest risk that collisions would involve deer, whereas roads with 4 or more lanes held the least risk (Table 2). Two-lane roads were 2 times as risky as 3-lane roads and almost 10 times as risky as roads with 4 or more lanes.

Road Conditions.--Accidents occurring on dry roads were nearly 2 times as likely to involve deer as accidents that occurred on wet roads (Table 2). Accidents occurring on roads with wintry conditions were the least likely to involve a deer.

Light Conditions. --A greater percentage of DVCs (68.1%) were reported to occur in conditions described as dark than non-DVCs (21.8%). Of these DVCs, more than 90% occurred in conditions described as dark unlighted, whereas less than 50% of non-DVCs were reported in these same conditions.

Accidents occurring during dawn, dusk, and at night in unlighted conditions were the most likely to involve deer (Table 2*e*). Of all accidents that occurred in dark unlighted conditions, 25.2% involved deer. Accidents in dark unlighted conditions were nearly 17 times as likely to involve deer as accidents that occurred in the daylight. Accidents occurring in the evening with artificial lighting were less likely to involve deer than accidents at dawn, dusk, and unlighted evening conditions.

Weather. --The rate of occurrence for DVCs and non-DVCs was similar across different weather conditions. Clear weather conditions were recorded when 54.5% of DVCs and 51.7% of non-DVCs occurred. For 34.0% of DVCs and 28.3% of non-DVCs, cloudy weather was recorded at the time of collision. DVCs were a relatively small proportion of the collisions reported during rainy (DVCs = 5.9% and non-DVCs = 11.2%) and snowy (DVCs = 2.4% and non-DVCs = 7.1%) conditions.

Accidents were particularly likely to involve deer during foggy weather (DVCs comprised 18.1% of all accidents during fog; Table 2). The lowest risk of collisions involving deer was associated with rainy and wintry conditions. Accidents occurring during clear and cloudy weather were 0.31 and 0.35 times as likely to involve a deer as accidents occurring during foggy weather.

Table 2. Effect of various factors on number of deer-vehicle collisions (DVCs), non-DVCs, and % of total crashes that were DVCs in Oakland, Washtenaw, and Monroe Counties, Michigan, USA, 2001-2003.

ACCIDENT FACTOR	DVCs	Non-DVCs	DVCs as % of total
a) Vehicle type:			
Passenger, station wagon	6,544	240,307	2.65
Van, motor home	908	25,161	3.61
Pickup	1,973	41,481	4.76
Trucks < 10,000 lbs.	299	10,060	2.97
Motorcycles	30	1,411	2.13
Trucks and buses > 10,000 lbs.	71	8,683	0.82
b) Posted speed limit (mph):			
0	1	247	0.40
5-20	3	646	0.46
25-30	448	34,584	1.28
35-40	786	44,236	1.75
45-50	3,852	55,314	6.51
55-60	3,223	10,652	23.23
65-70	1,100	22,034	4.75
c) Road type:			
Single lane	254	4,681	5.15
Two lanes	8,078	70,355	10.30
3 lanes	648	27,196	2.33
4 or more lanes	660	70,418	0.93
d) Road conditions:			
Dry	7,940	120,527	6.18
Wet	1,206	33,345	3.49
Ice, slush, snow	300	17,104	1.72
e) Lighting conditions:			
Daylight	1,952	125,953	1.53
Dark, with artificial lighting	499	19,954	2.44
Dawn	697	4,142	14.40
Dusk	389	5,160	7.01
Dark, with no lighting	6,109	18,172	25.16
f) Weather conditions:			
Clear	5,285	90,413	5.52
Cloudy	3,295	49,429	6.25
Fog, smoke	133	603	18.07
Rain, sleet, hail	574	20,054	2.78
Snowing, blowing snow	230	12,382	1.82

Accident Timing Characteristics

Time of day.--The non-DVC accident rate was low overnight, showed an initial peak during the 0800-0900 hr commuter traffic, and then increased progressively during the day to a more pronounced peak during the 1700-1800 hr commuter traffic (Figure 3*b*). In contrast, the DVC accident rate had 2 very pronounced peaks at 0600-0700 hr and 1800-1900 hr, a very low rate during the middle of the day, and a moderate rate during the hours of darkness (Figure 3*a*). The proportion of accidents involving deer peaked at dawn, and was consistently higher at night than during the day (Figure 3*c*). These patterns were similar in all 3 counties.

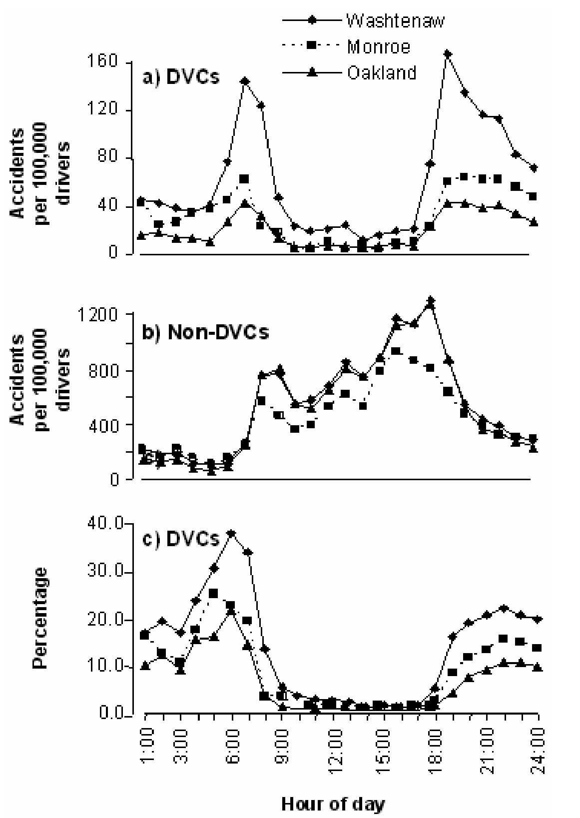

Figure 3. Variation by hour of day on a) the rate of DVCs, b) the rate of non-DVCs, and c) the percentage of all accidents that are DVCs, for Oakland, Washtenaw, and Monroe Counties in southeast Michigan, USA, 2001-2003.

Day of week.--Non-DVC accidents were slightly more common on weekdays than during the weekend, particularly in Washtenaw and Oakland counties (Figure 4*b*), whereas, the DVC accident rate was relatively similar throughout the week in all 3 counties (Figure 4*a*). Consequently, the proportion of accidents involving deer increased during the weekend (Figure 4*c*).

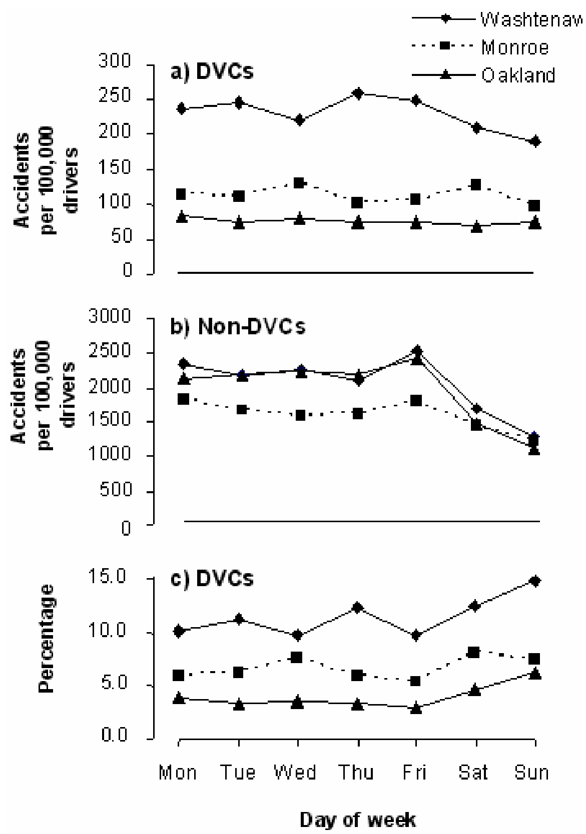

Figure 4. Variation by day of week in a) the rate of DVCs, b) the rate of non-DVCs, and c) the percentage of all accidents that are DVCs, for Oakland, Washtenaw, and Monroe Counties in southeast Michigan, USA, 2001-2003.

Time of year.--The rate of non-DVCs was relatively constant seasonally, with only a slight rise in winter months (Figure 5*b*). In contrast, in all 3 counties there was a pronounced increase in the rate and percentage of DVCs from October through January (Figure 5*a*,*c*).

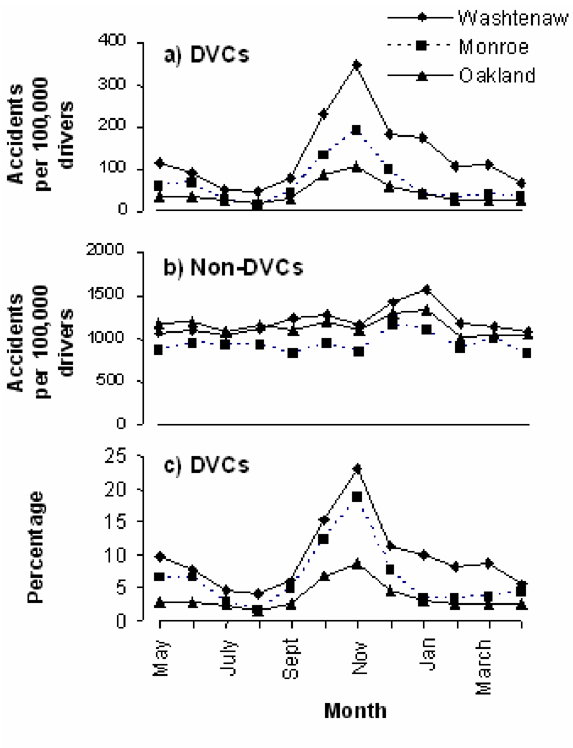

Figure 5. Variation by month in a) the rate of DVCs, b) the rate of non-DVCs, and c) the percentage of all accidents that are DVCs, for Oakland, Washtenaw, and Monroe Counties in southeast Michigan, USA, 2001-2003.

Driver Characteristics

Gender of driver.--The sex ratio of drivers in each county was very close to 1, whereas the percentage of DVCs and non-DVCs were skewed toward male drivers (61.0% and 56.5% male, respectively). Throughout each age range the percentage of male licensed drivers in the population remained consistently around 50%, until around age 65, beyond which the sex ratio became progressively more female-biased. Yet, the percentage of male drivers involved in both DVCs and non-DVCs was greater than 50 for all ages, peaking at 76.7% for 80 – 84 yr old drivers.

Age of driver.--The mean age of drivers involved in DVCs (39.9 yr) was slightly greater than the mean age of drivers involved in non-DVCs (37.5 yr). The mode for drivers involved in DVCs, however, was 44 yr, whereas the mode for drivers involved in non-DVCs was 17 yr (Table 3).

In all 3 counties, the proportion of collisions that involved deer increased steadily with age to a peak at ages 45 to 59 yr and then decreased among older drivers (Figure 6*a*,*b*,*c*). Male drivers were more likely than female drivers to hit deer, although this gender difference was more pronounced in Washtenaw and Oakland Counties than in Monroe.

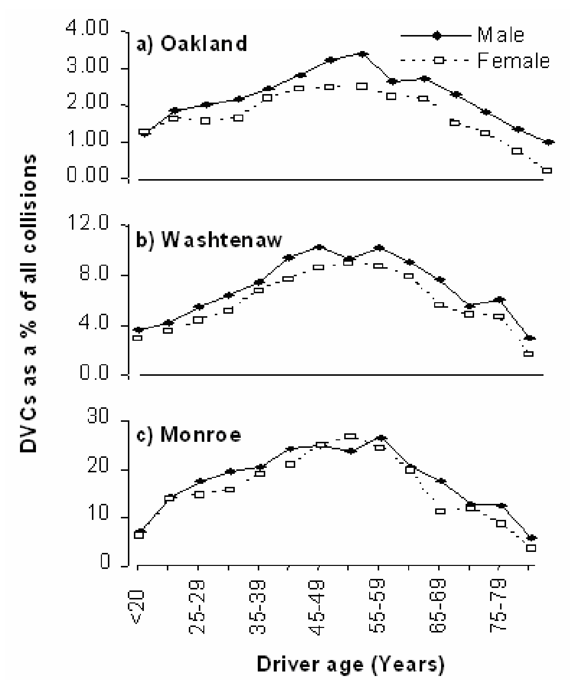

Figure 6. Gender and age effects on the proportion of deer-related vehicle collisions in a) Monroe, b) Washtenaw, and c) Oakland Counties, Michigan, USA, 2001-2003.

DISCUSSION

Deer-vehicle collisions are just one of many hazards facing motorists, but the greatest hazard involving wildlife (Romin and Bissonette 1996). Deer may be involved in nearly 15% of all vehicle accidents on roads with speeds of 45 to 60 mph, many which were constructed when the landscape was predominantly rural. Reduction of deer herd size and fencing are perceived by wildlife and transportation managers to be the two techniques with the strongest potential to reduce DVCs (Sullivan and Messmer 2003). Yet, reducing the rate of DVCs in many areas occupied by white-tailed deer will be challenging because of a growing inability to control white-tailed deer populations through public hunting (Riley et al. 2003) and because of excessive cost associated with fencing and other structures (Foster and Humphries 1995).

The higher density of deer in Washtenaw County and higher proportion of drivers commuting to work from rural into urban-suburban areas during the weekday, likely caused more DVCs per 100,000 people than in either of the other counties. The agricultural landscape of Washtenaw and Oakland Counties, like much of the upper Midwest, has gradually shifted from an agriculturally dominated landscape to a mix of remnant farms and small, fragmented land ownership patterns (Johnson 1993, Gobster et al. 2000). Projections about future land-use in southern Michigan suggest increases in commuter traffic volume from this land-use change are likely to continue through at least 2020 (Madill and Rustem 2001), and as such DVCs are likely to be a continuing impact from wildlife. Residents can be expected to desire reduced deer herd size if the real or perceived risk of DVCs increases further (Stout et al. 1993). If deer herds cannot effectively be reduced through public hunting (Brown et al. 2000), information and education directed toward motorists may play an important role in management of DVCs.

Educating drivers about the specific factors that put them at a greater risk for involvement in a DVC (e.g. hourly, monthly, and seasonal timing of DVCs; speed; and reduced visibility) will give them the choice to modify their driving behavior therefore reducing their risk of involvement in a DVC. Based on our data, information directed towards motorists should focus on raising awareness of when they need to be driving more cautiously with deer in mind. These timing characteristics should include time of year: the risks of DVCs increases markedly in fall, with a peak in mid-November. During any 24-hr period dusk and especially dawn are hazardous times, and the risks increase even more with travel in deer habitat after dark. Allen and McCullough (1976) found a strong relationship between deer activity and the rate of collisions. As evening traffic increased in correspondence with deer feeding times, DVCs also increased; after the morning peak in DVCs, traffic continued to increase but DVCs decreased suggesting a decrease in deer activity. Similarly, increased movement of deer during the fall rut may account for the peak of DVCs during those times.

If the posted speed limit is an indicator of the average speed traveled at the point of collision, speed affects the chance that a collision will involve a deer. Reducing speed by 10 – 15 mph may considerably decrease the risk of hitting a deer by increasing visibility and reaction time. The large amount of risk associated with 2-lane roads is an indication that DVCs are likely to occur where there are high-speed roads traveling through deer habitat.

Weather conditions affect DVCs by affecting drivers' road visibility, deer activity, and possibly human behavior. Deer are most likely to be less active during foul weather conditions, therefore creating less risk to drivers under wintry weather conditions and icy, slushy, and snowy roads. The same is true, to a lesser degree, with rainy weather and wet road conditions. The high risk associated with foggy weather suggests visibility plays an important role in reducing DVCs.

Understanding who is involved in DVCs can help target communication programs. In southeast Michigan, these drivers are most likely to be commuters. The individual risk of DVCs, however, may be pre–commuter time and affect those people who drive for a variety of reasons after dusk and before dawn. The youngest age classes of drivers are typically the focus of driver education because of their per capita rate of crashes. To reduce DVCs, however, information and education will have to also focus on people $\geq$ 40yr old, in the middle of their working years, with special attention to male drivers.

Much of the categorical UD-10 crash data is subjective to the judgment of law enforcement officials at the scene of the accident, or to the accident victim, who reported the DVC. These data reflect judgments of various officers, who filled out UD-10 Traffic Crash Reports. We recognize judgments by so many different data collectors likely introduced biases in the data. These biases, however, were not revealed in numerous discussions over a 2-year period with personnel from MDOT and OHSP.

All drivers should be educated about the risk factors that make an occurrence of a DVC more likely. Drivers can lower their risk of being involved in a DVC by using more caution, slowing their speed, and remaining alert and aware in areas and at times associated with increased DVC risk. Drivers fitting the 'at risk' gender and age profile should use extra caution at all times. Future research should focus on specific approaches for most effectively getting this information to drivers.

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