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Mortality of pen-raised white-tailed deer (Odocoileus virginianus) released on three areas in Louisiana

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MORTALITY OF PEN-RAISED WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) RELEASED ON THREE AREAS IN LOUISIANA

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ABSTRACT

I monitored 60 radio-collared and tagged pen-raised white-tailed deer (*Odocoileus virginianus*) to ascertain mortality rates on three areas in Louisiana from April 2001 – April 2002. Two of 60 were not used in the analysis because mortality occurred from complications with darting and an affixed radio-collar. Study deer were exposed to legal hunting mortality only if they emigrated from the three study areas. Twenty deer were released to the wild on the Louisiana State University Deer Study Area (LSUDSA) (4,810 ha), where 9 of 20 (45%) suffered mortality. Harvest accounted for 56%, vehicles 22%, and other 22% of the mortality on the LSUDSA. Two groups of 20 were released into 2 high fence enclosures, (275 ha and 608 ha), where 4 of 20 (20%) and 1 of 18 (6%) suffered mortality, respectively. Other mortality accounted for 100% of the losses in the high fence enclosures. Mortality rates were significantly lower in penned deer than in the released deer (Chi-Square 8.33 2df, $P<0.05$). These results suggest that high fence enclosures reduce emigration and hence deaths caused by hunting and vehicles and may reduce overall mortality. These results also suggest that a higher harvestable surplus may result from high fencing.

INTRODUCTION

Survival and mortality rates are important parameters in mammal populations (Caughley 1966), but fates of pen-raised white-tailed deer (*Odocoileus virginianus*) released into the wild by state wildlife agencies and private breeders are rarely determined (McCall et. al. 1988). Previous research has shown that pen-raised and translocated deer released into new surroundings are prone to experience higher mortality than native counterparts (Hawkins and Montgomery 1969, O'Bryan and McCullough 1985, McCall et al. 1988, Ozoga et al. 1992). Yet, the specific causes of mortality and dispersal in pen-raised and translocated white-tailed deer are seldom known. Also, investigations of mortality rates and their causes for maturing white-tailed deer are lacking in the Coastal Plain of the Southeast (Morgan et. al. 1995).

Many large relocation and restocking programs for white-tailed deer took place during the late 1950's and early 1960's. About 2,895 white-tailed deer were released at 94 locations in Louisiana (Moore 1979). Deer used for these stockings were from Texas, Wisconsin and two national wildlife refuges in Louisiana. There has been a special interest in the fates of deer restocked from northern states because northern deer are larger in body size and produce more trophy antlers than Louisiana deer (Ketchen 1996). Some areas stocked with northern deer in Alabama and Florida produced deer larger than native deer for a time (Barick 1951). The fates of northern deer, which were released to wild Louisiana habitats remains unknown. One hypothesis is that the genetics of released northern deer were simply diluted by larger numbers of native animals (Ellsworth et al. 1994). However, a second hypothesis is that the southern range is poorer in quality than northern range and cannot support animals of the same size as in northern areas (Short 1975).

Fewer deer are being released in the early 2000's than were released during the mid-1900s, but some releases continue especially into high-fence enclosures. Survival rates of such deer are unknown. There have been no such studies that directly investigated deer mortality in high-fence enclosures. The only available data that can be used to predict the survival of deer released into high-fence enclosures are based upon the release of pen-raised deer into the wild. Those studies suggest that released deer are unlikely to survive. In Texas, 13 pen-raised deer were released into the wild and 8 (62%) died within the first year, whereas all 20 wild deer in the study survived (McCall et. al. 1988). In Louisiana, Meyers (2001) observed only 37% survival rate of released pen-raised deer into the wild. There are no data that can be used to predict if pen-raised deer released into high-fence enclosures will have low survival rates observed similar to that when they are released into the wild. More so, they may experience higher, or even lower survival rates, when they are released into high-fence enclosures.

Many wildlife managers have mixed feelings about the release of pen-raised white-tailed deer for hunting purposes and for the intent to improve genetics within a certain population. Raising and hunting deer in high-fence enclosures is one of the most controversial issues in the field of wildlife management and will continue to be a highly debated topic for years to come. Biological issues related to confined ungulates include behavioral impacts on target species, diseases associated with confinement, genetic impacts of confinement and shipment across natural ranges, habitat impacts, and impacts on non-target species (Demarais et. al. 2002). During the course of this study a new biological issue in cervids has arisen. Chronic Wasting Disease (CWD) has become a serious biological concern across the United States and Canada. Several cases of CWD have been linked to pen-raised cervids in several states. Though the occurrences tended to be in smaller confined pen situations, ultimately many of those same animals are released into larger enclosures for hunting purposes. Many states have closed their borders to cervid imports and established scientific monitoring plans to detect CWD. For this, and other biological reasons, the majority of state and federal wildlife agencies are opposed to the establishment of high-fence enclosures, as well as many Non-governmental organizations. The Wildlife Society's policy on wild ungulates confined in high-fence enclosures states "Opposition of high-fenced enclosures, regardless of size, if they exclude free-ranging native wildlife from critical seasonal habitats or migration routes". Yet, many landowner rights issues arise in the midst of this controversy.

My primary goal was to compare mortality between pen-raised deer released to the wild and into high-fence enclosures during the first year post-release; secondary goals were to compare mortality rates that I observed to previous estimates of mortality rates of pen raised and wild white-tailed deer. I monitored the released deer with radio telemetry to determine mortality.

LITERATURE REVIEW

Each year the public and wildlife rehabilitators raise injured or orphaned white-tailed deer (McCall et al. 1988). After rehabilitation these deer are commonly released into the wild. However, survival rates of rehabilitated deer are usually very low (Spears 1994). Also, pen-raised deer are commonly released into the wild and suffer high mortality rates (McCall et al. 1988). Most losses occur within the first 4 months after release (McCall et al. 1988). Jones et. al. (1997) reported a mortality rate of 53% for translocated deer in New York. These results were significantly different from mortality rates of 25% and 12% for resident, wild deer in 2 consecutive years (Jones et. al. 1997). Other studies done on translocation of wild deer have shown mortality rates as high as 48.8% (Cromwell et al.1999). Yet, it has been shown that the age of released deer may be an important factor in survivability. In a study conducted in Virginia, 53.8% of orphaned fawns died, while 84.4% of wild fawns died between the ages of 7 and 30 months (Holzenbein and Marchinton 1992). Identification of mortality sources of white-tailed deer, particularly depredation and survival rates, is important for effective management (Ballard et al. 1999).

According to Jones and Witham (1990), capture-related stress, accidents with vehicles, and losses to hunters are the major mortality factors of wild white-tailed deer. Matschke et. al. (1984) stated that deer mortality rates are constantly affected by many interrelated factors, including poaching, predators, disease, parasites, nutrition, weather, and accidents. Depredation is a major source of mortality for white-tailed deer in certain areas of the United States. In a study done on predation, coyotes (*Canis latrans*), black bears (*Ursus americanus*), domestic dogs (*Canis domesticus*), and bobcats (*Felis rufus*) were the largest cause of mortality to white-tailed deer during the summer and autumn

(Ballard et al. 1999). For populations subject to hunter pressure, legal harvest is a major source of mortality (Morgan et. al. 1995). Dusek et. al. (1992) found that hunting, including legal harvest, wounding loss, and illegal kill, was the largest source of mortality among all study areas and study periods. In Michigan's central upper-peninsula, mortality patterns of deer are affected by male-biased hunting regulations (VanDeelen et al. 1997). VanDeelen et al. (1997) also found that differences in mortality rates between males and females were large and significant with respect to hunting mortality but small or insignificant in relation to non-hunting mortality.

Some studies have documented that rehabilitated and pen-raised deer released into the wild commonly disperse from release sites. McCall et. al. (1988) found that 31% of pen-raised deer made long-distance movements (≥11.3 km). Kammermeyer and Marchinton (1976) found similar results for 1 ½ and 2 ½ year-old wild bucks. These two age classes of males experienced great pressure from older bucks because of their subordinate social status (Kammermeyer and Marchinton 1976). Holzenbein and Marchinton (1992) found that 86.5% of wild fawns emigrated before they were 2 ½ years old. Though low survival and dispersal present problems for release or reintroduction efforts, most states must do so because it is illegal to raise or care for wildlife without proper state permits (McCall et al. 1988). In Louisiana, the Department of Wildlife and Fisheries mandates that any wildlife under a rehabilitation center's care must be released into the wild after three months (Title 76 Louisiana Administration Code, LA Department of Wildlife and Fisheries).

Although white-tailed deer management traditionally has been conducted over extensive areas by state natural resource agencies, private landowners are increasingly interested in intensively managing deer on their lands (Guynn et. al. 1983). One approach to deer management on private landholdings is quality deer management (QDM), a program designed to encourage hunters to take an active role in managing deer populations on private lands (Hamilton 1992). Because of deer farming and the continuing popularity of trophy white-tailed deer hunting, economic means to increase deer production may be significant. Some private landowners with small parcels of land use fencing to maximize control of their population (Nielsen et. al. 1997). Numerous studies have demonstrated that a well-maintained fence of sufficient height (3 m) is an effective means of restricting deer movements and allows for efficient management (McCullough 1979, Woolf and Harder 1979, Ozaga and Verme 1982). Private breeders release pen-raised deer into the wild and large enclosures to improve the genetic quality of the deer population in their area (McCall et al. 1988). In several states, interest has been shown in releasing genetically superior deer to improve the trophy quality of subsequent cohorts (McCall et. al. 1988). With hybridization already occurring and visible from past reintroductions (Kennedy et. al. 1987, Leberg et. al. 1994), it is possible that introductions of translocated deer can cause a genetic change in a recipient population (Day 1998). Though there are advantages to constructing large enclosures for a private landowner, fences designed to limit movements of free-ranging white-tailed deer can be problematic (Deer Committee 2001, unpublished).

The issue of constructing large enclosures for hunting purposes is exceptionally controversial and most anti-hunter groups generally oppose the idea of “canned hunts”. Also, harvesting deer inside fenced settings may not be viewed as fair chase by much of the hunting and non-hunting public and could result in reduced public acceptance of hunting and its role in wildlife management (Deer Committee 2001, unpublished). The high-fence enclosure issue is also controversial in that it limits movements of wild native deer. Establishment of high-fences may threaten the viability of wildlife populations and interfere with public ownership of the resource (Deer Committee 2001, unpublished). High-fences can block traditional travel corridors and force deer into situations where vulnerability is high, such as highways or railroad beds and increased deer mortality and conflicts with humans may result (Deer Committee 2001, unpublished). In a study by Holzenbein and Marchington (1992) 6 of 10 predator kills were found close to a fence and on two occasions dogs killed deer "when a fence hindered the deer's escape." Even though the high-fence enclosure issue is contentious, the fates of white-tailed deer released into high-fenced enclosures by private landowners are seldom known.

Mortality

Understanding population dynamics of white-tailed deer depends on the accurate measurement of survival and mortality (Nelson and Mech 1986). Estimated mortality and survival rates are necessary for the continued refinement of population models (Ballard et al. 1999). However, measuring mortality and its magnitude is difficult (Nelson and Mech 1986). Determining behavior of free-ranging animals by radio telemetry could be a powerful tool in wildlife research (Beier and McCullough 1988). Radio telemetry has been used to directly measure survival and detect sources of mortality for white-tailed deer (VanDeelen et. al. 1997, Giuliano et al. 1999, Heisey and Fuller 1985, Nelson and Mech 1986). However, such data are subject to biases associated with capture periods, representative sampling, and seasonal variation in survival (Nelson and Mech 1986). The benefit of using radio telemetry to study survival and cause-specific mortality is that survival data are obtained directly and causes of mortality are determined in a relatively unbiased manner (Nelson and Mech 1986).

Capture

Capture and immobilization of deer and other wildlife is often necessary in field studies and management, and minimizing capture-related stress should be a primary consideration (Delgiudice et al. 1990). Capture myopathy can affect animals up to 1 month after live capture (Bartsch et al. 1977, Harthoorn 1977). Traditionally, Clover traps and cannon nets were used to capture white-tailed deer on northern ranges (Clover 1954, Hawkins et al. 1968) with varying degrees of physical exertion and stress apparent in deer captured by these methods (Delgiudice et al. 1990). Delgiudice et. al. (1990) also found that Clover-trapped deer became acutely excited immediately upon seeing field personnel and apparently stress continued during manual restraint until deer were anesthetized. Capture-induced stress is reduced with darting equipment as compared to equipment with physical restraints (Delgiudice et al. 1990).

Economics

White-tailed deer are the major game animal for which much of the upland hunting lease activity revolves (Reed 2002). Landowners and hunters have no dependable means of estimating total mortality in the wild or in high-fence enclosures. But, the landowner assumes that mortality factors such as vehicle accidents, malnutrition, depredation, and harvest can be significantly reduced within a high-fence enclosure. Genetics of the deer within the high-fence enclosure can also be controlled to an extent. In that the landowner chooses the animals to be released into the enclosure and animals to be removed from the enclosure.

The buying and selling of breeder white-tailed deer is a substantial business within the state of Louisiana. According to the Louisiana State University Agriculture Center's annual summary of agriculture and natural resource revenue, 21 deer or antelope producers grossed $142,500 in 2002 (LSU Agriculture Center 2002). The landowners or deer breeders that purchased these animals have made large investments. The price of a certain breeder buck may reach into the tens of thousands of dollars. Another aspect involves the numerous pay-hunt ranches that have been established throughout the United States and Canada in the last 20 years. The welfare and survival of this investment is of critical importance. The option of establishing a high-fence enclosure involves a huge investment.

The cost of a high-fence enclosure usually ranges between $3.00 and $4.00 per foot to construct (Tim Miller pers. comm.). The layout of the enclosure can greatly affect the overall cost to the landowner. The Shaw Enclosure cost about $46,000 to enclose 275 hectares ($167/ha), as the Chouest Enclosure cost approximately $110,800 to enclose 608 hectares ($182/ha). These landowners decided that the cost of the enclosure did not outweigh the value of the breeder animals to be purchased.

DESCRIPTION OF STUDY AREAS

Release of Pen-raised Deer to the Wild

LSUDSA

The study was conducted on the Louisiana State University Deer Study Area (LSUDSA) in East Feliciana Parish, Louisiana (Figure 1). This area includes Blairstown Plantation and Idlewild Research Station. Blairstown Plantation is located about 5 km south of Clinton, East Feliciana Parish, Louisiana and covers a total area of 4,080 ha, of which 3,000 ha are forested. The area consists of mixed pine-hardwood forest with approximately 190 ha of open, native-grass pastureland dispersed among the forested areas. Cattle were continuously grazed on most pastures on the study area, but are excluded from about half of the study area during the winter. Annual ryegrass (*Lolium multiflorum*) is planted in the early fall to provide supplemental feed for cattle during the winter. Sixteen food plots, totaling 20 ha, are planted with winter wheat (*Triticum aestivum*) to supply deer with a fall/winter food source (Meyers 2001 unpublished).

Idlewild Research Station covers a total area of 730 ha and is located about 2.5 km south of Clinton, Louisiana. The area consists of approximately 190 ha of improved pasture and open grass, 30 ha in lakes, ponds, and creeks, 450 ha in mixed pine-hardwood forest, 21 ha in fruit trees, and 21 ha of enclosures for the captive deer herd. Chufa (*Cyperus esculentus* L.) and rye grass is planted for experimental weed research and winter cattle forage, respectively.

Soils

Soils are in the Providence and Lexington series of the Loessial Hills association. These soils are moderately well to well drained, acidic, silt loam soils occurring on gentle to moderately sloping uplands (SCS Soil Survey of Idlewild Experiment Station, Clinton, Louisiana, 1970). Soil fertility is low with respect to crop and pasture production. Soil samples collected from the study area were analyzed in 1985 at the Louisiana Agricultural Experiment Station Soil Testing Laboratory, Louisiana State University, Baton Rouge. Soil test results indicated low levels of exchangeable phosphorous (7.4 ppm), extractable potassium (34.7 ppm), calcium (609 ppm), and soil pH (4.5-5.9).

Vegetation

Dominant canopy species included loblolly pine (*Pinus taeda*), white oak (*Quercus alba*), Southern red oak (*Q. falcata*), cow oak (*Q. michauxii*), water oak (*Q. nigra*), willow oak (*Q. phellos*), American beech (*Fagus grandifolia*), mockernut hickory (*Carya tomentosa*), sweetgum (*Liquidambar styraciflua*), black cherry (*Prunus serotina*), blackgum (*Nyssa sylvatica*), and yellow-poplar (*Liriodendrom tulipifera*). The midstory and shrubby areas were comprised mainly of flowering dogwood (*Cornus florida*), yaupon (*Ilex vomitoria*), deciduous holly (*I. decidua*), boxelder (*Acer negundo*), elderberry (*Sambucus canadensis*), wax myrtle (*Morella cerifera*), common privet (*Ligustrum sinense*), and winged elm (*Ulmus alata*). Common understory species included greenbriers (*Smilax* spp.), blackberries (*Rubus* spp.), Japanese honeysuckle (*Lonicera japonica*), wild grape (*Vitis* spp.), yellow jessamine (*Gelsemium sempervirens*), French mulberry (*Callicarpa americana*), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), rattan (*Berchemia scandens*), trumpet creeper (Campsis radicans), and crossvine (*Bignonia capreolata*).

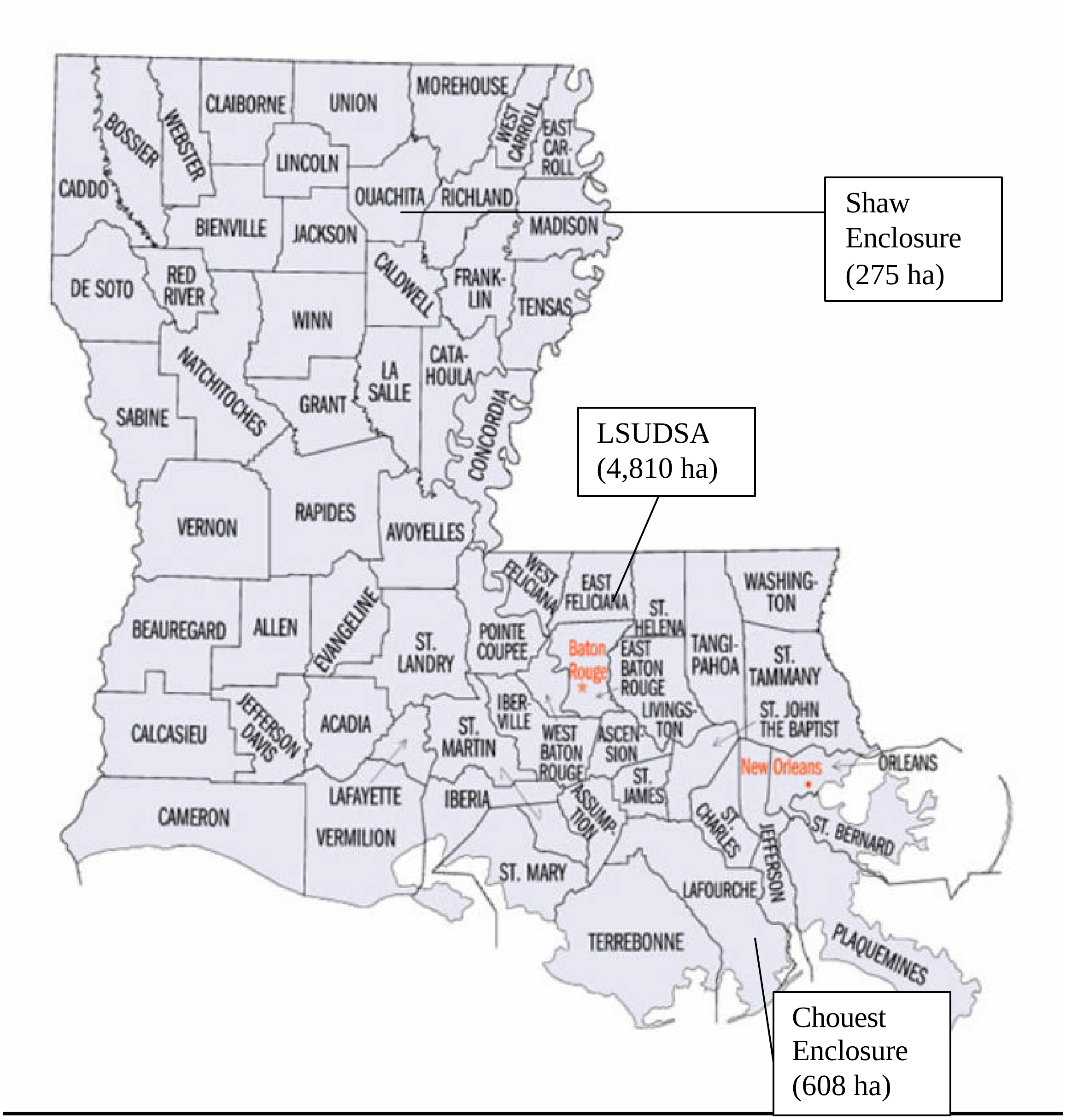

Figure 1: Map of Louisiana showing the location of the 3 release sites.

Release of Pen-raised Deer to Large Enclosures

<u>Shaw Enclosure</u>

A replication of the pen-raised deer release was conducted on a 275 ha enclosure approximately 2 km south of Monroe, Ouachita Parish, Louisiana on U.S. Highway 165 (Figure 1). An eight-foot high deer-proof fence established in the winter of 2000 surrounds the Shaw high-fence enclosure (SE). The estimated deer population after completion of the high-fence and before release of captive deer was approximately 12-15 native white-tailed deer (Sherman Shaw, landowner, pers. comm.). Approximately 15 white-tailed deer were released prior to this study and these animals were from a breeder in Farmerville, Louisiana. The area consisted of 52 ha of open cropland, 10 ha of open grass in right-of-ways and roads, and 213 ha of bottomland hardwood regeneration. Approximately 15 years ago the land was clearcut and allowed to naturally regenerate. The hardwood regeneration is mainly comprised of oak and elm species. Winter wheat, soybeans (*Glycine max*), and American joint vetch (*Aeschynomene americana*) are planted for a food source during the fall, winter, and early spring. Sunflowers (*Helianthus sp*.) are planted to attract doves (*Zenaida macroura*) during late spring through early fall. Approximately 10 gravity flow or automatic feeders, consisting of soybeans and a pelleted ration, are utilized year-round by the animals within the SE. There has been no harvest of white-tailed deer since the completion of the enclosure.

Soils

The Ouachita River Alluvium soils are in the Sterlington, Hebert, Perry, Forestdale, and Portland series. The Sterlington series, a silt loam, consists of deep, well-drained, moderately permeable soils that formed in silty alluvium. These soils are on level to gently sloping natural levees along present and abandoned channels of the Arkansas and Red Rivers. The Hebert series, a silt loam, consists of very deep, somewhat poorly drained, moderately slowly permeable soils that formed in silty alluvium. These soils are on natural levees along present and abandoned channels of the Arkansas and Red Rivers. The Perry series consists of very deep, poorly drained, very slowly permeable soils that formed in clayey alluvium. The Forestdale series, a silty clay loam, consists of very deep, poorly drained, very slowly permeable soils that formed in clayey and silty alluvium. These soils are on low terraces or natural levees bordering former channels of the Mississippi River and its major tributaries in the Southern Mississippi Alluvial Valley and are saturated late in winter and early in spring. The Portland series, a silty clay, consists of deep, somewhat poorly drained, very slowly permeable soils that formed in clayey alluvium from Permian geological formations. These level to nearly level soils are on flood plains and slack water areas along the Arkansas and Red Rivers and their former channels (USDA – NRCS Soil Survey Division 2000).

Vegetation

Dominant canopy trees included water oak, willow oak, winged elm, sweetgum, black willow (*Salix nigra*), and baldcypress (*Taxodium distichum*). The mid-story and shrubs were comprised of common privet, yaupon, elderberry, and swamp dogwood (*Cornus drummondii*). The understory vegetation included Japanese honeysuckle, trumpet creeper, poison ivy, greenbriers, French mulberry, Virginia creeper, and blackberries.

Chouest Enclosure

A second replication of the pen-raised deer release was conducted on the Chouest Farm enclosure (CE) which is a 608 ha area approximately 1 km east of LA Highway 308 near Golden Meadow, Lafourche Parish, Louisiana (Figure 1). An eight-foot high deer proof fence surrounded the area. The CE contained approximately 150 white-tailed deer, however 10 to 15 additional pen-raised deer are added to this area annually. The CE also contained several exotic species such as red stag (*Cervus elaphus*), axis deer (*Axis axis*), fallow deer (*Dama dama*), sika deer (*Cervus nippon*), and blackbuck antelope (*Antilope* *cervicapra*). The CE is believed to have contained upwards of 400 animals pre-study. From the fall of 2000 through the winter of 2001, only 16 white-tailed bucks were harvested and 16 exotic animals (Jay Duet, Farm Manager, pers. comm.). The area consisted of approximately 310 ha of wetland bottomland forest, 280 ha of open grassland, 10 ha of food plots, and 8 ha of bayous and oil field canals. White clover (*Trifolium repens*) and rye grass were planted annually for a supplemental food source. Sunflowers were planted as a game bird attractant and persisted as a food source from summer through early fall. Approximately 15 gravity flow or trough feeders were utilized year-round to provide soybeans and a pelleted ration. The CE was bordered on the north, east, and south by a man-made levee and on the west by a drainage canal. The U. S. Army Corps of Engineers, to prevent coastal flooding in southern LaFourche Parish, established the levee. Some of the enclosure was once natural intermediate marsh and used in a crawfish farming operation. A few natural ridges occurred throughout the enclosure and provided habitat for less flood tolerant trees and shrubs.

Soils

There are 8 main soil types within the study area that correspond to 3 main habitat types (Mattews 1984). Soils found immediately adjacent to natural levees and usually high in fertility are made up of the Commerce silt loam, Commerce silt clay loam, and Sharkey clay soil types. The forested areas contain Faussee-Sharkey association, Sharkey clay – occassionally flooded, and Rita muck soil types. These soils are characteristically flooded or wet. While commercial crops are difficult to grow here, water tolerant trees and plants thrive, giving rise to the palustrine wetlands and brushy areas. The third habitat area, open marsh, contains the Barbary-Faussee association and the Allemands muck soil types. These types are 2 dominant marsh soils, being semi-fluid and high in organic material (Day 1998).

Vegetation

Dominant canopy species included green ash (*Fraxinus pennsylvanica*), black willow, sugarberry (*Celtis laevigata*), Drummond red maple (*Acer rubrum* var. *drummondii*), live oak (*Q. virginiana*), diamondleaf oak (*Q. obtusa*), and Chinese tallow tree (*Sapium sebiferum*). The mid-story and shrubs were comprised of elderberry, buttonbush (*Cephalanthus occidentalis*), and Chinese tallow. Common understory species consisted of Japanese honeysuckle, greenbriers, French mulberry, poison ivy, and blackberries.

METHODS

Pen-raised white-tailed deer were equipped with mortality sensor radio collars and released into one unfenced and two high fence enclosures. All deer were released in 2001 and radio-tracked for one year.

Twenty pen-raised white-tailed deer in the 0.5 to 4.5-year age class were released to the wild on the Louisiana State University Deer Study Area (LSUDSA) in March 2001 (Table 1). Twenty pen-raised white-tailed deer in the 1.5 to 6.5-year age class were released into the Shaw Enclosure (SE) in April 2001 (Table 2). Twenty pen-raised white-tailed deer in the 1.5 to 6.5-year age class were released into the Chouest Enclosure (CE) between November 2000 and March 2001 (Table 3). Immigration and emigration was prevented in both enclosures by continuous fencing. All white-tailed deer used in this study originated from the LSU Idlewild Research Station captive herd. This herd consists of approximately 200 white-tailed deer held in 8 pens on 21 acres. The herd has been established at Idlewild research Station for about 15 years (Will Forbes pers. comm.).

I immobilized deer so that I could capture and transport them safely; I immobilized them by darting. A combination of Rompun® (xylazine; Mobay Corp., Shawnee, Kan.) and Telazol® (CI-744, tiletamine and zolazepam; A.H. Robins Co., Richmond, Va.) was used to immobilize deer (Schultz et al. 1992). The mixture used was a 167mg of Telazol to 200mg of Rompun ratio with an intra-muscular injection of 1 cc/45 kg. This ratio was found to be the most efficient tranquilizer in a study by Schultz et. al. (1992). After darting I waited for approximately fifteen minutes for the drug to take effect and the deer to be completely anesthetized. Each deer was fitted with an 8-hour mortality sensor radio collar, 2 large ear tags, and 1 small metal ear tag.

Table 1. Twenty pen-raised white-tailed deer released on the Louisiana State University Deer Study Area (LSUDSA) in 2001.

Sex/age (years)	Tag #	Tag Color	Frequency
F 1.5	54	Yellow	150.954
F 1.5	65	Yellow	150.622
F 1.5	67	Yellow	150.823
F 3.5	74	Yellow	150.294
F 3.5	76	Yellow	150.995
F 2.5	77	Yellow	150.254
F 2.5	78	Yellow	150.273
F 1.5	79	Yellow	150.214
F 0.5	81	Yellow	150.193
F 0.5	82	Yellow	150.173
F 2.5	86	Yellow	150.435
F 4.5	87	Red	150.701
M 0.5	L21/R64	Yellow	150.934
M 0.5	55	Yellow	150.094
M 1.5	L57/R58	Yellow	150.414
M 0.5	L60/R61	Yellow	150.594
M 2.5	L62/R63	Yellow	150.973
M 0.5	68	Yellow	150.134
M 1.5	70	Yellow	150.804
M 0.5	71	Yellow	150.054

Table 2. Twenty pen-raised white-tailed deer released into the Shaw Enclosure (SE) in 2001.

Sex/age (years)	Tag #	Tag Color	Frequency
F 4.5	R1/L11	Yellow	150.843
F 3.5	R2/L12	Yellow	150.012
F 4.5	R3/L13	Yellow	150.603
F 3.5	R4/L14	Yellow	150.033
F 4.5	R5/L15	Yellow	150.763
F 3.5	R6/L16	Yellow	150.862
F 6.5	R7/L17	Yellow	150.574
F 3.5	R8/L18	Yellow	150.535
F 3.5	R9/L19	Yellow	150.515
F 3.5	R10/L20	Yellow	150.493
M 1.5	91	Yellow	150.154
M 1.5	92	Yellow	150.395
M 1.5	93	Yellow	150.315
M 1.5	94	Yellow	150.354
M 1.5	95	Yellow	150.234
M 1.5	96	Yellow	150.915
M 1.5	97	Yellow	150.473
M 1.5	88	Yellow	150.253
M 1.5	89	Yellow	150.663
M 1.5	90	Yellow	150.704

Table 3. Twenty pen-raised white-tailed deer released into the Chouest Enclosure (CE) in 2000-2001.

Sex/age (years)	Tag #	Tag Color	Frequency
F 4.5	6	Orange	150.484
F 4.5	27	Yellow	
F 3.5	31	Green	
F 3.5	32	Green	
F 3.5	33	Green	150.464
F 6.5	40	Yellow	
F 4.5	42	Yellow	
F 3.5	44	Green	
F 3.5	51	Green	
F 3.5	54	Green	
M 1.5	2	Orange	150.154*
M 1.5	5	Orange	150.645
M 1.5	155	Purple	
M 1.5	156	Purple	
M 1.5	159	Purple	150.583**
M 1.5	160	Purple	
M 1.5	162	Purple	
M 1.5	163	Purple	150.564
M 1.5	164	Purple	
M 1.5	172	Purple	150.545

* Orange 2 suffered mortality due to capture myopathy.

** Purple 159 suffered mortality due to complications with the radio-collar.

The radio collar was checked for proper fit and function. The age of all studied deer was determined by tooth wear and replacement (Severinghaus 1949) and through LSU Idlewild Experiment Station records. Large ear tags were for visual recognition and small metal tags were for identification in case of loss of large ear tag or loss of radio collar. After transporting the deer, an intra-muscular reversal (Tolazine® injection) (Tolazoline: xylazine reversing agent; Lloyd Laboratories, Shenandoah, Iowa) was administered at approximately 1 cc/45 kg.

The 20 pen-raised deer released on the LSUDSA were darted, radio-collared, ear-tagged and moved to a designated pen on the Blairstown Plantation. These pen-raised deer remained in the pen for one month to become accustomed to the radio-collars and acclimated to the area. It has been found that relocated wild white-tailed deer often make long distance movements as soon as four days after relocation (Cromwell et al. 1999). I expected to lower dispersal rates of pen-raised deer by allowing for an acclimation period. The 20 pen-raised deer were released in April 2001 and tracked upon release, yet I allowed two weeks post-release before using a deer in the analysis as to avoid any mortality resulting from capture myopathy (Chalmers and Barrett 1982). The 20 pen-raised deer released into the SE were darted, radio-collared, and ear-tagged and taken to the SE in a horse trailer modified for hauling deer. Deer were moved to the release sites 10 at a time to prevent unnecessary stress to animals. The first release of 10 deer took place in the first week of April 2001. The second release of 10 deer was conducted during the second week in April 2001.

The 20 pen-raised deer used in the analysis in the CE were released between November 2000 and March 2001. The deer in the CE were darted and radio-collared on site. All of these animals had been released into the CE previous to this study and age class and sex was identified by color-coded ear-tags. Of the 20 deer, only 7 in the CE were radio-collared, yet 2 were lost due to difficulties with darting. Attempts to dart the remaining deer in the CE for the purpose of this study were halted due to complications with darting; one mortality from capture myopathy and one mortality due to strangulation from the affixed radio-collar. The remaining 13 animals were identified by re-sight techniques by way of color-coded ear-tags. The 20 animals used in the analysis in the CE coincided with the sex and age-class of the deer released into the SE.

All deer in the study were tracked from April 2001 to April 2002. Deer released onto the LSUDSA were tracked 2-3 times/week for 1 year using a radio telemetry receiver. Deer released into the SE and CE were tracked twice/month for 1 year using a radio telemetry receiver, and on the CE, by visual observation. The radio telemetry receiver uses a hand held "H" style yagi antenna (Advanced Telemetry Systems 1997). Deer mortality and dispersal was recorded. GPS coordinates were recorded with a hand held unit at all mortality sites. Each mortality was assigned to one of the following classes: (1) Harvest, (2) Vehicle, and (3) Other. Hunters on Blairstown Plantation were prohibited from killing a collared deer or any deer on Idlewild Research Station, and the doing so carries a monetary penalty. Hunting mortality only took place if the deer migrated off the LSUDSA property, was killed illegally, or was mistaken for a deer without a collar. No harvest of collared deer took place in either large enclosure area.

Annual survival and cause-specific mortality rates for each release treatment of deer (wild and enclosure) was compared among the sites using a Chi-square test. The percentage of deaths assigned to each of the treatments in this study was used to evaluate the highest cause of mortality in pen-raised white-tailed deer released to the wild and into high-fence enclosures.

RESULTS

Data from 2 of 60 radio-collared and tagged white-tailed deer were not used for analysis because one died from complications with the attached radio-collar, and the other died because of capture myopathy within a week of capture. Fourteen (24%) of the 58 deer monitored suffered mortality (Figure 2). Of the 14 deaths, 9 (64%) occurred in the wild (Table 4) and 5 (36%) occurred in the high-fence enclosures (Table 5). All deer that suffered mortality were grouped into a causal category, as such, 1) harvest, 2) vehicle, or 3) other (Figure 2).

Of the 20 monitored deer in 2001-2002 on the LSUDSA, nine (45%) suffered mortality. Five losses were due to harvest; 2 were harvested outside of the LSUDSA and 3 were poached from LA highway 959. The two deer taken by hunters were reported within a day of each occurrence. None of the 3 deer poached were retrieved from the study area. Two losses resulted from collisions with vehicles on LA highway 959, and 2 deaths were attributed to other mortality. Of the two deaths attributed to other mortality, one was undetermined and one animal was found in a pond on the study site. This animal showed signs of hemorrhaging which lead to the belief that Epizootic Hemorrhagic Disease may have been the cause of mortality.

Five deaths occurred in the high-fence enclosures. Of the 20 monitored deer in the Shaw enclosure, 4 (20%) suffered mortality. All four losses were due to other mortality. One was due to depredation (evidence of coyotes present), and 3 were simply accredited to other. One of these 3 was known to be fairly fearless of humans and when last seen was emaciated. The animal was found in a food plot soon after it was plowed; it is difficult to say whether the cause of death was illness or being run over by a tractor

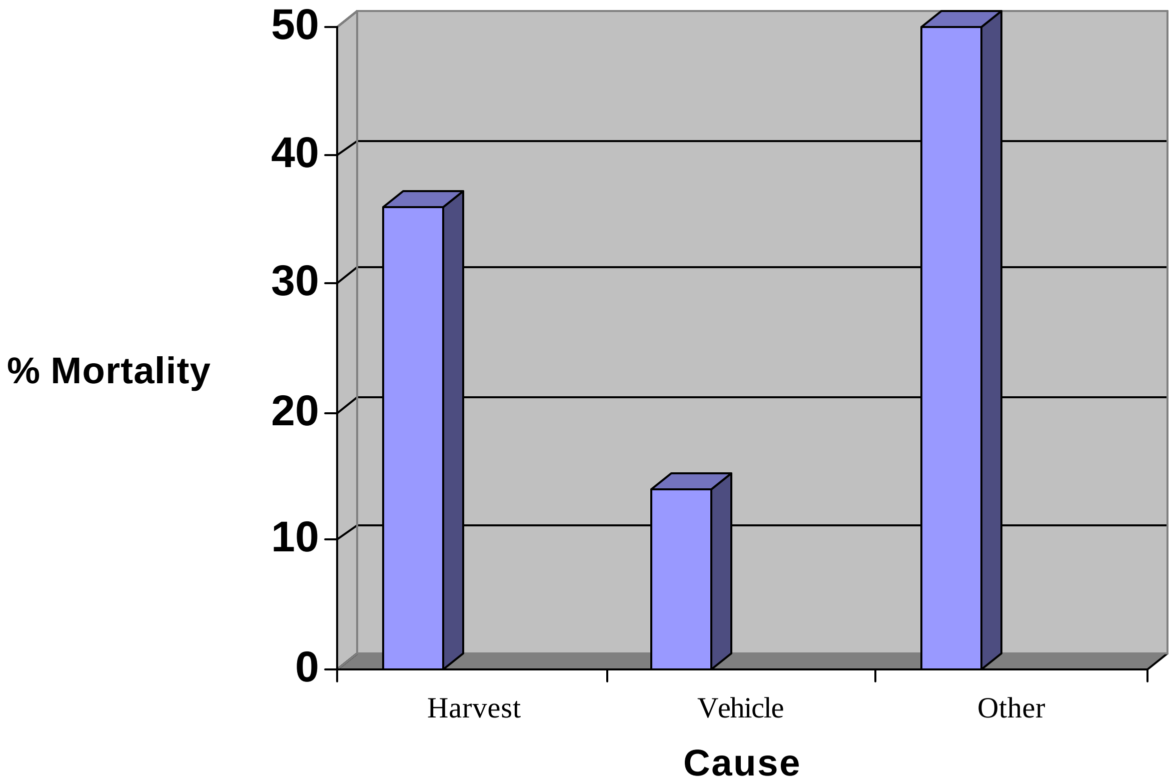

FIGURE 2: The total mortality (n=14) and cause of all monitored deer on all areas.

Table 4: Total mortality of pen-raised white-tailed deer released on the LSUDSA in 2001.

n=9

Year	Sex	Frequency	Age	Cause
2001	Male	150.054	0.5	Vehicle
	Male	150.094	0.5	Harvest
	Male	150.134	0.5	Harvest
	Female	150.273	2.5	Other
	Female	150.294	3.5	Harvest
	Male	150.594	0.5	Harvest
	Male	150.804	1.5	Other
	Male	150.934	0.5	Harvest
	Female	150.701	4.5	Vehicle

Table 5: Total mortality of pen-raised white-tailed deer released into high-fence enclosures in 2000-2001.

Year	Sex	Frequency	Age	Cause
Shaw Enclosure				
n=4	Female	150.012	3.5	Other
2001	Male	150.354	1.5	Other
	Male	150.915	1.5	Other
	Male	150.473	1.5	Other
Chouest Enclosure		**Tag**		
n=1	Female	Yellow 27	4.5	Other
2001				

during cultivation. The two remaining animals were found approximately 2 weeks after death and were both too decomposed to identify a definite mortality cause. Of the 18 monitored deer in the Chouest enclosure, one (6%) suffered other mortality.
The one mortality in the CE could not be determined due to decomposition.

Harvest accounted for 56%, vehicle accidents 22%, and other mortality 22% of the total mortality (n=9) for the pen-raised deer released to the LSUDSA in 2001. Other mortality accounted for 100% of the total mortality (n=5) for the pen-raised deer released into the SE and CE in 2001.

A Chi-square analysis was performed to determine if the mortality rate of pen-raised white-tailed deer released to the wild differed from these released into high-fence enclosures (Table 6). The Chi-square value was 8.33 with 2 d.f. and the resulting P value was < 0.05. The interpretation is that there was a significant difference in survived between both high-fence enclosures and the wild. Note that while the expected value for survived on the LSUDSA was 15.17, I actually found only 11, while I expected to find 15.17 survived in the SE, I actually found 16, and while I expected to find 13.66 survived in the CE, I actually found 17.

I also performed a Chi-square analysis to determine if 'Other' mortality of pen-raised white-tailed deer released to the wild and released into high-fence enclosures differed (Table 7). The Chi-square value was 1.704 with 2 d.f. and the resulting P value was < 0.05. The interpretation is that there was no significant difference in 'Other' mortality between deer released to the wild and high-fence enclosures. Note that while the expected value for survived on the LSUDSA was 11.22, I actually found 11, while I expected to find 17.25 survived in the SE, I actually found 16, and while I expected to find 15.53 survived in the CE, I actually found 17.

I did not perform a Chi-square analysis for the remaining sources of mortality (harvest and vehicle) because no deaths occurred in the high-fence enclosures from either cause.

Table 6: Chi-square table of pen-raised white-tailed deer released to the wild and into high-fence enclosures.

Observed			
Release	**Survived**	**Dead**	
LSUDSA 01	11	9	
SE	16	4	
CE	17	1	
Observed Test of High-fence Enclosures			
Release	Survived	Dead	
LSUDSA 01	11	9	Totals
SE	16	4	20
CE	17	1	20
			18
Totals	44	14	
			58
X^2 Expected Values			
Release	Survived	Dead	
LSUDSA 01	15.17	4.83	
SE	15.17	4.83	
CE	13.66	4.34	
X^2 Cell Values			
Release	Survived	Dead	
LSUDSA 01	1.15	3.6	
SE	0.05	0.14	
CE	0.82	2.57	

$$X^2 = \sum_{i=1}^{k} \frac{(O-E)^2}{E}$$

k = number of cells
O = observed cell frequency
E = expected cell frequency = $\frac{\text{(row total)(column total)}}{\text{grand total}}$

$$X^2 = \frac{(11 - 15.17)^2}{15.17} + \frac{(9 - 4.83)^2}{4.83} + \frac{(16 - 15.17)^2}{15.17} + \frac{(4 - 4.83)^2}{4.83}$$

$$\frac{(17 - 13.66)^2}{13.66} + \frac{(1 - 4.34)^2}{4.34} = 8.33 \text{ with 2 d.f.}$$

$P < 0.05$

Table 7: Chi-square table of Other mortality among white-tailed deer released to the wild and into high-fence enclosures.

Observed			
Release	**Survived**	**Dead**	
LSUDSA 01	11	2	
SE	16	4	
CE	17	1	
Observed Test of High-fence Enclosures			
Release	Survived	Dead	Totals
LSUDSA 01	11	2	13
SE	16	4	20
CE	17	1	18
Totals	44	7	51
X^2 Expected Values			
Release	Survived	Dead	
LSUDSA 01	11.22	1.78	
SE	17.25	2.75	
CE	15.53	2.47	
X^2 Cell Values			
Release	Survived	Dead	
LSUDSA 01	0.004	0.027	
SE	0.091	0.568	
CE	0.139	0.875	

$$X^2 = \sum_{i=1}^{k} \frac{(O-E)^2}{E}$$

k = number of cells
O = observed cell frequency
E = expected cell frequency = $\frac{\text{(row total)(column total)}}{\text{grand total}}$

$$X^2 = \frac{(11 - 11.22)^2}{11.22} + \frac{(2 - 1.78)^2}{1.78} + \frac{(16 - 17.25)^2}{17.25} + \frac{(4 - 2.75)^2}{2.75}$$

$$\frac{(17 - 15.53)^2}{15.53} + \frac{(1 - 2.47)^2}{2.47} = 1.704 \text{ with 2 d.f.}$$

$P < 0.05$

DISCUSSION

Mortality attributed to capture myopathy and to the radio collars was 3% (2 of 60), which was fairly low compared to previous studies. Capture mortality in this study was similar to findings of Ozaga et. al. (1992) where 4.9% of adult males recaptured suffered mortality in a study in Michigan. Ozoga et. al. (1992) also found capture mortality was responsible for 12.3% of male fawns in the same study. Likewise, Jones and Witham (1990) found a 12% mortality rate from capture mortality in Illinois. Beringer et. al. (1996) found a 9% mortality rate from capture myopathy in northwestern Missouri. Beringer et. al. (2002) found that capture myopathy accounted for 29% of total mortality of translocated white-tailed deer in a study in Missouri.

Mortality differed among the three groups of deer, with greater mortality in the released deer (45%) than in the penned deer (20% and 6%). The lower mortality appeared to be primarily due to eliminating human-induced mortality. The mortality rates that I observed for released deer were lower than observed in several previous studies. In a study by McCall et. al. (1988) in Texas, 13 pen-raised deer were released into the wild and 8 (62%) died within the first year, whereas all 20 wild deer in the study survived. Meyers (2001) released 16 pen-raised deer and found 10 of 16 (63%) suffered mortality. Conversely, Ozoga et. al. (1992) found lower mortality rates (26%) for pen-raised and large enclosure-raised deer released to the wild. I found the majority, 7 of 9 (78%), of the mortality found in pen-raised deer released to the wild in 2001 was due to human factors. One component of the mortality in pen-raised released deer may have been due to a lack of fear towards human activities (i.e. hunters and vehicles). I found a couple of studies that examined mortality rates of rehabilitated or translocated deer that were raised in a population that frequently encountered humans. Bowers and Forster

(2002) released 17 rehabilitated buck fawns, with 10 of 17 fitted with radio-collars in 1995 on Ossabaw Island in Georgia. Sixty percent (n=10) of radio-collared deer died within 3 weeks of release in the Ossabaw Island study. Beringer et. al. (2002) found a 70% mortality rate in translocated deer (n=80) in south central Missouri. O'bryan and McCullough (1985) translocated 15 wild Columbian black-tailed deer (*O. hemionus columbianus*), accustomed to human interaction, from Angel Island in San Francisco Bay, California to a recreational area inland. Eighty-five percent of those deer died within the 1-year study (O'bryan and McCullough 1985). Previous researchers also observed variable mortality rates in wild deer. Beringer et. al. (2002) found only a 31% mortality rate for resident wild deer (n=25) in south central Missouri. VanDeelen et. al. (1997) found a 61% mortality rate for wild deer (n=95) over 3 years in Michigan. Nixon et. al. (2001) found annual mortality rates of 44% for dispersing 2-year-old females, 8% for 8 year old females, 65% for dispersing 2-year-old males, and 24% for sedentary yearling males in Illinois. Morgan et. al. (1995) discovered a 39% mortality rate for females and a 41% mortality rate for males in South Carolina. Lamoureux et. al. (2001) found that females suffered 27% mortality and males 34% mortality in Quebec.

Ozoga and Clute (1988) found captured and tagged newborn fawns suffered 9% mortality and untagged fawns not handled suffered 18% mortality in a 252 ha. enclosure. I found only one occasion where mortality was recorded for adult pen-raised deer released into a high-fence enclosure. Though this was not a scientific study, Dr. Robert D. Brown of Texas A & M University stated that a rancher released 9 pen-raised bucks in a 1,500 acre enclosure in south Texas and 100% suffered mortality within 1 year (pers. comm. R. D. Brown). Because this was not a scientific study, no information on mortality sources for this occurrence could be found (pers. comm. R. D. Brown). I spoke with several other white-tailed deer experts and none were aware of any other studies conducted with pen-raised deer released into high-fence enclosures.

Differences in harvest mortality among the three groups of deer contributed to the overall differences in mortality among the three groups. Harvest mortality was greater in the released deer (56%) than in the penned deer (0% and 0%). Harvest was found to be the highest cause of mortality for released deer in 2001. This was surprising because harvest was not intended on any of the deer marked for this study. However, previous researchers also observed that harvest was an important cause of mortality in released deer. Beringer et. al. (2002) found 46% of mortality in translocated deer was from harvest. Previous researchers also observed that harvest was an important cause of mortality in wild deer. Nixon et. al. (2001) found that males were more likely to die from hunting than from other causes. Mayer et. al. (2002) found a 13% mortality rate for wild does in southeastern Massachusetts, where harvest accounted for 8% of the 13%. They also found that bucks suffered a 19% mortality rate where harvest accounted for 16% of the 19%. Likewise, Beringer et. al. (2002) found 12% of mortality in wild deer from harvest. VanDeelen et. al. (1997) found harvest related mortality rates in wild deer to be 4% for adult females, 72% for adult males, 12% for yearling females, and 47% for yearling males. In a study in Quebec, hunting mortality accounted for 39% of known deaths (Lamoureux et. al. 2001). Hunting accounted for 79% of all mortality in a study in Maryland (Rosenberry et. al. 1999).

Differences in collisions with vehicles among the three groups of deer also contributed to the overall difference in mortality among the three groups. Vehicle collisions played a major role in the higher mortality rates of released deer (22%) but not in the penned deer (0% and 0%). Previous researchers also observed that collisions with vehicles were a significant cause of mortality in released deer. Beringer et. al. (2002) found 9% of mortality of translocated deer from vehicle accidents. Previous researchers also observed that collisions with vehicles were a significant cause of mortality in wild deer. Nettles et. al. (2002) found the predominant mortality factor in Key Deer (*O. virginianus clavium*) during February 1986-September 2000 was accidents with motor vehicles. Beringer et. al. (2002) found 68% of mortality in wild deer from vehicle accidents. Likewise, O'Gara and Harris (1988) discovered that 68% of mortality for mule deer (*O. hemionus*) and white-tailed deer in western Montana resulted from vehicle collisions. Clevenger et. al. (2001) discovered that fencing in Banff National Park in Canada reduced ungulate-vehicle collisions by 80%.

Mortality resulting from predation and disease (other) was similar among the groups of deer studied (2, 4, and 1 deaths on the LSUDSA, SE, and CE, respectively) (Chi-square = 1.704 with 2 df, $P < 0.05$). McCall et. al. (1988) accredited 1 of 8 (12.5%) to predation. I observed that predation and disease accounted for rates similar to that observed by previous researchers. VanDeelen et. al. (1997) found that 21% of total mortality in wild deer (n=58) was accredited to predation and 10% was from malnutrition. Stout (1979) found that after coyote removal on Fort Sill, Oklahoma the deer harvest approximately doubled. In a study by Epstein et. al. (1982), predation accounted for 71.4% of fawn mortality and disease for 23.8% of fawn mortality. Hansen and Beringer (1993) found 3% of mortality was from disease and 17% was from unknown causes in north central Missouri. Nixon et. al. (2001) found that females were more likely to die from other causes, such as predation or disease. Ditchkoff et. al. (2001) stated that male deer >3.5 years old were more likely to die from non-human factors such as fighting, predation, or disease. Annual natural mortality rates averaged

15% for male white-tailed deer in south Texas over a 3 year period (Demarais et. al. 1988).

Immigration and emigration play important roles in the survival of white-tailed deer. Three of 20 released deer emigrated from the LSUDSA in 2001. Sixty-seven percent (2 of 3) emigrants died from harvest once off the study area. Fourty-three percent of the total mortality that occurred on the LSUDSA in both years was a result of the radio-collared deer leaving the study site (5 harvests and 1 vehicle). Likewise, in a study by Ditchkoff et. al. (2001) in southeastern Oklahoma, male white-tailed deer suffered 38% mortality, where the majority of mortality in young bucks, that traveled longer distances, was accredited to hunting and vehicle accidents. Neither harvest nor vehicle accidents were a cause of mortality for pen-raised deer released into the high fence enclosures. Albeit, the harvest of radio-collared or tagged deer was prohibited in both high fence enclosures and vehicular operation was at a minimum, by eliminating emigration from the study areas, the landowners were able to eliminate these two mortality factors. Nielsen et. al. (1997) found that 64% of yearlings (up to 30 months) emigrated from a partial enclosure in western New York. Yet, Nielsen et. al. (1997) found that the partial enclosure appeared to delay emigration in most males and to retain a limited number of males on the property, thereby facilitating Quality Deer Management.

Age and sex can play an integral role in mortality of deer populations. Through dispersal and competition, higher mortality is usually found in younger cohorts, primarily young males. This study involved deer from various age classes. Age and sex of the deer in the 2 enclosures were identical; where as the 20 deer released to the LSUDSA differed in age and sex from both enclosures. The different age and sex of the 20 deer released to the wild may have influenced the higher rate of mortality.

Thirteen of the animals in the Chouest Enclosure were identified by re-sight techniques by way of color-coded ear-tags. It was a possibility that the lack of radio collars on these 13 deer, and the subsequent reliance upon observation might have biased mortality estimates of CE deer upward because animals not relocated could have been alive. However, only three of these deer died during the study. Two were excluded from analyses because they died within 2 weeks of release, and the third was located and the cause of death was determined to be other mortality. Therefore, the mortality rate for this herd was not over-estimated even though all the deer were not radio collared.

The habitat types in this study differed between sites. Food availability did not seem to be an issue with the deer released on the LSUDSA because of biannual food plots. The LSUDSA was upland mixed hardwood and pine habitat with an ample food source for deer, through food plots or native vegetation. Both enclosures were bottomland hardwoods habitat. The Shaw Enclosure was primarily immature hardwoods with very little mast production, yet had an abundance of food for deer through agriculture plantings and supplemental feeding. The Chouest Enclosure was marginal bottomland habitat with Chinese tallow being the dominant canopy tree. Though Chinese tallow is not thought of as a significant browse species for deer, I observed on numerous occasions, deer browsing on the foliage of fallen mature Chinese tallow and deer would commonly strip the tree of foliage with 2 days. Conversely, deer rarely browsed on Chinese tallow saplings. Several mature oak species provided some mast for deer and ample food was available through food plots and supplemental feeding. For the purpose of this study, food availability and habitat type did not seem to affect the results.

I am not aware of the fates of the remaining 11 study deer on the LSUDSA, yet for the purpose of retrieving radio-collars for refurbishment, the hunters on Blairstown Plantation were allowed to harvest these animals if encountered during hunting seasons post-study. The surviving 16 study deer in the SE were tranquilized after the study and the radio-collars were removed. As of August 2003, all 17 surviving study deer in the CE were still alive.

The mortality of the pen-raised deer in this study released into these two enclosures was minimal and the reduction of mortality sources was evident. I found a 32% decrease in mortality from the released deer 45% (9 of 20) to the penned deer 13% (5 of 38), which suggests that releasing pen-raised deer into an enclosure may increase possible harvest opportunities.

CONCLUSION

Results of this study have shown higher white-tailed deer survival in high-fence enclosures as compared to deer released to the wild, however there are many factors involved that may influence the drastic difference in these results. Several causes of mortality were eliminated or significantly reduced within the high-fence enclosure. Also, intensive supplemental feeding occurred in both enclosures which may have decreased mortality. This practice may have also given a false perception of the true carrying capacity within these 2 enclosures.

Future research should focus on releasing deer to the wild in the same habitat type and in the same general vicinity as a release into a high-fence enclosure. This should eliminate any bias towards food availability, nutrients in vegetation and soil, and climatic factors. Age and sex should also coincide within the releases to eliminate any bias towards higher mortality from one release group to another.

The main concerns of the heated high-fence enclosure issue from a biological perspective are herd overpopulation and disease, such as Chronic Wasting Disease. From the viewpoint of animal rights activist groups, the high-fence issue is one of ethics. The question if hunting in an enclosure is considered fair-chase is left to the individual. The landowner must weigh the pros and cons of a high-fence enclosure and decide if the investment is worthwhile, both financially and ethically.

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VITA

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