ABATEMENT STRATEGIES AND DISEASE ASSESSMENT

FOR FERAL HOGS IN EAST TEXAS

A Dissertation

by

SAMUEL AARON SUMRALL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2011

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Co-Chairs of Committee,	Roel R. Lopez
	Nova J. Silvy
Committee Members,	Billy J. Higginbotham
	Bo Norby
	Tyler A. Campbell
Head of Department,	Thomas E. Lacher, Jr.

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ABSTRACT

Abatement Strategies and Disease Assessment for Feral Hogs in East Texas

(May 2011)

Samuel Aaron Sumrall, B. S., Sam Houston State University;

M.S., Sam Houston State University

Co-Chairs of Advisory Committee: Dr. Roel R. Lopez
Dr. Nova J. Silvy

Feral hogs (*Sus scrofa)* are considered an exotic, free-ranging ungulate distributed within numerous countries and continents, including the United States. The reproductive efficiency, lack of predators, land use practices for domestic livestock, and diet are leading factors in the expansion of feral hogs throughout their range. Feral hogs negatively impact floral and faunal communities, agricultural lands, and residential and recreational areas which adds to concerns about public safety and disease transmission. My study objectives were to (1) assess feral hog abatement strategies, and (2) assess prevalence levels for feral hog diseases. I evaluated 3 corral trap designs differing in the addition of electric fence configurations. Feral hog capture success data were collected and used to determine trap design efficacy.

Based on disease study results, I recommend that natural resource managers take necessary precautions to protect themselves by wearing protective equipment and equipment and properly cooking feral hog meat. Additionally, resource managers should properly administer vaccinations to domestic and companion animals, and

restricting domestic and companion animals from areas of high risk (e.g., carcasses of dead hogs and wallows).

DEDICATION

Roel Lopez and Nova Silvy
To each of you, my sincerest gratitude for your willingness to give me a chance to fulfill a life-long dream. Your patience, experience, friendship, and stability will never be forgotten.

My Family (*Marianne, Caleb, Gabe, and Josie)*
Your unwavering love, understanding, and unselfishness throughout this process are amazing. I could not have reached this point without your strength and dedication on which I depend.

My Lord and Savior
This successful experience would not have been possible without His guidance and mercy.

ACKNOWLEDGMENTS

First, I would like to thank Drs. Roel Lopez and Nova Silvy for their guidance, expertise, and patience as co-chairs through this process. They have dedicated much of their precious time with advice and counsel to an old student in a relatively new field. In addition, I would like to thank my committee members, Drs. Billy Higginbotham, Bo Norby, and Tyler Campbell. They all have provided the technical knowledge needed and a patient ear throughout the course of the degree and the dissertation preparation process. Dr. Michael Masser is most appreciated for introducing me to Dr. Lopez and Dr. Silvy in order to convey my drive to go in another direction. I also would like to thank Dr. Israel Parker, Janell Mellish, and Lee Kusak for their assistance in various facets of data collection and providing additional resources necessary to the research. Furthermore, this entire process could not have become a reality without the daily support and help from my wife and kids. Marianne, Caleb, Gabe, and Josie were a daily part of the entire process from making me get up to be to class on time to hauling and setting up research equipment throughout the study area regardless of the weather or location. Great appreciation is extended to Dr. Dee Ellis and to Dale Preston with the Texas Animal Health Commission for disease analysis of submitted samples. This appreciation also is extended to the Renewable Resources Extension Act (RREA) for providing partial funding for this study. Lastly, I would like to thank Mr. Justin Irek, Ms. Ann Christian, Mr. Fielding Browder, Mr. Gary Coogler, Mr. David Wright, Mr. Keith Andres, Ms. Linda Murphy, and Mr. Cullen Mancuso for providing the access to their private properties in order to conduct the necessary research.

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE Page

LIST OF TABLES

TABLE Page

CHAPTER I

INTRODUCTION

Feral hogs (*Sus scrofa*) are considered an exotic, free-ranging ungulate (Taylor and Hellgren 1997) distributed within numerous countries and continents to include the United States. Their origin is that of an Old World species from the Family Suidae. Domestic hogs were introduced into what is now the United States as early as 750–1000 A.D. during the settlement of the Hawaiian Islands (Towne and Wentworth 1950, Smith and Diong 1977) followed by introduction to the West Indies during the 1400s (Belden and Frankenberger 1977). Feral hogs were introduced into what is now Florida by De Soto in 1539 as a domestic species (Taylor and Hellgren 1997). Since that time, domestic individuals have accidentally escaped or have been intentionally released becoming feral. In 470+ years of occupancy, feral hogs have grown to a current estimated national population of 5–6 million individuals (Romero et al. 1997) occupying 40 states (Ditchkoff and West 2007). Population estimates are somewhat questionable at state and national levels leading to guiding assessments based on damage. Introduced to Texas in 1542 (Mayer and Brisbin 1991), the feral hog population began to steadily increase as settlers advanced westward in the 1680s (Taylor and Hellgren 1997). Population estimates for feral hogs are problematic due to the methods used in obtaining these estimates. More important with the observed increases in feral hogs is the damage associated with these population increases.

This dissertation follows the style of The Journal of Wildlife Management.

Pimental et al. (2005) estimated feral hog damage nationally at $800 million while Adams et al. (2005) surveyed Texas landowners to assess feral hog damage and determined mean damage levels at $7,515/Texas landowner annually.

Several factors are attributed to the increased expansion of feral hogs in the United States to include their reproductive efficiency, lack of predators, land use practices for domestic livestock (e.g., feeding stations, introduced water sources), and omnivorous diet (Taylor 2003). Reproductive efficiency is arguably the leading component driving population increases and natural expansion into new areas. Feral hogs have the highest reproductive potential of any ungulate in North America (Hellgren 1999). For example, with adequate nutrition, individuals can become reproductively viable at 6 months to 1 year of age (Hellgren 1999, Reed 2007). Typically, onset of reproduction will not begin until 10 months to 1 year of age. Feral hog sows have an average of 1.5 litters annually (Mayer and Brisbin 1991) averaging 4–6 piglets after a 115 day gestation period. Litter sizes up to 10 piglets are not uncommon during periods of optimal conditions (Choquenot et al. 1996). A lack of natural predators also is attributed to expansion of feral hogs. Many predators of feral hogs such as grey wolf (*Canis lupus*), mountain lion (*Puma concolor*), and black bear (*Ursus americanus*) have been removed through human encroachment, allowing feral hogs to reach maturity and reproductive potential. Collectively, the increased use of land use practices for domestic livestock (e.g., feeding stations, introduced water sources, intense cropping practices), wildlife supplementation including 308 million pounds (Billy Higginbotham, personal communication) of shelled corn annually and the removal of predators have provided a more conducive environment for feral hog population growth. These factors coupled with their general diet requirements improve the adaptability of the species. The diet of feral hogs is comprised of animal (<10%) and plant matter (>90%) (Spitz 1986); however, due to an inefficient digestive system (Wood and Roark 1980) feral hogs are required to feed almost constantly. During feeding, feral hogs also can consume all forms of plant matter, invertebrates, small mammals, and other wildlife species (e.g., ground nesting birds) (Gingrich 1994). Depredation of wild and domestic fauna is obviously a concern to natural resource managers. For example, Wicove et al. (1998) reported many wildlife species and necessary habitat being adversely affected due to feral hog feeding behaviors and encroachment. As a result, many species (400 of 958) listed as threatened or endangered under the Endangered Species Act (USDA 2002) are impacted by feral hog populations.

MANAGEMENT CHALLENGES

Efforts to reduced population numbers have been employed throughout the range of feral hogs with mixed success. Current legal management options in the United States are limited to ground shooting/hunting, snares, aerial gunning, hunting dogs, traps, and exclusion fencing (West et al. 2009). Drop nets are currently being evaluated as a potential management option for feral hogs. There is no single method of effective control of feral hogs; however, trapping is a commonly used management technique and is suggested to be the foundation to any feral hog management control program. An effective feral hog management effort should remove 70% of the annual population to prevent additional increase (Coblentz and Bouska not dated)**.** Choquenot et al. (1993)

suggests trapping efforts can remove 80–90% of the localized feral hog population. Much variation in trapping efficacy is observed among trapping techniques due to human activity, land use practices, previous removal efforts, time of year, and naturally occurring available food resources. A common trap design used is the box trap. Most box traps are typically <1.22 m in width, <1.22 m in height, and <1.83 m in length. The restricted size of box traps is the primary disadvantage with regard to efficacy defined as the number of individuals trapped per unit effort (Atkins and Harveson 2007). Corral traps are much larger and can be integrated into natural settings to improve trapping efficacy (Schuyler et al. 2001). Unlike typical box traps of the above mentioned dimensions, corral traps are capable of holding a larger number of feral hogs in a single catch event. Despite the advantages in efficacy of corral traps, more labor and construction costs are greater compared to box traps (West et al. 2009). Reidy et al. (2008) evaluated the use of electric exclusion fence to repel feral hogs from sensitive areas. Findings of that study indicated electric fencing would restrict movement of feral hogs from sensitive areas/crops. Such fencing is readily incorporated in controlling the movement of domestic livestock. Similar “barrier” fencing (not electrified) has been reported to improve the trapping of Lower Keys marsh rabbits (*Sylvilagus palustris hefneri*; Faulhaber et al. 2005) through the “funneling” of target animals to trap opening. Similar techniques are used for other animals (e.g., arrays used in trapping herps) and have been incorporated in trapping techniques dating back to the 1950s (Ludeman 1954). However, the value in use of electric fencing in combination with corral traps to improve overall trapping efficacy needs further consideration.

Baiting options and consumption by non-target species are a continued concern in the control of feral hogs when using traps (Campbell and Long 2007). Fermented corn is commonly used as bait and readily consumed by feral hogs as well as other domestic and wildlife species (Campbell and Long 2007). As a result, trap triggers are frequently activated by non-target species, removing the possibility of feral hog capture. Additionally, the capture of non-target species such as deer can be detrimental to trapping efforts and attempts to release these non-target species could result in injury and/or death of the species. The identification of a feral hog-specific bait would increase trapping efficacy through the reduction of non-targets and aid in disease control efforts requiring species-specific baits (Campbell and Long 2008). Several baits are currently used in efforts to capture feral hogs. Such baits range from deer entrails and carcasses to grains and commercial baits (Peine and Farmer 1990, Richardson 1995, Reidy et al. 2008). Strawberry-based baits evaluated by Campbell and Long (2008) have shown promise to swine-specifity in south Texas.

The transmission of diseases is of increasing importance to consumers and agriculture industries. Feral hogs can serve as a mode of infectious disease transmission to humans, domestic livestock, and wildlife species. Transmission if infectious disease to the domestic livestock industry could result in loss of many millions of dollars, quarantined livestock, and potential contamination of agriculture commodities. Feral hogs are known to carry in excess of 30 viral or bacterial diseases (Forrester 1991) of which many can be contracted by humans and other domestic and wildlife species. It is known that feral hogs pose a disease risk to humans, domestic livestock, and wildlife, but the prevalence of diseases is unknown in most regions (Davidson and Nettles 1997, Jay et al. 2007). In Texas, elevated levels of disease prevalence in feral hogs have been reported (Witmer et al. 2003) and include brucellosis and pseudorabies (Wyckoff et al. 2005); however, the reported prevalence among these studies varies greatly. A study of selected viral and bacterial pathogens in feral swine by Campbell et al. (2008) indicated prevalence of pseudorabies and brucellosis at 0% to 85% and 0% to 31%, respectively. Similar findings were observed in other studies (Wyckoff et al. 2005, Wyckoff et al. 2009). A need to understand the specific prevalence of diseases of concern (e.g., pseudorabies, brucellosis, etc.) can serve to implement disease control measures and ultimately reduce losses of wildlife and livestock species, and lessen the risk to humans. Diseases known to be carried by feral hogs carry a zoonotic risk (e.g., *Brucella suis)* while others result in potentially serious complications to domestic livestock and wildlife (e.g., pseudorabies).

STUDY AREA

The project study area in Southeast Texas in San Jacinto, Walker, Liberty, Milam, and Montgomery counties (the figure on page 9). The study site includes 3 ecoregions: Coastal Plains, Post Oak Savannah, and Pineywoods (Crook and Hung 2005). The majority of the study site is within the Pineywood ecoregion. The study area is thoroughly occupied by feral hogs and sizable populations of native wildlife and domestic animals. Native wildlife populations include: raccoon (*Procyon lotor*), opossum *(Didelphis virginiana)*, coyote (*Canis latrans*), gray (*Urocyon cinereoargentenus*) and red (Vulpes vulpes) fox, gray (*Sciurus carolinensis*) and fox (*S.*

niger)squirrels, white-tailed deer (*Odocoileus virginianus*), mink (*Neovision vision*), otter (*Lontra canadensis*), beaver (*Castor canadensis*), nutria (*Myocastor coypus*), bobcat (*Lynx rufus*), stripped skunk (*Mephitus mephitis*), rodent spp. (Order Rodentia), and many avian species (Class Aves). Domestic animals include cattle, horses, sheep, goats, hogs, dogs, and cats (Taylor 2003). Temperature highs during summer months commonly exceed 35° C with winter lows reaching the mid-negative 7° C range. Average summer high temperatures are from 35–36° C and winter low averages hovering in the low 4° C range (Hebert and Jack 1998). The annual rainfall is 114.3 cm–121.9 cm with an average atmospheric relative humidity of 55%. Soil type varies from deep sand to tight clay profiles.

The Pineywoods ecoregion of the study area (Fig. 1.1) has been altered from historic vegetative land cover primarily due to changes in land uses. Prior to extensive logging efforts, the Pineywoods was a conglomeration of longleaf pine (*Pinus palustris*), loblolly pine (*P. taeda*), slash pine (*P. elliottii*), interspersed with hardwood and brush species (Coulson et al. 2005). Hardwood species include: white oak (*Quercus alba*), red oak (*Q. ruba*), post oak (*Q. stellata*), water oak (*Q. nigra*), overcup oak (*Q. lyrata*), live oak (*Q. virginiana*), chinkipin oak (*Q. muehlenbergii*), elm (*Ulmus spp.),* dogwood (*Cornus sanguinea*), gum (*Liquidambar styraciflua*), black cherry (*Prunus serotina*), maple (*Acer spp.*), and birch (*Betula spp*). Brush species include American beautyberry (*Callicarpa americana*), yaupon (*Ilax vomitoria*), hackberry (*Celtis spp.*), wax myrtle (*Myrica cerifera*), bay spp. (*Magnolia spp.*), flame leaf sumac (*Rhus copallina*), and sparkleberry (*Vaccinium arboreum*) as the more common species. Common vine species include grape spp. (*Vitis spp.*), jasmine (*Jasminum spp.*), honeysuckle (*Lonicera japanica*), green briar (*Smilax spp.*), black berry (*Rubus spp.*), and Virginia creeper (*Parthanocissus quinguefolia*). Natural occurring fire managed vegetative communities periodically preventing successional climax of many species.

The Post Oak Savannah ecoregion has an equally diverse vegetative community. This ecoregion historically was maintained by wildfires. The Post Oak Savannah is a gently rolling topography interspersed with oak motts and expanses of various grass species. Hardwood species within the ecoregion are primarily post oak, live oak, mesquite (*Prosopis glandulosa*), blackjack oak (*Q. marilandica*), and elm. Common brush species within the region include: juniper (*Juniperus spp.*), yaupon, flame leaf sumac, berries spp. (*Rubus spp.*), catclaw (*Acacia greggii*), and honey locust (*Gleditsia triacanthos*). Majority of grass species include little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*).

The smallest proportion of the study area is comprised of the Coastal Prairie ecoregion. Fire holds a defining role in the succession of the vegetative communities within the Coastal Prairie. Historically, the area was dominated by prairie grasslands in a climax community (Morrow et al. 1996) with such dominant species like little bluestem, big bluestem, Indiangrass, and switchgrass. Hardwood and brush species are commonly found along stream side management zones (SMZs) or in motts defined by previous fire. Common hardwood and brush species include live oak, black willow (*Salix spp.*), sycamore (*Platanus occidentalis*), yaupon, and macartney rose (*Rosa* *bracteata*). Slope of the region will vary from 1–3% (Morrow et al.1996) resulting in poor drainage of the sandy soils which dominate.

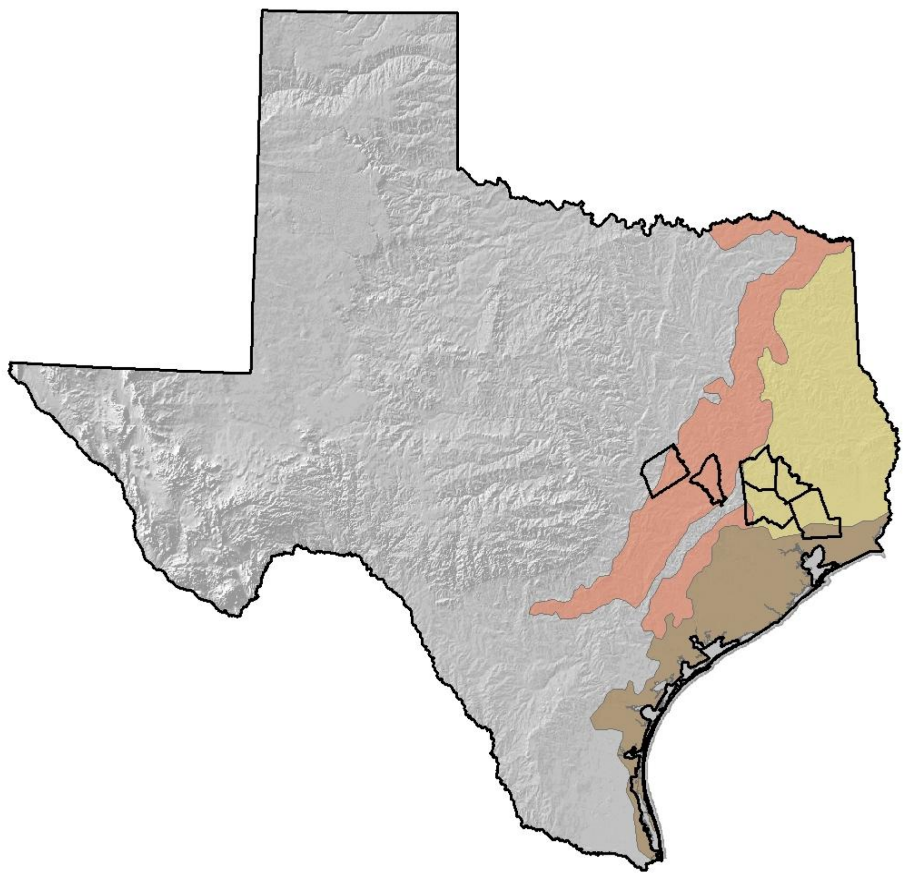


Fig. 1.1. Ecological regions (left) in Texas to include the Pineywoods (green), Post Oak Savannah (orange) and Coastal Prairie (blue) and study area in East Texas, 2010.

RESEARCH OBJECTIVES

The overall study objective was to evaluate management tools and assess disease prevalence for feral hogs in East Texas. This information will assist natural resource managers by increasing efficiency in feral hog control efforts, and provide insight to the prevalence of selected diseases in maintaining public safety. This dissertation addresses these broad objectives specifically within each chapter:

1. Evaluate trapping efficiency of corral traps and electric fencing (Chapter II).
2. Identify feral hog-specific baits/attractants (Chapter III).
3. Landowner outreach strategies for feral hog control (Chapter IV).
4. Evaluate disease prevelance in feral hogs (Chapter V).
5. Summary and conclusions (Chapter VI).

CHAPTER II

EFFICACY OF DRIFT FENCES IN FERAL HOG ABATEMENT

Feral hogs (*Sus scrofa*) have proven to be a world-wide concern to natural ecosystems. The origin of feral hogs is that of an Old World species of the Family Suidae. This highly opportunistic omnivore (Wood 1980) has expanded its range across 40 of the 50 states since introduced over 480 years ago into the continental United States (Ditchkoff and West 2007). Current population estimation efforts suggest the national population to be nearing 6 million individuals (Romero et al. 1997) with 1.5 million in Texas (Taylor 2003). Texas' feral hog population is now confirmed in 240 of 254 counties (Rollins et al. 2007). Though population estimates for feral hogs are problematic due to methods used to obtain these estimates, ultimately damage observed from feral hogs is an important factor for private landowners and natural resource managers. Pimental et al. (2005) estimated feral hog damage nationally at $800 million with Adams et al. (2005) surveyed Texas landowners assessing feral hog damage and determined mean damage levels at $7,515/Texas landowner annually. Feral hog expansion also is being assisted with introductions of captured animals into new areas by humans despite laws restricting transportation across state boundaries (Gipson et al. 1997, Seward et al. 2004, Witmer et al. 2003).

Natural resource managers are aware of the negative impacts caused by feral hogs to natural ecosystems. Floral and faunal communities are compromised to the point species are listed as endangered or extinct due to feral hogs (USDA 2002). Natural areas experience a loss of topsoil (Singer et al. 1984), loss or decreased levels of critical soil nutrients (Seimann et al. 2009), and increases in erosion on sloping topography due to ground cover losses caused by feral hog feeding/rooting (Chavarria et al. 2007). Human impacts include degradation of homeowner properties from damage to landscaping and potential loss of wildlife and companion animals due to diseases vectored by feral hogs (Williams and Barker 2001). Agriculture damage to commodity crops, pastureland, and livestock also has been well documented (Seward et al. 2004). Recent attention has been given to the negative impacts posed by feral hogs on wetland communities associated with rooting behavior and soil disturbance (Choquenot et al. 1996, Engeman et al. 2001). Collectively, these factors are cause for concern by natural resource managers resulting in a desire to control or mitigate damage caused by feral hogs in natural landscapes.

MANAGEMENT CHALLENGES

Efforts to reduced population numbers have been employed throughout the range of feral hogs with mixed success. Current legal management options in the United States are limited to hunting, snares, aerial gunning, hunting dogs, traps and exclusion fencing (West et al. 2009). Drop nets are currently being evaluated for efficacy in feral hog management efforts. However, landowners are the first line of defense in Texas and are in need of Best Management Practice (BMP) information on control techniques. There is no single method of effective control of feral hogs; however, trapping of feral hogs is a commonly used management technique and is suggested to be the foundation to most feral hog management control program. Trapping efforts can remove 80–90% of the localized feral hog population (Choquenot et al. 1993). Much variation in trapping efficacy is observed by technique and success can vary due to human activity, trap design, land use practices, previous removal efforts, time of year, and naturally occurring available food resources. A common trap design used in trapping feral hogs is the box trap. Most box traps are <1.22 m in width, <1.22 m in height, and <1.83 m in length. The restricted size of box traps is the primary disadvantage with regard to efficacy, defined here as the number of animals trapped per unit effort (Atkins and Harveson 2007). Corral traps are much larger and can be integrated into natural settings to improve trapping efficacy (Schuyler et al. 2001). Unlike box traps, corral traps are capable of holding large numbers of feral hogs in a single catch event. Despite the advantages in efficacy of corral traps, more labor is required in trap deployment and construction is more expensive (West et al. 2009). Efforts to improve the numbers of trapped animals via corral traps can serve to offset these disadvantages (i.e., cost, labor, etc.). Reidy et al. (2008) evaluated the use of electric fencing to repel feral hogs from sensitive areas, and reported that electric fencing restricted movement of feral hogs. Such fencing is readily incorporated when exclusion of domestic livestock is desired. In contrast, the use of electric fencing also can be used to direct animal movements in conjunction with trapping efforts to improve overall efficacy. Fencing has been used to improve trapping of Lower Keys marsh rabbits (*Sylvilagus palustris hefneri*; Faulhaber et al. 2005). The value in use of electric fencing in combination with corral traps to improve overall trapping efficacy needs further consideration. The study objective was to evaluate trapping efficacy of corral traps with and without electric fencing for use in feral hog abatement programs.

STUDY AREA

The study area (the figure on page 9) was located in Southeast Texas in San Jacinto, Walker, Liberty, Milam, and Montgomery counties. The area includes the ecological regions of the Coastal Plains, Post Oak Savannah, and Pineywoods (Crook and Hung 2005). The area is heavily populated with feral hogs and sizable populations of native wildlife and domestic animals. Other wildlife populations present include: raccoon (*Procyon lotor*), opossum *(Didelphis virginiana)*, coyote (*Canis latrans*), gray (*Urocyon cinereoargentenus*) and red (*Vulpes vulpes*) fox, gray (*Sciurus carolinensis*) and fox (*S. niger*) squirrel, white-tailed deer (*Odocoileus virginianus*), mink (*Neovision vision*), otter (*Lontra canadensis*), beaver (*Castor canadensis*), nutria (*Myocastor coypus*), bobcat (*Lynx rufus*), striped skunk (*Mephitus mephitis*), rodent spp. (Order Rodentia), and many avian species (Class Aves). Domestic animals include cattle, horses, sheep, goats, hogs, dogs, and cats (Taylor 2003). Temperature highs during summer months commonly exceed 35° C with winter lows reaching the mid-negative 7° C range. Average summer high temperatures are from 35–36° C and winter low averages hovering in the low 4° C range (Hebert and Jack 1998). The annual rainfall is 114.3 cm–121.9 cm with an average atmospheric relative humidity of 55%. Soil type varies from deep sand to tight clay profiles.

METHODS

I evaluated the effectiveness of electro-braid fencing arrays in 2 configurations in conjunction with a corral trap (the figure on page 17). Reidy et al. (2008) found feral hogs could be restricted from sensitive areas with the use of electric fencing with 2 strands positioned at 20 cm and 46 cm above ground level. This configuration was used in this study to guide or "funnel" feral hogs into corral traps. The base trap was a corral trap constructed of 5 galvanized livestock panels 1.25 m x 6.1 m with 10.16 cm square spacing within each panel completed with saloon door catch gates. Panels were attached to "T" post along the perimeter of the trap at 1.22-m increments. The height of the "T" post was 2 m and driven into the ground until level with the top of the trap panels. There were 4 attachments along each "T" post securing the panel to the post with #9 bailing wire. The triggering mechanism was a trip string attached to a collapsing board holding the catch gate in an open position. The trip string was positioned 1.25 m from the back wall of the trap at 35 cm from ground level. The trip string consisted of #18 braided fishing line (green). When the string was tripped, the hinge on the board collapsed allowing the catch gate to close.

Three fence-array designs were evaluated. The first design did not employ electric fencing and acted as a control (Fig. 2.1). The second design was similar to the control but employed a single leg of electric fencing extending at a right angle from the catch gate and terminating 25 m from the trap (Fig. 2.1). Plastic electric fence posts were placed at 2.44-m increments throughout the expanse of the fence. The fence was grounded with the use of a steel "T" post and powered with a Gallager B75 fence charger and a 12-volt deep cycle battery at a 7.2 kV charge (Gallagher Animal Management Systems, North Kansas City, Missouri, USA) similar to that used by Reidy et al. (2008). The third configuration included a corral trap with the addition of 2 legs of electric fencing extending from the catch gate at 45 degree angles forming a "V" and each leg terminating 25 m from the trap.

Trap treatments were deployed on public and private properties of sufficient acreage (>184.5 ha) to allow proper spacing of treatments (Fig 2.2). Traps were spaced at a minimum of 0.5 km apart to in order to not significantly alter the environment causing feral hogs to leave the area. Each treatment was replicated 30 times. A grid was placed over each property and each trap set location was chosen randomly. The size of each grid section was a minimum of 46 ha. Traps were located within each grid to avoid livestock trails and/or areas of observed erosion while incorporating vegetation into the trap site for animal welfare purposes. Treatments were pre-baited daily for 7 days with 9.6 l of sour corn supplemented with grape flavoring. Pre-baiting was employed in order to condition hogs to trap locations and allowing hogs to familiarize themselves with the trap to include the catch gate. All traps were monitored with Stealth Cam game camera (I450, Stealth Cam, Grand Prairie, Texas, USA) during the trapping period. Trap triggers were activated for 7 days following the pre-bait stage, and traps were checked daily. Trap success was determined by the number of successful catch nights divided by the total number of trapping nights per trap treatment. Data were analyzed using parametric (Shapiro-Wilk) and non-parametric (ANOVA, Chi-square, ANOVA) tests accounting for the following dependent variables: Success (i.e., animals trapped, yes/no), number of individuals trapped, time of day (i.e., day, night), and sex (males, females). All activities were approved in accordance with the guidelines listed in the Animal Use Protocol (AUP), AUP 2008-160.

Fig. 2.1. Example of corral trap (top) with catch gate (bottom left) with arrays of electric fencing (bottom) in East Texas, 2010.

RESULTS

Due to weak conformity to parametric statistical assumptions, I chose to use both parametric and non-parametric analysis to evaluate trapping data. My ANOVA analysis indicated there were no ($df = 2$, $P > 0.05$) differences between trap designs (Fig 2.2). Additional non-parametric analyses confirmed these conclusions. Even though differences between treatment means were small and comparisons were limited by sample size, the corral design with 2 electric legs was consistently inferior (Table 2.1) to the other designs in all tests. The ANOVA tests of normality between treatment groups indicated the dependent variables (success, number of individuals, and sex) were not normally distributed (df = 2, $P < 0.05$) (Fig. 2.3). My analysis indicated that total females trapped have unequal variance among treatment groups ($df = 2$, $P < 0.05$). All other variables were determined to be homoscedastic ($df = 2$, $P > 0.05$) with respect to treatment groups. Non-parametric assessments confirmed these findings.

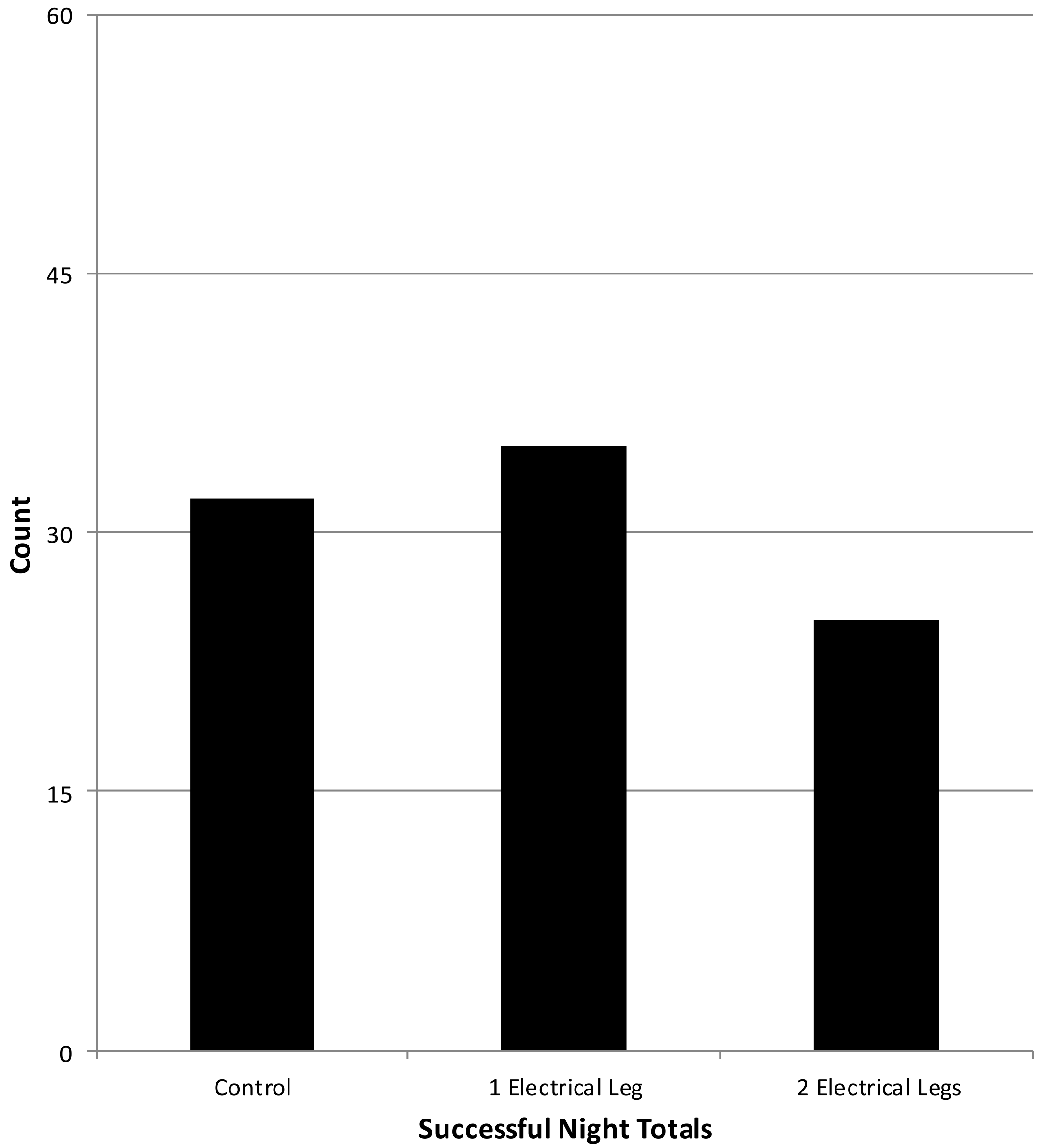


Fig. 2.2. Summary of trapping efforts by treatment (corral trap, no fencing, corral trap with 1 leg of fencing, corral trap with 2 legs of fencing), conducted in East Texas, 2010.

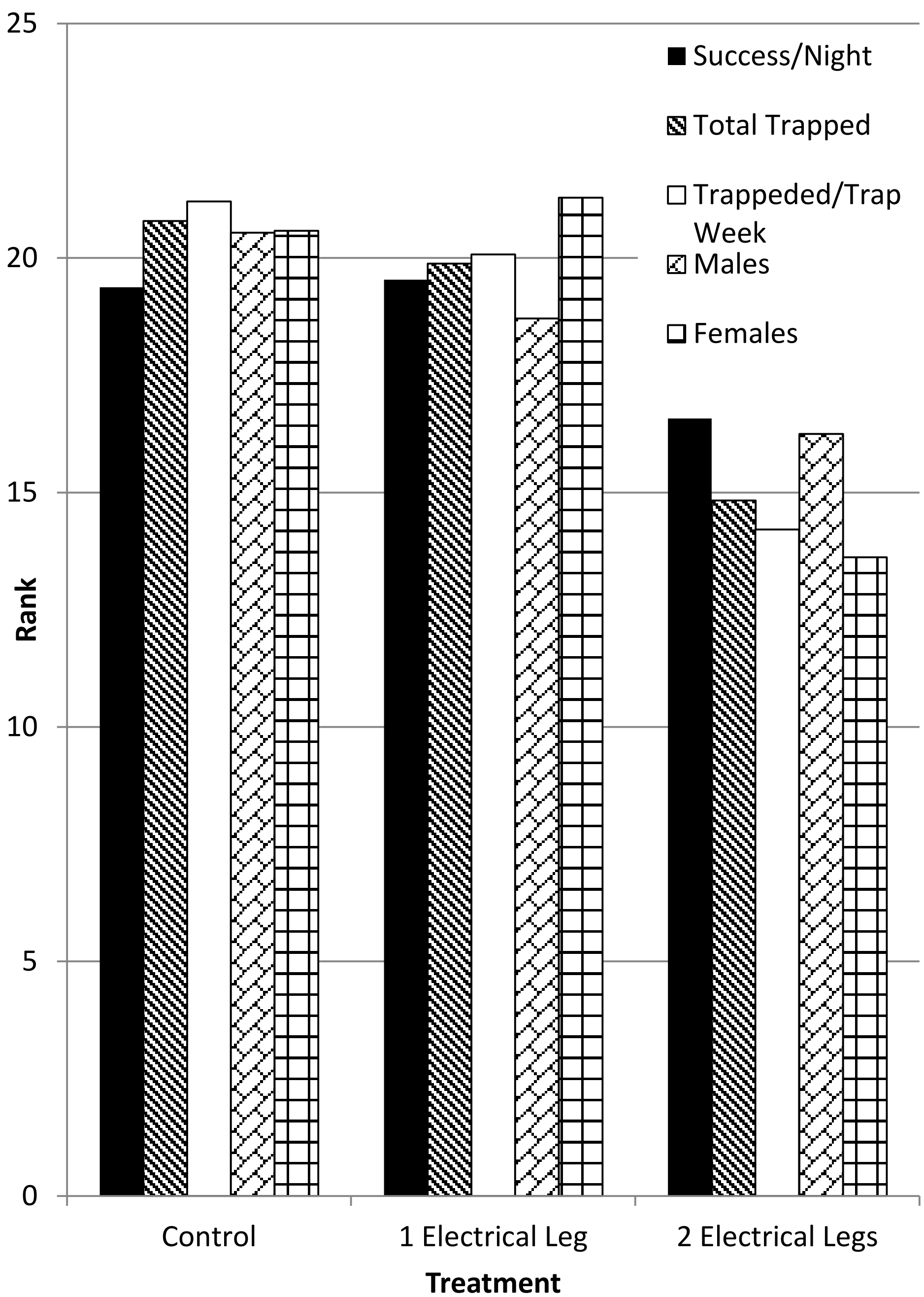


Fig. 2.3. Distribution of dependent variables by trap treatment, conducted in East Texas, 2010.

Results using non-parametric tests were similar to findings from parametric analyses. Trap success by night was determined by presence or absence of trapped feral hogs. The capture of multiple individuals by night was not used in determining success (trapping efficacy). Differences between treatment means were small and comparisons were limited by sample size. However, the corral design with 2 electric fence legs were consistently inferior (Table 2.1) to the other designs in all tests.

I conducted additional analyses to determine if trapping success was uniform across all nights within a trap week, and if the temporal distribution of success differed between trap designs. Both ANOVA (parametric) and Pearson's Chi-square indicated no significant ($df = 2$, $P = 0.758$) difference in the distribution of trapping success (Table 2.1) between treatments ($df = 2$, $P = 0.758$ and $df = 2$, $P = 0.987$, respectively). However, Pearson's Chi-square evaluation of trap success by night indicated a significant ($df = 2$, $P < 0.001$) difference between nights. Examination of these data confirms the majority of trapping success occurs within the first 4 trap nights, regardless of design (Fig. 2.4).

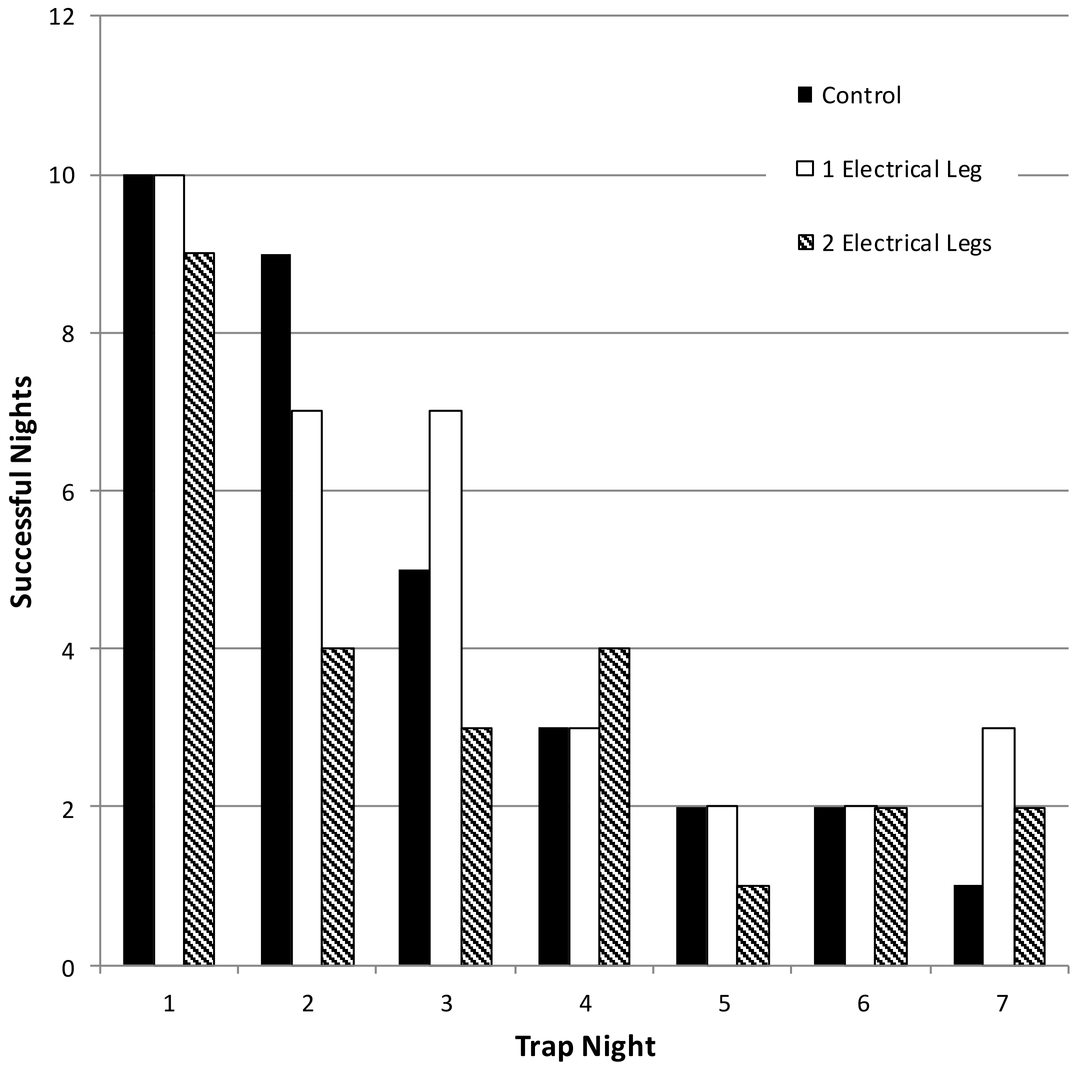


Fig. 2.4. Trapping efforts by night and treatment (corral trap, no fencing [top], corral trap with 1 leg of fencing [middle], and corral trap with 2 legs of fencing [bottom]), conducted in East Texas, 2010.

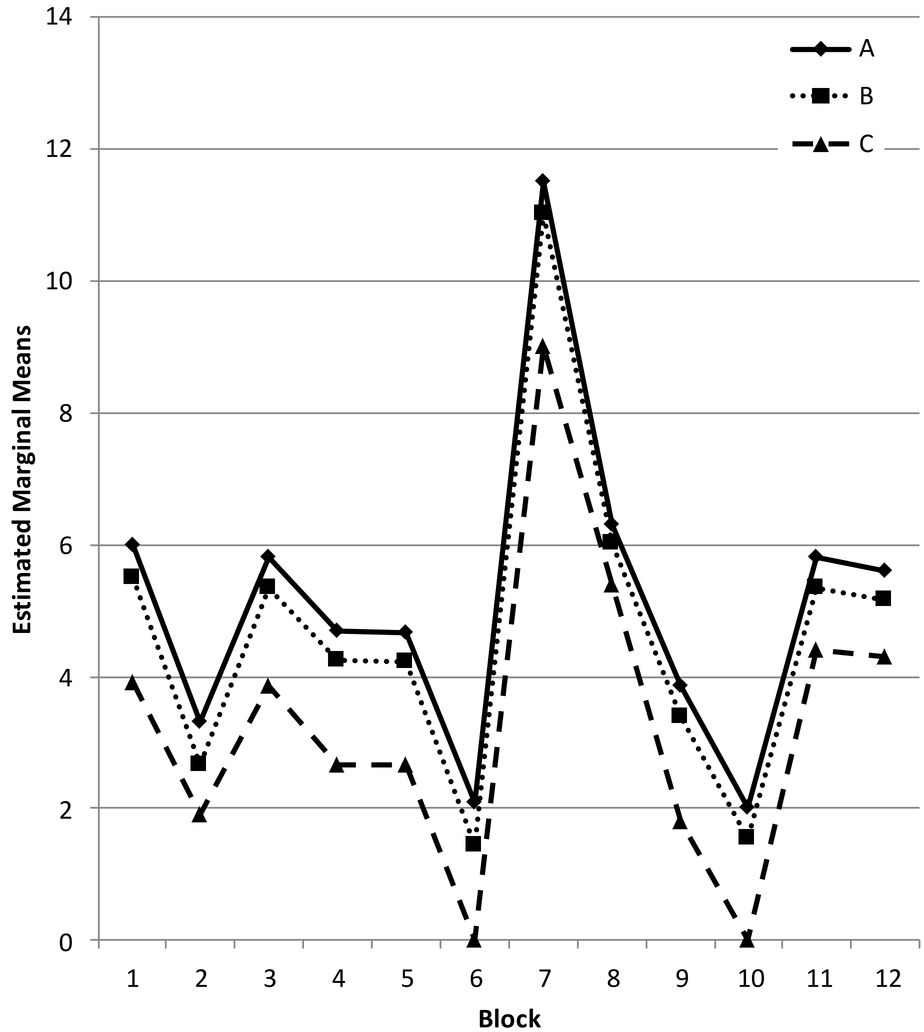


Fig. 2.5. Estimated marginal means for number of pigs trapped by trap type in a randomized block ANOVA (i.e., block = trapping property) as observed in East Texas, 2010.

Final analysis evaluated mean number of individuals captured or gender by treatment to determine if differences exited. A Chi-square analyses indicated there were no significant ($df = 2$, $P = 0.511$) differences in gender between all treatments. The mean number of individuals captured did not differ ($df = 2$, $P < 0.05$) between treatments. Mean individuals captured between treatments was 4.5 with the range between treatments of 4.3 to 4.6. Further analyses examined the occurrence of catch events with a single individual. This occurred in 26 instances with no significant differences between treatments ($df = 2$, $P < 0.05$); however, 24 of 26 (92.3%) instances involved the capture of a single boar (Table 2.2). Mean and median weights of solitary catch boars were 97.9 kg and 99.1 kg, respectively. Mean and median weights of boars included in multiple catch events were 29 kg and 19 kg, respectively (Table 2.2).

Table 2.1. Summary of trapping efforts by treatment (corral trap, no fencing [A], corral trap with 1 leg of fencing [B], corral trap with 2 legs of fencing [C]), conducted in East Texas, 2010.

Treatment *Sex*	Trap nights	Individuals caught	Catch nights	Mean individuals captured by treatment
A	210		32	4.6
Males		70		
Females		71		
B	210		35	4.6
Males		75		
Females		88		
C	210		25	4.3
Males		57		
Females		51		

Table 2.2. Summary of catch events for single boars between treatments conducted in East Texas, 2010.

Successful nights	Solitary catch total	Solitary boar catch	Multiple catch including boars	Mean wt. (kg) (boar only)	Median wt. (kg) (boar only)
92	26 (28.2%)	24 (24 individuals) (92.3%)		97.8	99.1
			66 (178 individuals) (71.8%)	29	19

DISCUSSION

Study results indicated no differences existed between treatments and did not support initial hypothesis of improving trap efficacies with electric drift fences. Across all 12 properties on which traps were evaluated, electric fencing did not improve trapping efficiency. In contrast, I observed that inclusion of electric fencing with corral traps actually decreased the total number of individuals and number of successful nights (Table 2.1). Use of "drift" fences in combination with a trap has proven to be effective tools in management of other species (e.g., Nettleship 1969, Bury and Raphael 1983, Corn 1994, Faulhaber et al. 2005). For example, Bury and Corn (1987), Greenberg et al. (1994), and Faulhaber et al. (2005) observed improved catch ratios in small mammal and herpetofaunal studies through the use of fencing. The decreased efficacy of drift fences in this study may be due to the type of fencing evaluated. Studies employing drift fences on small mammals, reptiles, and amphibians used a "barrier" type fence with no negative reinforcement. Reidy et al. (2008) employed this technique successfully in repelling feral hogs from sensitive areas. The negative reinforcement of the electrical shock was determined to be the repelling agent. This fence type could have induced the same effect. Observations by camera and in person noticed domestic livestock and feral hogs exploring the electric fence by smell. The electric shock of the fence would induce an instantaneous response causing the animal to leave the site. Such response is believed to be the case among treatments with electric fence legs. Other studies that used fencing to improve trapping (e.g., Clawson and Basket 1982, Vogt and Hine 1982, Dodd 1991, Greenberg et al. 1994, Faulhaber et al. 2005) used rigid forms of "hard" fencing to funnel species to trap locations. Additional assessment of "hard" fencing rather than electric fencing needs further evaluation in improving the capture of medium and large-sized mammals using corral traps.

No studies could be located that evaluated gender associations with solitary catch events. Current theory among resource managers is boars are solitary creatures only interacting with sounders during mating (Kruz and Marchinton 1972). The frequency of solitary catch boars compared to all solitary catch events brings potential validity to that theory. Obviously, areas holding significant populations of large solitary boars can adversely affect catch averages making trap efficacy measures of individuals captured by night less impressive.

I found there were no differences between trap treatments within the study area with a capture mean of 4.5 between all treatments. Mersinger and Silvy (2007) had similar success with corral traps averaging 4.2 individuals in each catch event. Corral traps can prove to be more effective in feral hog removal when compared to box traps. Average catch totals by event are consistently lower for box traps as observed in findings of Adkins and Harveson (2007) of 2.3 individuals per catch event.

Traps were constructed and allowed to stand for 2 nights prior to pre-baiting. Pre-baiting was employed 7 consecutive nights prior to trigger activation to condition feral hogs. No other studies have reported the value of pre-baiting when trapping feral hogs. Study results found that trap success declined after the fourth night across all treatments. Trap triggers were activated for 7 consecutive nights, however, trap success declined >50% after the fourth night. Bury and Corn (1987) indicated that a continuous extended period of time (e.g., 60 days) was needed in order to thoroughly compile an accurate, concise outcome with trapping efforts using drift fences on small mammals and snakes. Pre-baiting is believed to be the single most important factor influencing trap efficacy in this study. The absent step of pre-baiting in other studies could be the reason for delayed capture. Though trapping success continued beyond the fourth day, I observed a significant decrease in success beyond the third day. I attribute this decline in success to (1) trap wariness and avoidance of trap following trap use, and (2) removal of resident population (i.e., diminishing returns with continuous trapping).

MANAGEMENT IMPLICATIONS

Study results do not support the use of electric fencing in conjunction with corral traps, thus are not recommended in feral hog abatement programs. Future research evaluating hard fences may be an effective alternative and should be evaluated further. I recommend that trapping using corral traps be conducted in short, intense durations. It is recommended to, after the necessary pre-bait period necessary in conditioning feral hogs to enter the trap consistently, trap for no more than 4 consecutive nights then (1) move the trap to a new location, or (2) delay future trapping efforts within the area for 45 to 90 days. If the traps are to remain in the same trapping location for future efforts, bait the trap on the final check with triggers de-activated. Subsequent visitation by feral hogs will result in a positive reinforcement in the form of food that could result in faster re-visitation by feral fogs when trapping efforts resume.

CHAPTER III

FERAL HOG SPECIFIC BAIT ASSESSMENT

Since introduction into what is now the continental United States some 480 years ago (Town and Wentworth 1950, Belden and Frankenberger 1977), feral hogs (*Sus scrofa)* have negatively impacted landscapes and natural ecosystem processes (Seward et al. 2004). Feral hog damage includes habitat destruction or degradation (Barron 1980, Lipscomb 1989, Choquenot et al. 1996, Engeman et al. 2001), biodiversity (Stone and Keith 1987) and agricultural commodity losses (Singer et al. 1984), depredation of native flora and/or fauna (Hellgren 1993, Chavarria et al. 2007), degradation of soil fertility (Lacki and Lancia 1986, Mungall 2001), disease transmission (Williams and Barker 2001) and other public safety issues (Forrester 1991). The resulting damage caused by feral hogs is largely due to their high adaptability to various environments and high reproductive potential (Gipson et al. 1997, Hellgren 1999). Feral hogs currently occupy 40 of the 50 states including Texas (Ditchkoff and West 2007). In Texas, feral hogs occupy 240 of 254 counties (Rollins et al. 2007) with damage associated with their expansion and occupation of these new areas. Damage estimates can be ascertained with more validity than population figures. Pimental et al. (2005) estimated feral hog damage nationally at $800 million with Adams et al. (2005) surveyed Texas landowners assessing feral hog damage and determined mean damage levels at $7515/Texas landowner annually. Once established, feral hogs are difficult to eradicate or even maintain at population levels where associated damage is acceptable. In order to hold feral hog populations constant, 70% of the annual population must be removed through natural and/or introduced practices (Coblentz and Bouska 2002).

Current legal management options for controlling feral hog populations are limited to hunting, snares, aerial gunning, hunting dogs, traps, and exclusion fencing (West et al. 2009). There is no single method of control that is 100% effective for feral hog control; however, trapping is a commonly used technique in abatement programs that can serve to remove 80–90% of localized populations (Choquenot et al. 1993). Success levels of feral hog removal are not known in the United States; however, best management practices (BMPs) are necessary to increase management efficacies. Capture of non-target species are an issue in feral hog trapping (Campbell and Long 2007). Trap triggers are frequently activated by non-target species removing the possibility of feral hog capture. Additionally, the capture of non-target species such as deer can be an animal welfare concern. Attempts to remove non-target species can result in undue stress and/or injury to the species. Several baits have been used to capture feral hogs ranging from deer entrails and carcasses to grains and commercial baits (Peine and Farmer 1990, Richardson 1995, Reidy et al. 2008). Strawberry-based baits evaluated by Campbell and Long (2008) have shown some promise of swine-specifity in south Texas. Identification of feral hog-specific bait would not only aid in improving the efficiency of trapping programs but also would support the delivery of reproductive inhibitors or toxicants currently being developed for feral hog control. Thus, the objective of the study was to identify feral hog-specific baits for used in feral hog abatement programs.

My hypotheses were baits/attractants would be identified that were similar to other bait visitation trials for feral hogs.

STUDY AREA

The study area (Fig. 1.1) in Southeast Texas is comprised of San Jacinto, Walker, Brazos, Liberty, Milam, and Montgomery counties. This study area includes the Coastal Plains and Post Oak Savannah ecoregions with the majority of the study area represented by the Pineywoods ecoregion (Crook and Hung 2005). This area is heavily populated with feral hogs and sizable populations of native wildlife and domestic livestock. Other wildlife populations present include: opossum *(Didelphis virginiana)*, coyote (*Canis latrans*), gray (*Urocyon cinereoargentenus*) and red (*Vulpes vulpes*) fox, gray (*Sciurus carolinensis*) and fox (*S. niger*) squirrels, white-tailed deer (*Odocoileus virginianus*), mink (*Neovision vision*), otter (*Lontra canadensis*), beaver (*Castor canadensis*), nutria (*Myocastor coypus*), bobcat (*Lynx rufus*), stripped skunk (*Mephitus mephitis*), rodents (Order Rodentia), and many avian species (Class Aves). Domestic animals include cattle, horses, sheep, goats, hogs, dogs, and cats (Taylor 2003). Temperature highs during summer months commonly exceed 35^{o} C with winter lows reaching the mid-negative 7^{o} C range. Average summer high temperatures are from 35–36^{o} C and winter low averages hovering in the low 4^{o} C range (Hebert and Jack 1998). The annual rainfall is 114.3 cm–121.9 cm with an average atmospheric relative humidity of 55%. Soil type varies from deep sand to tight clay profiles.

METHODS

I evaluated a total of 14 bait combinations: 3 candidate PIGOUT™ (250 g; Animal Control Technologies, Somerton, Australia) baits offered in 3 flavors (i.e., strawberry, fish, vegetable), and 4 fermented grain baits (i.e., corn, barley, wheat, rice) absent from trapping locations. Grain baits were soured by submerging grain in a closed black barrel and exposed to direct sunlight. Grain was monitored daily to determine the stage of fermentation and add water if needed in order to maintain submerged grain. Baits were determined to be sufficiently fermented when the grain possessed a pungent odor and, as a result of the fermentation process, bubbles began to form on the surface of the water. Each of these 7 baits were evaluated with and without the use of raccoon repellant (Get Away; 3 ml; McGregor Small Animal Control, Sandwich, Massachusetts, USA) resulting in the 14 bait combinations.

Road transects (3–5 km) were used to evaluate candidate baits as prescribed by Campbell and Long (2008). Candidate baits were placed at intervals of 100–125 m along road transect within a given property boundary. Roads were selected according to proximity to a residence or area of increased human activity (e.g., barn, feedlot) or the ability to travel the road during normal conditions. No road transect originated or terminated within 0.5 km of another transect. For each interval along the road transect, candidate baits were placed on either side of the road (side determined by flip of coin) (hereafter "bait trial"). For each trial, candidate bait was evaluated by evaluating visitation of both target and non-target species for 4 days with the use of Stealth Cam (Stealth Cam, LCC, Grand Prairie, Texas) game cameras. Each bait trial was replicated

40 times. Hence, a total of 560 bait trials were conducted (14 candidate baits x 40 trials/bait = 560 trials) in my study.

Grain baits were evaluated by placing highly absorbent cotton saturated with 25 ml of sour water from each bait placed in a capped PVC tube (15.24 cm long x 2.54 cm wide, drilled 10 times (0.95 cm each) to allow scent to escape) (Fig. 3.1). Each PVC container was tethered to the ground with string (#18 braided) and a galvanized nail (20 cm) fully driven into the ground. PIGOUT™ baits were self-contained baits not needing a protective canister as with the grain baits. PIGOUT™ baits were placed on the ground following the same process as used with the grain baits but were not tethered. Cameras monitored all baits from a distance of 5 m. Upon returning to bait sites, camera memory cards were evaluated on site with a hand-held reader and categorized.

I determined species-specific visitation and removal rates for all candidate baits through examination of photographs. I defined visitation as the total number of individuals within 3 m of baits prior to and including bait removal. Species visitation to candidate baits was determined following the procedure established by Campbell and Long (2006). Results are presented as counts. Photographic data were categorized into 1 of 5 removal categories: (1) definitely removed by species, (2) likely removed by species, (3) possibly removed by species, (4) removed by unknown species, and (5) not removed (Campbell and Long 2006). I considered baits in the definitely and likely categories as removed with the remaining categories defined as not removed. Visitations were compared among treatments for species using a Chi-square and ANOVA non-parametric evaluations (Dowdy and Weardon 1991).

Fig 3.1. Canister used in grain bait evaluation, conducted in East Texas, 2010.

RESULTS

I began the analysis of bait data by determining if relationships exist among broad bait categories (PIGOUT™ versus grain, regardless of repellant) for feral hogs. There was no significant ($df = 12$, $P < 0.05$) relationship between broad bait categories and bait visitation according to Chi-square test for feral hogs (Fig 3.2). Feral hogs did not indicate preference when determining visitation of broad bait categories; however, there was a significant ($df = 2$, $P = 0.013$) relationship between specified bait categories and bait visitation for feral hogs. An ANOVA analyses for feral hogs indicated significant ($df = 2$, $P < 0.05$) visitation for PIGOUT™ strawberry, corn, and rice baits (Fig 3.2). The use of repellant had no direct impact on bait visitation by feral hog and other non-targets (e.g., deer); however, the use of repellant did influence bait visitation by raccoons. The depressed visitation at bait sites with repellant by raccoons observed in my study resulted in more baits available to feral hog use (Table 3.1).

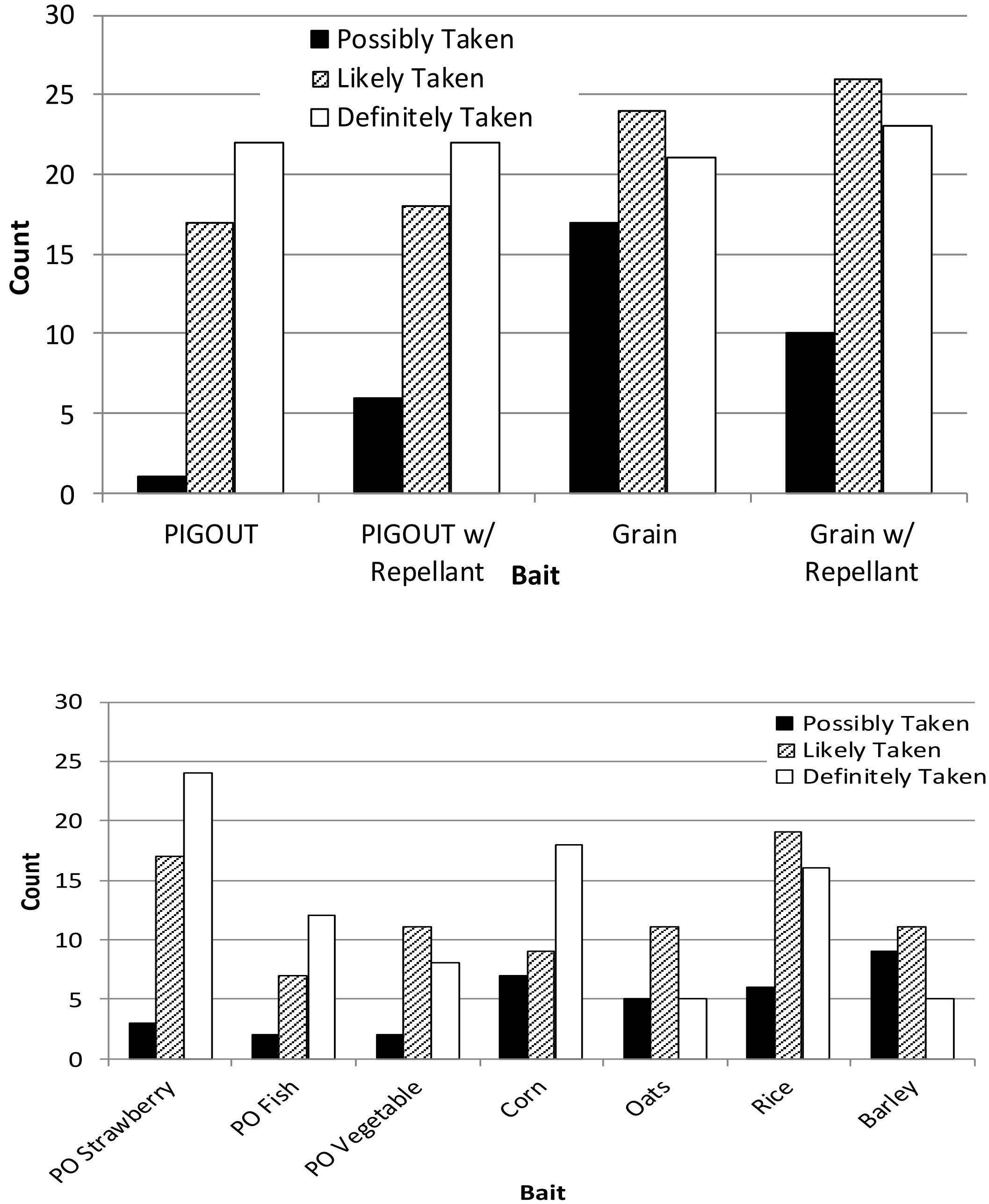
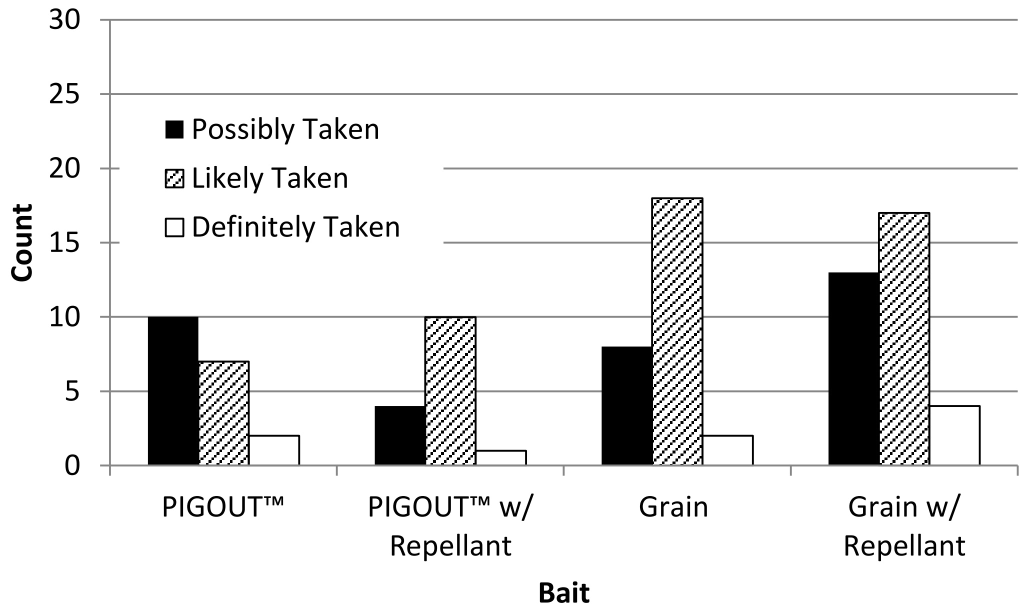


Fig 3.2. Bait visitation (broad, top; specific, bottom) by type (PIGOUT™ [PO], grains) for feral hogs, conducted in East Texas, 2010.

Table 3.1. Summary of bait combination visitation by mammalian species (feral hog, deer, raccoon, other), conducted in East Texas, 2010.

Bait combinations	Feral hog	Deer	Raccoon	Other
PIGOUT (PO) Strawberry	20	4	8	7
PO strawberry w/ repellant	24	5	4	8
PO Fish	10	4	12	9
PO Fish w/ repellant	11	3	4	9
PO vegetable	10	11	8	9
PO vegetable w/ repellant	11	7	8	8
Corn	18	4	24	4
Corn w/ repellant	16	9	15	8
Rice	22	8	9	10
Rice w/ repellant	19	9	4	9
Oats	9	6	8	9
Oats w/ repellant	12	6	4	11
Barley	13	10	5	10
Barley w/ repellant	12	10	5	9
Total	207	96	118	120

Further evaluation of bait data using specific categories for non-target species were similar to broad category results. A Chi-square test indicated there were no significant relationships between bait category and bait visitation for deer ($df = 12$, $P = 0.776$) (Fig. 3.4) or raccoons ($df = 12$, $P = 0.198$), respectively. Repellant usage had no significant ($df = 2$, $P < 0.05$) impact on deer visitation of available baits. Though not significant, deer visited PIGOUT™ with less frequency than grain baits. Raccoon avoidance of baits with repellants differed ($df = 2$, $P < 0.05$) compared to baits with no repellants. Photographic data suggested that raccoons would continue to visits baits (at a reduced frequency) but consumption of the bait was significantly reduced. No conclusions could be deduced in the "other" category due to low visitation frequencies.



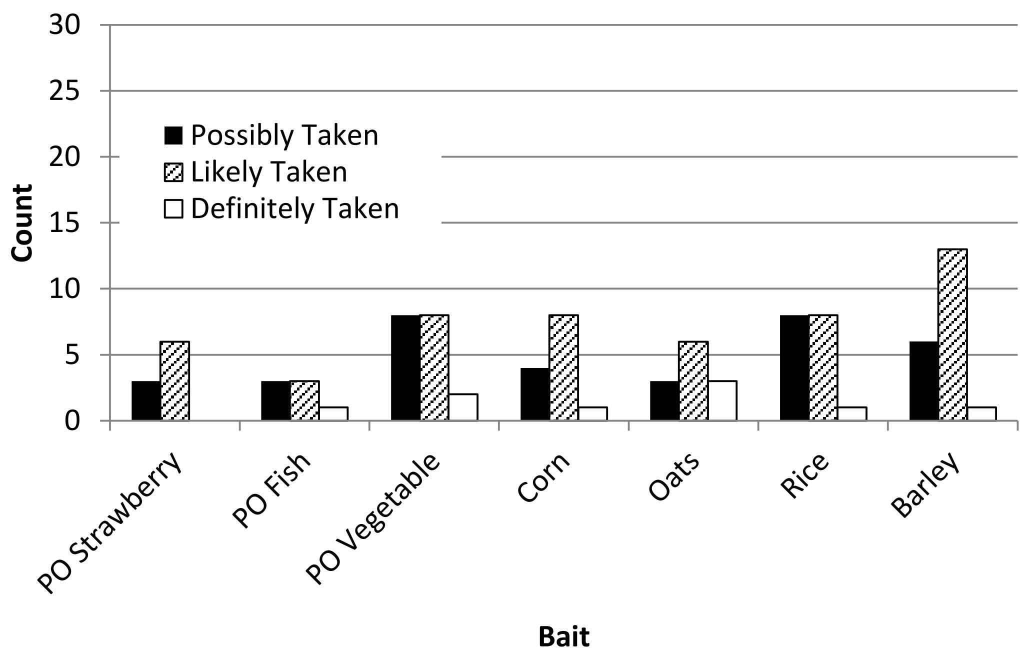


Fig. 3.3. Bait visitation (broad, top; specific, bottom) by type (PIGOUT™ [PO], grains for deer, conducted in East Texas, 2010.

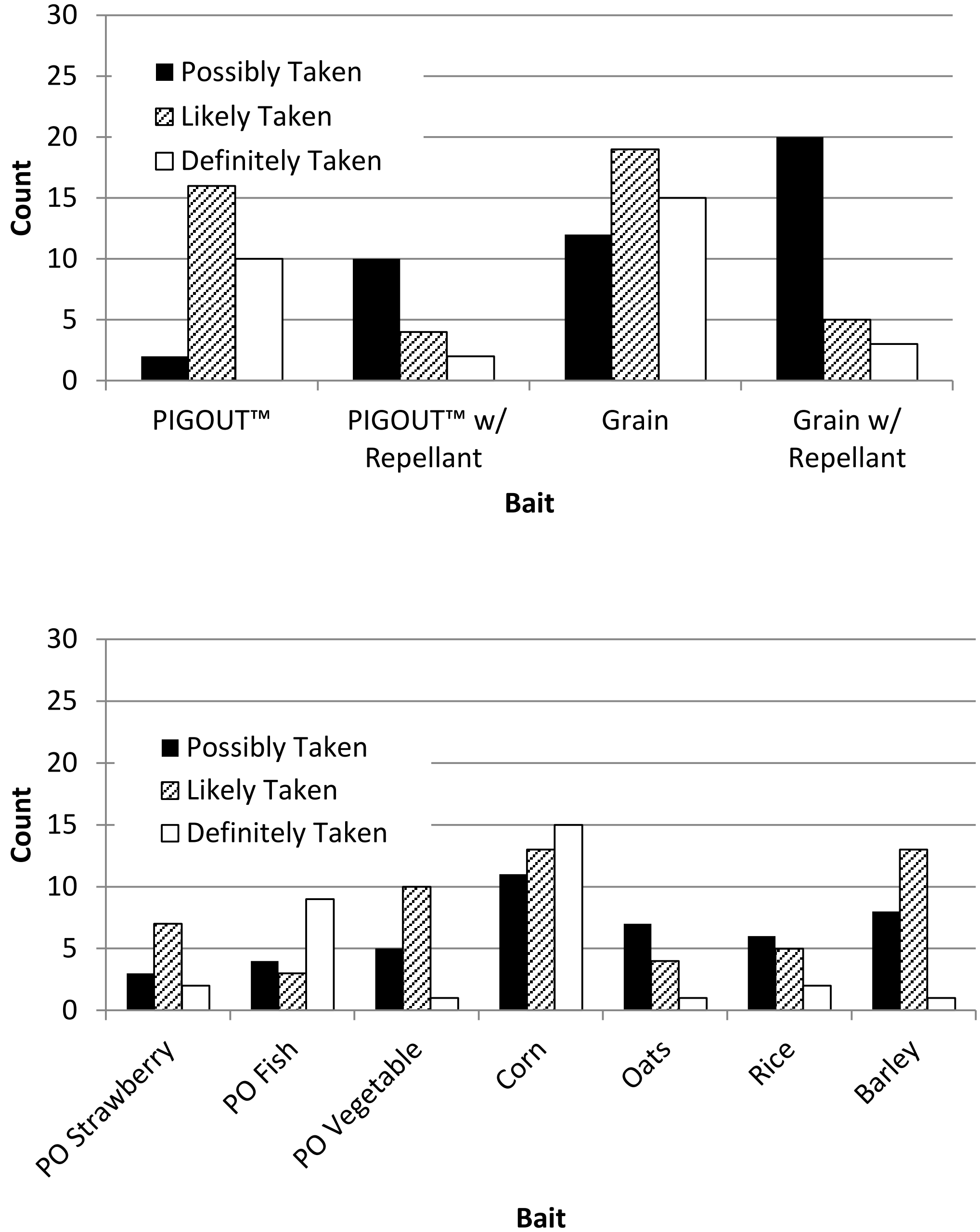


Fig. 3.4. Bait visitation (broad, top; specific, bottom) by type (PIGOUT™ [PO], grains) for raccoons, conducted in East Texas, 2010.

DISCUSSION

I evaluated 14 different baits to determine if preference to baits was present and found feral hogs preferred PIGOUT strawberry-flavored, rice, and corn baits, respectively (Fig. 3.3). Similar findings were observed by Campbell and Long (2006) and Campbell and Long 2008) in respect to strawberry baits/attractants. Additionally, grain baits were selected for by feral hogs at a higher frequency than other bait types. Study results suggested that non-target species (primarily raccoon) had substantial impact on grain baits as confirmed by Hartin et al. (2006). Also apparent was the elevated bait use by feral hogs when repellant was used. Spurr and Porter (1998), and Morgan (1999) indicated non-target species interference at bait stations in the absence of species-specific repellant. The repellant had no direct impact on feral hogs or deer but significantly impacted raccoon usage of available baits (Table 3.1). Feral hog use was most impacted by interference imposed by raccoons. Deer did not indicate significant preferences for any offered baits but, did appear to select for grain baits at higher frequencies (Fig. 3.4). Raccoons did significantly select for corn but also selected for most other offered baits. The use of raccoon repellant could be incorporated into potential bait delivered methods/ products for feral hog visitation.

The geographic configuration of the study area was represented by Pineywoods, Coastal Prairie, and Post Oak Savannah ecoregions. Though not reflected in data analysis, baits evaluated in areas known for commercial production of grain (i.e., rice, corn) showed wild and domestic species selected for the bait commonly grown in the area at a higher frequency. Implications are that natural resource managers should select baits regionally. Observations indicated feral hogs more frequently visited bait stations that included commodities typically produced in the area. Feral hogs are accustoming to feeding on regional commodities due to familiarity of the product.

Domestic livestock and red imported fire ants (*Solenopsis invicta)* heavily influenced bait usage in the "other" category. During periods of stress (i.e., drought, cold, excessive stocking rate) use of baits by livestock and/or fire ants was observed. Additionally, it was further noted that fire ants heavily selected for PIGOUT™ strawberry and PIGOUT™ fish baits while domestic livestock primarily selected for grain based baits. Therefore, current weather conditions must be considered when selecting baits used in feral hog management efforts. Additional research is needed to gain additional understanding and confirmation of feral hog-specific baits. This could include candidate baits that are common to the specific region.

MANAGEMENT IMPLICATIONS

Baiting has been identified as a needed tool in feral hog management efforts by natural resource managers. The variation of feral hog diet makes finding feral hog-specific bait relatively difficult. A feral hog-specific bait can serve to reduce the consumption and interference by non-target species during trapping and other management efforts (i.e., toxicant and/or pharmaceutical delivery). Study results suggest that 3 candidate baits evaluated (i.e., PIGOUT strawberry, corn, and rice) resulted in the greatest feral hog specifity and/or lowest interference in trapping by other non-target mammalian species. Specific commodities available to feral hogs within a region should be considered to be a starting point for baiting feral hogs within that localized area. It is suggested that natural resource managers select baits that experience less visitation by non-target species such as the aforementioned. To add to this, baiting efforts could be more effective by alternating bait choices.

CHAPTER IV

IMPROVED TRAPPING STRATEGIES FOR FERAL HOGS

Since introduction to the continental United States some 480 years ago, feral hogs (*Sus scrofa)* have negatively impacted landscapes and natural resources throughout their range. Feral hog damage includes habitat destruction or degradation, biodiversity and agricultural commodity losses, depredation of native flora and/or fauna, degradation of soil fertility, disease transmission, and other public safety issues. The resulting damage caused by feral hogs is largely due to their high adaptability to various environments and high reproductive potential. Feral hogs currently occupy 40 of the 50 states including Texas. In Texas, feral hogs continue to expand their range and now occupy 240 of the 254 counties in the state (Rollins et al. 2007).

FERAL HOG DAMAGE

In 2007, Texas landowners reported losses of agricultural commodities associated with feral hogs at nearly \$52 million and/or \$200/feral hog in damage (Higginbotham et al. 2008). Current legal management options in controlling feral hog densities and reducing damage to natural resources are limited to hunting/shooting, snares, hunting dogs, aerial gunning, and trapping. Trapping should be the foundation to any feral hog abatement program; however, trap efficiency often times varies by trap type and associated size. A common trap design used in trapping feral hogs is the box trap. The restricted size of box traps is the primary disadvantage with regard to efficacy or the number of animals trapped per unit effort. Corral traps are much larger and can be integrated into natural settings to improve trapping efficacy (Fig. 2.1). Unlike box traps, corral traps are capable of holding large numbers of feral hogs in a single catch event. Despite the advantages in efficacy of corral traps, more labor is required in trap deployment and construction is more expensive (West et al. 2009). Efforts to improve the numbers of trapped animals via corral traps can serve to offset these disadvantages (i.e., cost, labor, etc.). Reidy et al. (2008) evaluated the use of electric fencing to repel feral hogs from sensitive areas, and reported that electric fencing restricted movement of feral hogs. The value in use of electric fencing in combination with corral traps to improve overall trapping efficacy needs further evaluation.

Capture of non-target species are also an issue in feral hog trapping (Campbell and Long 2007). Trap triggers are frequently activated by non-target species removing the possibility of feral hog capture. Additionally, the capture of non-target species such as deer can be an animal welfare concern while in the trap or during attempts to remove animals. Identification of feral hog-specific bait would not only aid in improving the efficiency of trapping programs but also would support the delivery of reproductive inhibitors or toxins currently being evaluated for feral hog control.

Fig. 4.1. Example of corral trap (top figure) with catch gate (bottom left) with arrays of electric fencing (bottom figures) in East Texas, 2010.

RESEARCH DEMONSTRATION

A research demonstration was conducted to (1) evaluate the utility of electric fencing in various configurations in conjunction with corral traps (Fig. 4.2), and (2) evaluate feral hog-specific baits that can be used in trapping efforts. Methods for each of these research objectives are described further.

Corral Traps

Common technique for livestock producers is to use existing fences to funnel or direct livestock to desired locations. For this reason, I evaluated electro braid electric fence configurations at corral trap locations (Fig. 4.2). Traps were constructed on site and pre-baited 7 consecutive nights prior to activating triggers for the subsequent 7 nights. The number of successful nights (≥1 individual), total individuals, and night of the trap week were recorded for each trap design. Evaluation of data collected indicated there were no differences between trap designs (Fig. 4.3). These data also indicated there were no statistical differences in the total number of hogs captured in each trap design. Furthermore, the corral trap design with 2 electrical legs was consistently inferior to other evaluated designs. Recorded in the findings were successful nights within the trap week. Evaluation of these data indicated the period of the week with successful catch nights was significant to the first 4 nights of the week (Fig 4.4).

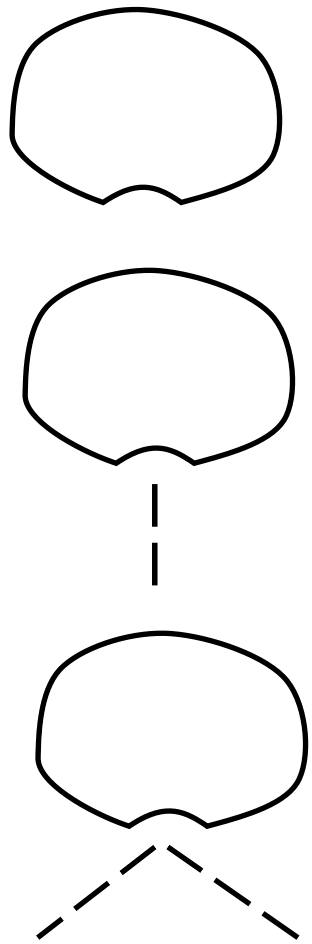


Fig. 4.2. Diagram of control corral treatment, with no electrical leg (top); treatment corral trap with 1 electrical leg (middle); treatment corral trap with 2 electrical legs (bottom), conducted in East Texas, 2010.

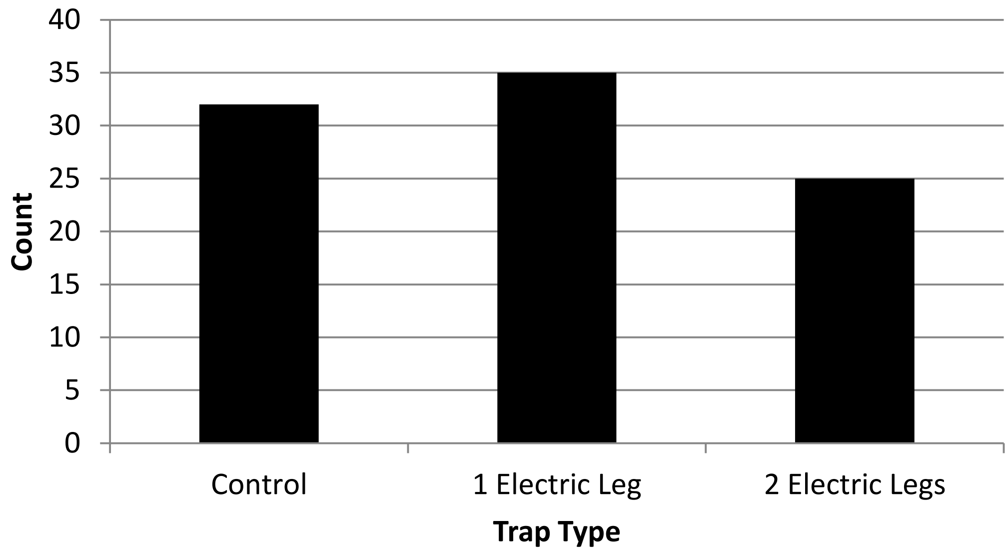


Fig. 4.3. Summary of trapping efforts conducted in East Texas, 2010.

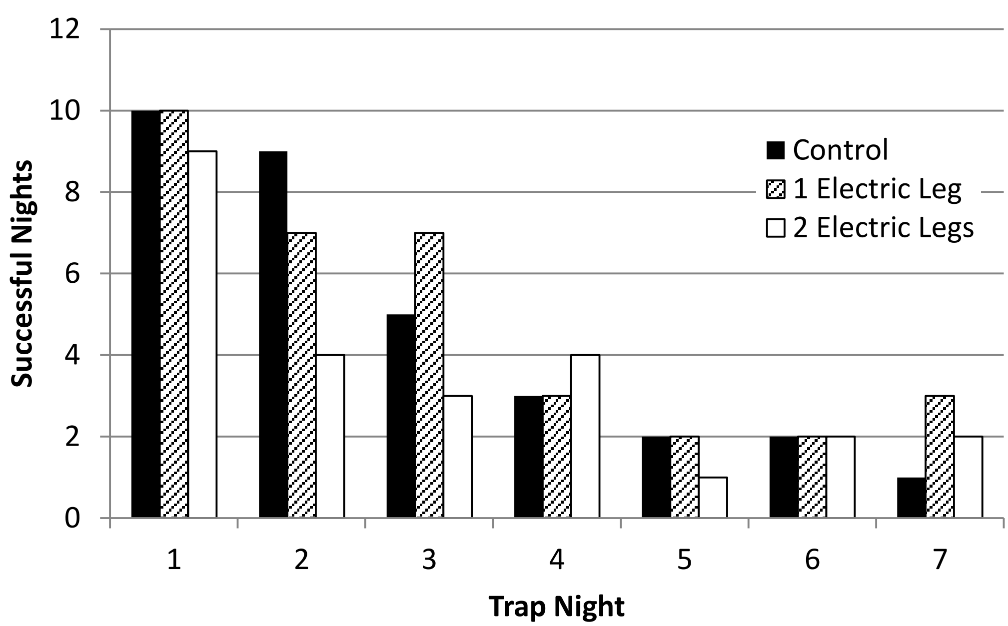


Fig. 4.4. Trap success for the trap week decreased significantly after the fourth night in East Texas, 2010.

Baits

I evaluated 14 bait combinations recording species visitation and frequency of bait removal by species. Baits evaluated included 3 PIGOUT™ baits available in 3 flavors (i.e., strawberry, fish, and vegetable) and 4 fermented grain baits (i.e., corn, rice, barley, and oats). In addition, I evaluated these 7 baits with the addition of raccoon/squirrel repellent (Get Away™) at a rate of 3 ml per bait. Species visitation was determined using remote cameras. Study results suggest feral hogs preferred PIGOUT strawberry-flavored, rice, and corn baits, respectively (Fig. 4.5). Additionally, grain baits were selected for by feral hogs at a higher frequency than other bait types. Study results suggested that non-target species (primarily raccoon) had substantial impact on grain baits; however, use of repellants was effective in reducing raccoon consumption (Fig. 4.6). Though not reflected in data analysis, baits evaluated in areas known for commercial production of grain (i.e., rice, corn) showed wild and domestic species selected for the bait commonly grown in the area at a higher frequency. Implications are that natural resource managers should select baits regionally.

Baiting has been identified as a needed tool in feral hog management efforts by natural resource managers. The variation of feral hog diet makes finding bait for feral hogs relatively easy. The reasoning behind the need for feral hog-specific bait(s) is to reduce the interference by non-target species in trapping and other (toxicant and/or pharmaceutical delivery) management efforts. As a result of my study, natural resource managers should be willing to alter baits to avoid non-target species issues. Feral hogs selected for primarily 3 baits (PIGOUT strawberry, corn, and rice) with varying interference by other mammalian species. Specific commodities available to feral hogs within a region should be considered to be a starting point for baiting feral hogs within that localized area.

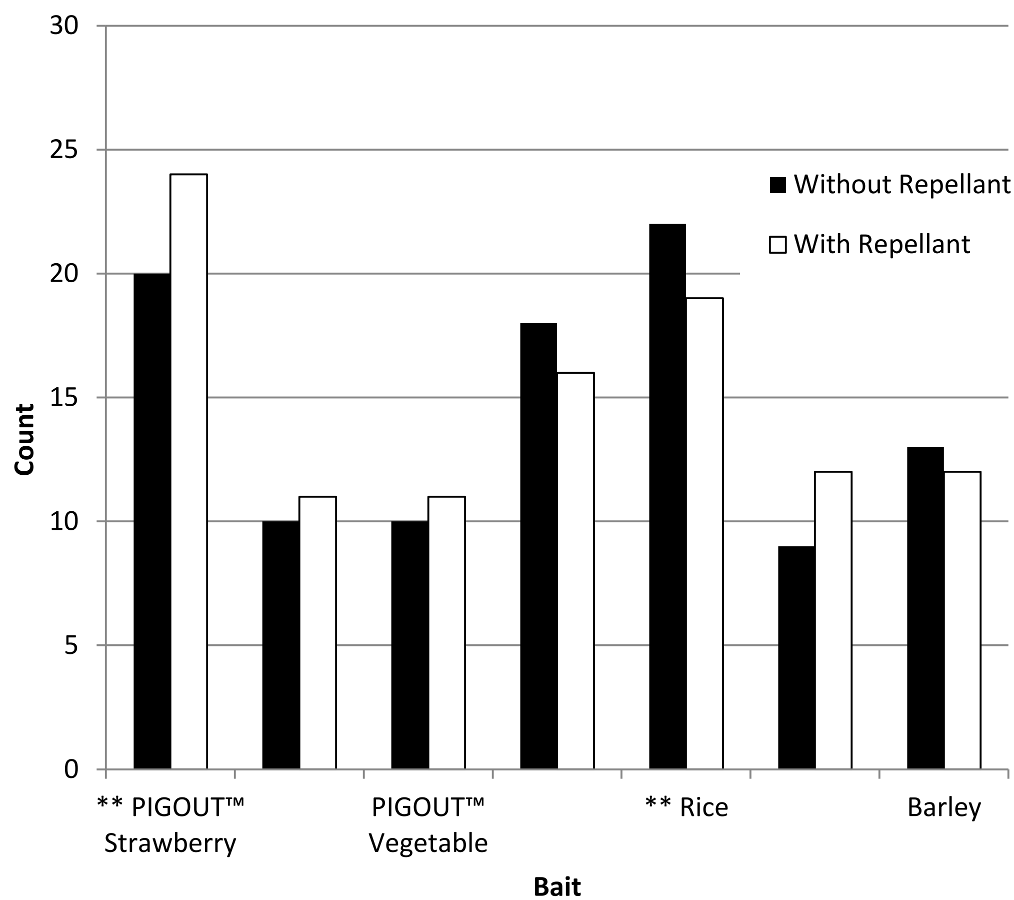


Fig. 4.5. Feral hog visitation of specific bait category with and without repellant in East Texas, 2010.

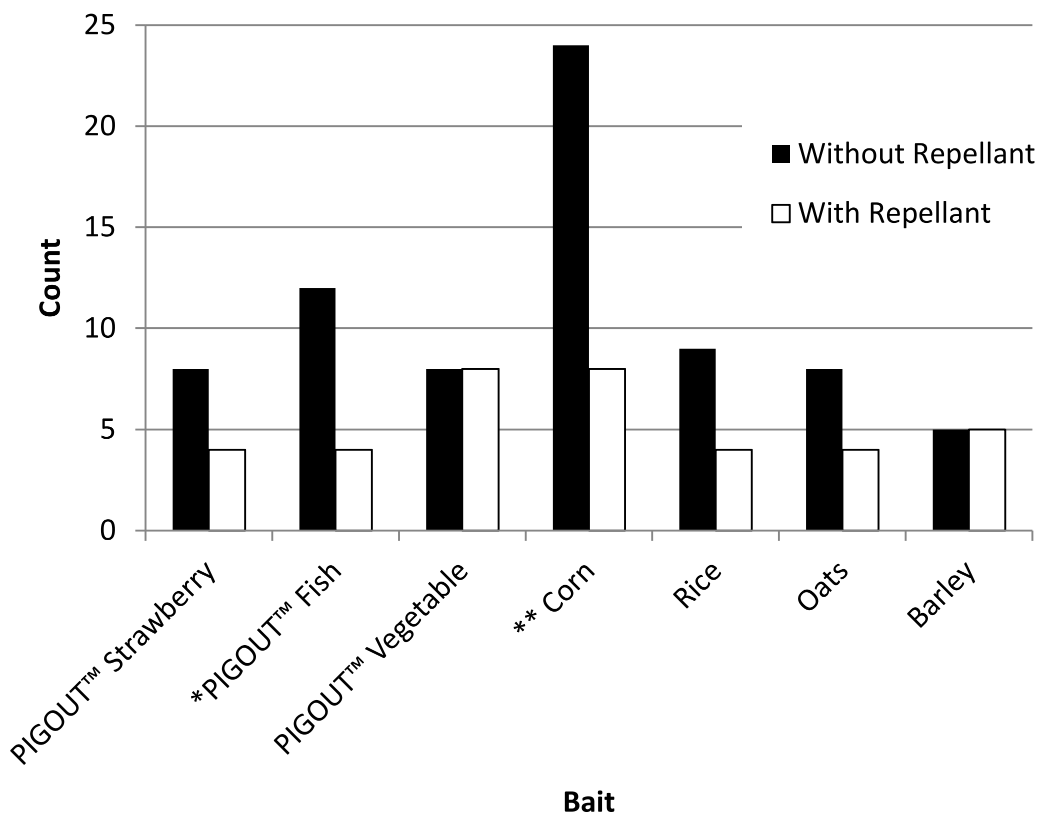


Fig 4.6. Raccoon evaluated specific bait visitation in East Texas, 2010.

MANAGEMENT RECOMMENDATIONS

Study results do not support the use of electric fencing in conjunction with corral traps, thus are not recommended in feral hog abatement programs. Future research evaluating hard fences may be an effective alternative and should be evaluated further. I recommend that trapping using corral traps be conducted in short, intense durations. Pre-baiting is encouraged prior to activating triggers. The duration of pre-baiting can be determined using wildlife cameras. Activate triggers following the pre-baiting period only after the majority of the visiting sounder(s) individuals are freely entering and exiting the trap. It is recommended to, after the necessary pre-bait period, trap for no more than 4 consecutive nights then (1) move the trap to a new location, or (2) delay future trapping efforts within the area for 45 to 90 days. If the traps are to remain in the same trapping location for future efforts, bait the trap on the final check with triggers de-activated. Subsequent visitation by feral hogs will result in a positive reinforcement in the form of food that could result in faster re-visitation by feral fogs when trapping efforts resume.

Baiting has been identified as a needed tool in feral hog management efforts by natural resource managers. The variation of feral hog diet makes finding feral hog-specific bait relatively difficult. A feral hog-specific bait can serve to reduce the consumption and interference by non-target species during trapping and other management efforts (i.e., toxicant and/or pharmaceutical delivery). Study results suggest that 3 candidate baits evaluated (i.e., PIGOUT strawberry, corn, and rice) resulted in the greatest feral hog specifity and/or lowest interference in trapping by other non-target mammalian species. Specific commodities available to feral hogs within a region should be considered to be a starting point for baiting feral hogs within that localized area.

PRE-BAITING/BAITING AND WILDLIFE CAMERA CONSIDERATIONS

The baiting process is a step that should be methodical in approach. The pre-baiting process should begin with the majority of the selected bait being placed on the outside of the trap and catch gate area. The first days of pre-baiting are to introduce feral hogs to the trap and the location of the catch gate. Wildlife cameras at trap locations will inform the natural resource manager when to begin working more bait into the trap. Pre-baiting duration should not be predetermined; wildlife cameras should be used to determine when the pre-baiting period should end and triggers set. Research suggests that 70% of the annual population must be removed in order to hold the population steady. With this in mind, triggers should be activated when the majority of the sounder is entering and exiting the trap freely. With the onset of trapping, baiting technique should change as well. A correctly baited trap should have >90% of the bait in the trap. This will minimize feral hogs loitering on the outside of the trap. The majority of the bait on the inside of the trap should be between the catch gate and the trigger. Feral hogs will consume bait as it is encountered slowing progress to the trigger. This will allow more of the sounder to enter the trap prior to activating the trigger.

Wildlife cameras should be in the “tool bag” for feral hog management. Such cameras can serve many roles. The duration of the pre-bait period can be determined by the use of cameras requiring fewer man-hours in the trapping effort. Cameras will indicate the size of sounders in the area allowing resource managers to determine the necessary size of the trap. Dynamics of the sounder can also be determined. Many times younger feral hogs will rush into the trap pre-maturely activating the trigger. Sounder dynamics can indicate the necessary height of the trip string to avoid pre-mature triggering by young feral hogs increasing likelihood of more individuals captured. Cameras also will indicate the non-target species and their frequencies to trap locations. Knowing this will allow resource managers to select the appropriate trigger to decrease potential of non-target species interference.

CHAPTER V

SEROLOGIC ASSESSMENT OF SELECTED HOG DISEASES

Ecological concerns surrounding feral hogs (*Sus scrofa)* is continuously growing due to increases in population numbers and associated damage. Pimental et al. (2005) estimated feral hog damage nationally at $800 million. In Texas, Adams et al. (2005) surveyed private landowners and estimated annual feral hog damage at $7,515/Texas landowner. In addition to natural resource damage caused by feral hogs, disease risks also are a concern to natural resource managers and public health officials. Feral hogs are known to carry or serve as a reservoir in excess of 30 diseases or pathogens of viral or bacterial origin (Davis et al. 1981, Forrester 1991, Davidson and Nettles 1997) and serve as a host to 47 spp. of external parasites. Such concerns have led states to implement disease eradication programs, for example, for pseudorabies (PRV) and *Brucella suis.* The potential range size of feral hog sounders serves to increase disease risks to many domestic animals and wildlife species (Forrester 1991, Davidson and Nettles 1997, Dexter 1999, Hubalek et al. 2002) to include transmission of PRV and/or *B. suis*. Pseudorabies (PRV) can prove fatal to all mammalian species except humans and the higher apes (Kocan 1990). Prior to eradication programs, it was estimated that PRV cost the national pork industry an estimated $40 million in market losses (Wyckoff et al. 2005). Since 2005, PRV in Texas and the United States has been eradicated in domestic hogs; however, the hog industry continues to monitor PRV and prevent the re-emergence of the disease. Pseudorabies can be fatal within 24-48 hours (Merry Vann, DVM, personal communication) after infection for companion animals and domestic livestock.

Swine brucellosis is a concern with domestic and wild mammalian spp. (Tessaro 1990, Davidson and Nettles 1997). The *suis* strain of brucellosis is a bacterial infection transmitted between individuals through oral and venereal routes (Wyckoff et al. 2009). This and all strains of *Brucella* carry with it a zoonotic classification with transmission routes to humans resulting in contact with infected body fluids (Thorne 2001). More commonly observed clinical signs/symptoms are related to reproduction to include abortion, fetal absorptions, infertility in sows, orchitis in boars and, mortality of infected piglets near 100% (Conger et al. 1999). Incubation period for *B. suis* can vary from days to weeks (Davidson and Nettles 1997). Transmission to non-swine species is through handling or contact with infected body fluids and/or exposed placenta (Ewalt et al. 1997). Domestic cattle can and do contract *B. suis* but are considered a dead end host (Ewalt et al. 1997). Vaccines exist for some strains of brucellosis but the swine strain is not included (Wyckoff et al. 2005). *Brucella abortus* is a concern in the beef industry. Herds infected will be quarantined and subject to additional testing. This possibility of a false positive test could prove costly. In the case of a false positive, cattle will be quarantined and exposed to additional testing resulting in lost income due to potentially missing optimum sale markets. Continuously changing prevalence of antibodies against PRV and *B. suis* is the cause for ongoing assessment. I evaluate the prevalence of antibodies for PRV and *B. suis*.

STUDY AREA

The study area (Fig 1.1) is Southeast Texas comprised of the following potential counties: San Jacinto, Walker, Brazos, Liberty, Milam, Montgomery. This study area includes the ecological regions of the Coastal Plains and Post Oak Savannah ecoregions with the majority of the proposed area represented by the Pineywoods ecoregion (Crook and Hung 2005). This area is heavily populated with feral hogs and sizable populations of native wildlife and domestic animals. Other wildlife populations present include: opossum *(Didelphis virginiana)*, coyote (*Canis latrans*), gray and red fox (*Urocyon cinereoargentenus*), gray (*Sciurus carolinensis*) and fox (*Sciurus niger*)squirrel, white-tailed deer (*Odocoileus virginianus*), mink (*Neovision vision*), otter (*Lontra canadensis*), beaver (*Castor canadensis*), nutria (*Myocastor coypus*), bobcat (*Lynx rufus*), stripped skunk (*Mephitus mephitis*), rodent spp. (Order Rodentia), and many avian species (Class Aves). Domestic animals include cattle, horses, sheep, goats, hogs, dogs, and cats (Taylor 2003). Temperature highs during summer months commonly exceed 35^{o} C with winter lows reaching the mid-negative 7^{o} C range. Average summer high temperatures are from 35–36^{o} C and winter low averages hovering in the low 4^{o} C range (Hebert and Jack 1998). The annual rainfall is 114.3 cm–121.9 cm with an average atmospheric relative humidity of 55%. Soil type varies from deep sand to tight clay profiles. The proposed area is comprised of floral species of pine, hardwood, and wood brush. Numerous spp. of vines, weeds, and grasses are present.

METHODS

Feral hogs were captured using corral traps and euthanized according to an approved Animal Use Protocol (AUP) (AUP 2008-160). Feral hogs were euthanized by brain shot while in the trap using a .22 caliber rifle with full cap ammunition. Hogs were then placed in one of 3 maturity classes (e.g., piglet, juvenile, and adult) according to body weight and visual evaluation. Approximately 20% of each age class captured in each trap was randomly selected and tissues collected (e.g., blood, tonsil, liver). Blood samples were centrifuged and serum collected, and frozen to -20^{o}C. Samples were sent delivered to the Texas Animal Health Commission (TAHC) laboratory in Austin, Texas. Diseases to be assessed were pseudorabies and brucellosis. The brucellosis testing consisted of running all sera samples on the card test (e.g., Rose Bengal Test or Buffered Brucella Antigen [BBA]) and the Parcel Concentration Flourescence Immunoassy (PCFIA) in parallel. The non-negatives on either the card and/or PCFIA were then tested using the following 3 Brucella test protocols in order to confirm or refute: Rivanol Plate Antigen, Complement Fixation, and Fluorescence Polarization (FP). Pseudorabies testing consisted of running all sera samples on the Autolex anti-PRV screen; samples that were retest (R) and positive (+) were then confirmed on the PRV Manual Latex using the heat inactivated (HI) protocol. If the Autolex R's and +'s are HI negative, then the sample is considered negative for PRV. If the Autolex R's and +'s are HI positive, then the sample is considered positive for PRV. All euthanized feral hogs were disposed of according to AUP 2008-160.

RESULTS

A total of 412 feral hogs was captured within the study area of which 86 (21%) were sampled for analysis of disease prevalence. A total of 18 (20.9%) samples tested positive for the prevalence of antibodies for pseudorabies virus (PRV) and 12 (14 %) samples tested positive for the prevalence of antibodies for brucellosis, respectively.

Age classification of the positive test indicated 16 (88.9%) were adults and 2 (11.1%) were piglets with no juveniles testing positive for antibodies of PRV.
As a result of testing, 12 (14%) individuals tested positive for Brucella antibodies (Table 5.1). Age classification of the positive test indicated 8 (66.7%) were adult and 4 (33.3%) were juveniles with no piglets testing positive for antibodies of Brucella.

Randomized Block Design (RBD) analyses indicated there were no existing correlations between disease antibody prevalence and dynamics of captured individuals with regard to feral hog density. The RBD ANOVA, blocked for location and again for density, estimated of the location based on total number of individuals captured for that location with no significant ($df = 12$, $P < 0.05$) findings for either.

Table 5.1. Comparison of disease prevalence findings (pseudorabies and *Brucella suis)* in feral hogs with the findings of research conducted in East Texas, 2010.

Disease tested	Total confirmed	Adult	Juvenile	Piglet
Pseudorabies				
*East Texas (Sumrall)	20.9%	88.9%	0%	11.1%
*East Texas (Wyckoff)	18%			
*South Texas (Campbell)	35%			
*34 Texas Counties (Partin)	17.3%			
*Florida (van der Leek)	35%			
*Georgia (Pirtle)	29%			
*South Carolina (Gresham)	61%			
*Tennessee (New)	0%)			
Brucella suis				
*East Texas (Sumrall)	14%	66.7%	33.3%	0%
*East Texas (Wyckoff)	24%			
*South Tesas (Wyckoff)	5%			
*34 Texas Counties (Partin)	0%			
*Florida (Becker)	53%			
*South Carolina (Gresham)	18%			
*California (Clark)	4%			
*Tennessee (New)	0%			

Sumrall = Sumrall et al. (2011)
Wyckoff = Wyckoff et al. (2009)
Campbell = Campbell et al. (2008)
Partin = Partin (1995)
van der Leek = van der Leek et al. (1993)
Pirtle = Pirtle et al. (1989)
Gresham = Gresham et al. (2002)
New = New et al. (1994)
Becker = Becker et al. (1978)
Clark = Clark et al. (1983)

DISCUSSION

Feral hogs are known to be a disease reservoir to a multitude of diseases throughout their range. Such diseases are of viral or bacterial in origin and will vary in prevalence depending on geographic location. Antibody prevalence for PRV in Texas has been identified 36% (south Texas, Campbell et al. 2008). Prevalence in other states vary from 0% to 4% (California) 29% in (Georgia, Pirtle et al. 1989)**,** 35% (Florida, van der Leek et al. 1993), and 61% (South Carolina, Gresham et al. 2002). I compared PRV prevalence within the study area (Table 5.1) to other prevalence studies within the same region of the state. Wyckoff et al. (2009) identified PRV prevalence in East Texas as 18% comparable to the findings of my study at 21%.

Pseudorabies is important to land and resource managers and is known to be present within the study area. Pseudorabies is a constant concern due to the fatal possibilities in many domestic and native wildlife species. This disease is included in the considerations of using hunting dogs as a management option. Hunting dogs exposed to PRV could have a fatal outcome. Infection of domestic and native wildlife can occur by contact with body fluids, aerosols, and/or sexually. Infection could prove catastrophic to the domestic swine market in the event of re-emergence of PRV. To date, humans have not been known to contract the disease. Final analysis indicated a prevalence of 20.9% for pseudarabies. This is a similar finding to that observed by Wyckoff et al. (2009) in East Texas. Partin (1995) found prevalence of PRV antibodies in 17.3% of feral hogs in 34 Texas counties. My study and Partin (1995) sampled feral hogs in multiple counties to include Brazos and San Jacinto. The Partin (1995) assessment found no PRV prevalence in Brazos or San Jacinto County, whereas my assessment found PRV prevalence in each of the counties. Analysis of 86 submitted samples indicated prevalence of 13.9% within the study area similar to findings of Wyckoff et al. (2009) in East Texas. This potential is a concern that future mutations could become much more critical in domestic livestock management.

Brucella suis is known to have been endemic to East Texas for several decades due to a prevalence of 10.5% detected by Lawhorn (1984) though this was not the findings of Partin (1995) which identified no prevalence of *B. suis* in a Texas assessment. *Brucella suis* prevalence in my study area was assessed at 14% of the 86 individuals sampled. Both Partin (1995) and I sampled Brazos and San Jacinto counties. Partin (1995) found no prevalence of *B. suis* in either of the 2 counties, whereas, I detected prevalence in each. Disease prevalence assessments in East Texas conducted by Wyckoff et al. (2009) resulted in positive tests of 24% of the sampled individuals. Prevalence of *B. suis* will vary throughout the nation from 0%–53%. Prevalence for *B. suis* ranged from 0% in Tennessee (New et al. 1994) to 53% in Florida (Becker et al. 1978) (Table 5.1). There were no significant findings correlating disease and population density for feral hogs within the study area. More evaluation is needed to determine if this consistent in other locations. I concur with Campbell et al. (2008) that modes of disease spread include natural and/or artificial dispersal but, more study is needed to correlate feral hog disease prevalence and population density. Positive test for *Brucella* will result in quarantine of domestic livestock in order to isolate the strain of the disease. Livestock can contract *B. suis* by direct exposure to contaminated/infected feral hogs or body fluids. This presents a concern to sport hunters undertaking the task of processing harvested feral hogs. People can and do become infected with by the bacteria through open wounds or mucosal membranes such as the eyes or in the mouth. Once infected, humans must undergo antibiotic treatment.

A need to understand the prevalence of diseases of concern (e.g., pseudorabies, brucellosis, etc.) can serve to implement population control measures and ultimately reduce losses of wildlife and livestock species, and lessen the risk to humans. Much of the observed concern is due to potential impact to food supplies, domestic livestock and companion animals, human contraction, and residues in/on the environment (Kocan 1990, Tessaro 1990, Davidson and Nettles 1997, and Romero et al. 2003). The potential of disease possibilities are exacerbated by the adaptability and movement of feral hogs and introductions into new ranges by the aid of humans. Feral hogs have known to seroconvert due to latent infection or a new exposure to the pathogen (Hahn et al. 1999). Feral hogs may be exposed to a pathogen during a point in their life with the disease becoming latent resulting in a false prevalence assessment. The possibility of inaccurate testing is a concern in the domestic livestock industries because of the potential quarantine restrictions.

MANAGEMENT IMPLICATIONS

Land and resource managers and sport hunters should be aware of disease possibilities in their area and take preventative measures as needed. In the case of PRV, prevention can be achieved by administering the proper vaccinations prior to exposure of domestic and native species to the virus. Pseudorabies vaccines only exist for domestic hogs. Preventing exposure to the disease is the key to safety for native wildlife and other domestic livestock. Vaccinate necessary species against *B. suis* prior to exposure. Reduce contact of domestic livestock with feral hogs by constructing proper fences or implement double fencing around feeding, birthing, and/or housing facilities. Preventing infection by *B. suis* can be achieved in humans by the use of personal protection equipment such as latex gloves and eye protection. Reducing overall feral hog local populations will reduce the possibility of encountering an infected feral hog. Infected feral hogs do not present a concern during consumption of meat because the infection is in the blood rather than the meat. Proper preparation and cooking will remove all infection possibilities to humans.

CHAPTER VI

CONCLUSIONS AND IMPLICATIONS

The purpose of this chapter is to provide a summary of the dissertation. This chapter begins by summarizing research highlights from previous chapters in the dissertation. Management implications from research findings are presented, reviewed, and critiqued in order to improve feral hog abatement strategies.

RESEARCH HIGHLIGHTS

Efficacy of Drift Fences in Feral Hog Abatement Efforts

Evaluations of trap treatments did not indicate significant differences between treatment designs (Chapter II, Fig. 2.4). Though differences between treatment means are small and comparisons are limited by sample size, the corral design with 2 electrical legs was consistently inferior (Table 2.1) to the other designs in all tests. Analyses of the 3 designs blocked for dependent variables (Success, Individuals, Males, and Females) individually in order to determine impact of overall trap performance. No dependent variable posed a significant influence (Chapter II, Fig. 2.5) when evaluating design. Though there were no significant differences between treatments with regard to trap success by night, additional analyses indicated significance in trapping success when assessing successful nights within the trap week (Chapter II, Fig. 2.6). According to both parametric and non-parametric analysis, successful trapping efforts occurred much more frequently during the first 4 nights of the effort (Chapter II).

Feral Hog Specific Bait Assessment in East Texas

There were 40 replicates of each bait treatment totaling 560 bait evaluations within the study area. Analyses of species usage indicated there was a significant relationship between bait categories and bait use for feral hogs (Chapter III, Fig. 3.2). Feral hogs selected for PIGOUT™ strawberry, corn and rice more frequently than all other baits. Feral hogs selected for grain baits than PIGOUT™ baits more frequently when repellant were absent. There was no significant relationship between bait type and bait use for deer regardless of the presence or absence of repellant (Chapter III, Fig. 3.3). Raccoon selection of baits offered was somewhat different. There was a significant relationship between bait type and bait use for raccoons, however, there was no significant relationship between bait type and bait use regardless of the presence or absence of repellant (Chapter III, Fig. 3.5). However when evaluating the selected baits for significance regarding repellant presence, a significant relationship did exist. "Other" species did indicate a significant relationship selecting for PIGOUT™ fish more frequently. Furthermore, significant relationship between bait type and bait use for "Other" both with and without repellant (Chapter III, Table 3.1).

Serologic Assessment of Selected Feral Hog Diseases

There were 412 feral hogs captured during the trapping evaluations. These individuals served as candidates for serological assessment. There were 86 (21%) of the 412 individuals euthanized and necessary tissue (blood) was taken for determining disease prevalence. A disease was not deemed existing unless conformation from a minimum of 2 tests resulted in a positive prevalence for that disease. There were 86 individuals sampled and submitted for testing to the Texas Animal Health Commission (TAHC) laboratory in Austin, Texas to determine prevalence of pseudorabies (PRV) and *Brucella suis.* Analyses indicated a level of prevalence for pseudorabies within the study area to be 18 (20.9%) of 86. Analysis indicated a level of prevalence for *B. suis* within the study area to be 12 (13.9%) of 86. There were no significant relationships in geographic location and disease prevalence.

MANAGEMENT IMPLICATIONS

Efficacy of Drift Fences in Feral Hog Abatement Efforts

Though there were no significant differences between trap treatments, land and resource managers can employ variation in trapping approach and experience elevated success. My analysis of trap treatments was completely random in trap selection for a given location. The ability to match the correct treatment with the trap location was removed by this randomization in study design. Land and resource managers whom match the correct trap design with the given trap location can be more successful in trapping efficiency for feral hogs. Electrical drift fences should not be used in trap locations. Additional study is necessary to evaluate additional forms of fencing to re-direct feral hogs to trap locations. This may require more training and understanding of feral hog trapping to better match trap designs to the trapping location. Additionally, trapping efforts could remove larger numbers of feral hogs if such efforts focus on stress points of the year for feral hogs. Such stress periods could be prior to or after birthing for sows and re-conditioning after breeding periods for boars, drought, extreme cold, and/or immediately following deer season. Finally, land and resource managers should not employ continuous extended trapping efforts, rather, short, intense efforts of no longer than 4 day increments. Subsequent trapping efforts in the same area should be delayed for up to a month before additional efforts.

Wildlife cameras should be in the "tool bag" for feral hog management. Such cameras can serve many roles. The duration of the pre-bait period can be determined by the use of cameras requiring fewer man-hours in the trapping effort. Cameras will indicate the size of sounders in the area allowing resource managers to determine the necessary size of the trap. Dynamics of the sounder also can be determined. Many times younger feral hogs will rush into the trap pre-maturely activating the trigger. Sounder dynamics can indicate the necessary height of the trip string to avoid pre-mature triggering by young feral hogs increasing likelihood of more individuals captured. Cameras will also indicate the non-target species and their frequencies to trap locations. Knowing this will allow resource managers to select the appropriate trigger to decrease potential of non-target species interference.

Feral Hog-Specific Bait Assessment

Baiting has been identified as a needed tool in feral hog management efforts by land and resource managers. The variation of feral hog diet makes finding bait for feral hogs relatively easy. The reasoning behind the need for feral hog-specific bait(s) is to reduce the interference by non-target species in trapping and other (toxicants and/or pharmaceutical delivery) management efforts. As a result of my study, land and resource managers may need to alter baits to avoid non-target species issues. Feral hogs selected for primarily 3 baits (strawberry, corn, and rice) with varying interference by other mammalian species. To further remove non-target species complications, managers can employ the use of commercially available repellants.

Serologic Assessment of Selected Feral Hog Diseases

Education is the key when understanding the possibilities of disease. Land and resource managers and sport hunters should be aware of disease possibilities in their area and take preventative measures as needed. In the case of PRV, prevention can be achieved by administering the proper vaccinations prior to exposure of animals to the virus. Preventing infection by *B. suis* can be achieved by the use of personal protection equipment such as latex gloves and eye protection. Reducing overall feral hog local populations will reduce the possibility of encountering an infected feral hog. Infected feral hogs do not present a concern during consumption of meat because the infection is in the blood rather than the meat. Proper preparation and cooking will remove all infection possibilities to humans.

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VITA

SAMUEL AARON SUMRALL
sasumrall@ag.tamu.edu

ADDRESS

C/O Dr. Nova Silvy
Department of Wildlife and Fisheries Science
Texas A&M University
College Station, TX, 77843-2258

EDUCATION

Doctor of Philosophy, Wildlife and Fisheries Sciences, Texas A&M University, 2011

Master of Science, Agriculture, Sam Houston State University, 2001

Bachelor of Science, Animal Science, Sam Houston State University, 1997

EMPLOYMENT

County Extension Agent, Texas AgriLife Extension Service, San Jacinto County, 2002–present.

Teacher/Coach, Trinity High School, Trinity, Texas, 2001–2002.

Welder/Electrician, Take-3-Trailers, Brenham, Texas, 1997–2001.