Efficiency of Surveying, Baiting, and Trapping Wild Pigs at Fort Benning, Georgia

by

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Abstract

This study, conducted at Fort Benning, Georgia, sought to develop more efficient ways of surveying for and trapping wild pigs (*Sus scrofa*), an abundant, destructive invasive species found on Fort Benning. Game cameras set at a 9-minute time-lapse interval yielded detection results no different than cameras set at a previously-validated 3-minute interval. Pigs did not arrive more quickly nor remain longer at sites baited with soured corn than those baited with whole corn. Wild pigs of all demographics entered corral traps at a greater rate than box traps. Corral traps captured more pigs per trap night and more pigs per dollar than box traps. Surveys for wild pigs using game cameras set at roughly 10-minute time-lapse intervals over sites baited with whole corn are more efficient than a number of other options. When feasible, the use of corral traps is more efficient than the use of box traps for trapping wild pigs.

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I. EFFICIENCY OF TIME-LAPSE INTERVALS AND SIMPLE BAITS FOR CAMERA SURVEYS OF WILD PIGS

ABSTRACT

A number of techniques for conducting population surveys rely on the ability to identify individual animals observed in images captured by motion-triggered or time-lapse game cameras. In species for which this is a feasible concept, and especially for abundant, relatively easy to observe species, the ability to capture a sufficient number of images containing the desired animals while minimizing efforts necessary to complete a survey is invaluable. We conducted surveys of a portion of the wild pig (*Sus scrofa*) population on Fort Benning, Georgia, utilizing game cameras set at varying time-lapse intervals to determine if a longer time-lapse interval than had been previously used in surveys of wild pigs would still generate acceptable detection results for use in subsequent population estimations. We concurrently examined whether the use of soured corn at camera sites decreased the time necessary for pigs to locate a new camera site and/or increased the time pigs lingered at a site. Our results suggest that a 9-minute time-lapse interval generates dependable detection results for pigs and also that soured corn neither attracts pigs to a site any quicker than plain, dry, whole-kernel corn nor holds them at a site longer.

INTRODUCTION

Population assessment may be one of the most fundamental elements in any wildlife management plan. Valid estimates of population sizes provide managers important data on the up-to-date status of a population while also providing a crucial means to monitor and evaluate the success of any future management practice (Engeman et al. 2001). Recently, the ability to accurately and efficiently monitor invading and expanding populations of wild pigs (*Sus scrofa*) has become a priority among managers in a number of countries around the globe. In many of these places, the wild pig has become the most biologically and economically important invasive animal species; however, disturbingly, few managers have been able to successfully reverse or even restrict the ongoing expansion of the wild pig population (Wood and Barrett 1979, Engeman et al. 2003, Ditchkoff and West 2007).

Among the many difficulties associated with controlling wild pigs has been an inadequate ability to survey a population before a management or control practice is implemented and then again during or after this activity. This shortcoming has often resulted in an inadequate or non-existent objective evaluation of the effectiveness of the action implemented (Engeman et al. 2001). However, in the past 25 years or so, the use of motion-activated or time-lapse game cameras has afforded the professional wildlife manager and the lay outdoorsman a valuable tool in the quest to discover many details in the lives and habits of a wide variety of animal species, including wild pigs, which would otherwise have only been available via direct observation (Seydack 1984, Jacobson et al. 1997, Larrucea et al. 2007). Indeed, while game cameras have been used with some success to quantify and describe the makeup of isolated wild pig populations, the process of collecting these data has still been somewhat time-consuming, often requires large amounts of digital storage space, and can be expensive (Sweitzer et al. 2000, Hanson et al. 2008, Holtfreter et al. 2008). Among the variables to be considered when surveying a population of wild pigs using game cameras are the method used to collect images (time-lapse vs. motion- or infra-red-activated) and the attractant, if any, used to draw pigs to a photo station. When photographing a species prone to remain at a food source for extended periods of time, motion- or infra-red-activated programs can result in a very large number of pictures; therefore, it seems logical to increase the time interval between successive photographs to the longest interval possible while still obtaining sufficient photographic evidence of pigs from which to generate an accurate assessment of the given population. While studies conducted using a 3-minute time-lapse interval have produced what are thought to be accurate assessments of wild pig populations, the data generated from these studies required large amounts of digital storage space along with dozens of hours of human processing time in order to arrive at these assessments (Holtfreter et al. 2008). The ability to increase this interval while collecting the data necessary for an accurate assessment would be welcomed.

In addition to the ability to maximize the time-lapse interval necessary to generate an accurate representation of the size or composition of a population of wild pigs, the ability to attract and hold pigs at a camera station during a survey should further improve effectiveness of time-lapse surveys set at longer intervals. Logically, the effectiveness of any survey utilizing time-lapse photographic equipment/techniques is affected by the length of time an animal remains within a camera's field of view, and if a camera's photo interval is increased, the ability to positively influence the length of time an animal visits a camera station further assures usable data (i.e., pictures of animals) will be gathered during a given survey. Furthermore, a survey dependent upon identification of unique individuals (Sweitzer et al. 2000, Holtfreter et al. 2008), would be aided by more than one image of any particular individual. Therefore, the ability to quickly attract animals to a camera site while also providing incentive for those animals to remain in view of a camera for longer than a brief, initial investigation should further increase the effectiveness of such survey methods. While an array of attractants and baits have been used in efforts to draw pigs into camera or trap sites (Campbell and Long 2008), one of the most simple and common has been soured corn (Hanson et al. 2008), the malodorous result of the fermentation of corn. However, to our knowledge, its effectiveness as an attractant, especially in comparison with dry corn, has not been objectively evaluated.

We attempted to evaluate the effectiveness of extending time-lapse intervals associated with game camera surveys for wild pigs by testing the hypothesis that individuals would stay at a bait site long enough to ensure that photographs were available for population estimation even at intervals longer than 3 minutes. We predicted that extending a previously-validated 3-minute interval out to as much as 9 minutes would still yield data sufficient to generate accurate population estimates based on individual pig identification. Additionally, we attempted to evaluate, by comparison, the effectiveness of dry and soured corn as wild pig attractants and retainers. We hypothesized that, due to its distinct odor, soured corn would serve as a more effective attractant than dry corn but that, potentially due to greater palatability, dry corn would serve as a more effective food source (i.e., pigs would feed longer at dry corn sites). We predicted that pigs would arrive at sites baited either wholly or with a mixture of soured and dry corn more quickly than at sites baited solely with dry corn. We also predicted that wild pigs would remain at sites baited either wholly or partially with dry corn longer than at sites baited solely with soured corn.

MATERIALS AND METHODS

Study Area

This study was conducted on the ~737 km^2 Fort Benning military installation located in west-central Georgia and extreme east-central Alabama [32° 21′ N, 84° 58′ W]. The sandy, rolling hills divided by hardwood bottomlands found on Fort Benning were characteristic of the Fall Line region between the Piedmont and Coastal Plain physiographic regions in which Fort Benning is situated (Dilustro et al. 2002, Hanson et al. 2009). The drier, sandier hills found on Fort Benning were largely populated with managed stands of longleaf pine (*Pinus palustris*), a specific and regionally rare habitat type critical for the survival of the endangered red-cockaded woodpecker (*Picoides borealis*; King et al. 1998, Dilustro et al. 2002). Other pine species including loblolly (*P. taeda*) and shortleaf (*P. echinata*) along with other tree species such as blackjack oak (*Quercus marilandica*), bluejack oak (*Q. incana*), and common persimmon (*Diospyros virginiana*) were all encountered frequently throughout the upland portions of Fort Benning not specifically managed for longleaf (King et al. 1998, Holtfreter et al. 2008). While various other oak and hickory (*Carya* spp.) species dominated the more mature portions of bottomlands, many other tree species including yellow poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), flowering dogwood (*Cornus florida*), and American beech (*Fagus grandifolia*) were also common; other plant species including muscadine (*Vitis rotundifolia*), blackberry (*Rubus* spp.), gallberry (*Ilex* spp.), American beautyberry (*Callicarpa americana*), and wax myrtle (*Myrica cerifera*) were also abundant (King et al. 1998, Holtfreter et al. 2008). This project was conducted within one ~100 km^2 contiguous tract of land delineated for wild hog research by the Natural Resources Branch at Fort Benning. This study area, which was physiographically characteristic of the installation as a whole, was theoretically kept free of hunters and external bait sources for the duration of this study. Recent preliminary surveys suggested a pig density of approximately 1.15 pigs/km^2 on Fort Benning (Holtfreter, unpublished data), which was similar to previous estimates (Hanson et al. 2008).

Field Methods

Field methods for comparing the efficacy of time-lapse intervals largely followed Holtfreter et al. (2008). We selected a total of 12 camera sites at random from a larger pool of sites within the study area where pig sign (tree rubs, wallows, scat, etc.) had been observed. We then randomly assigned each site to 1 of 3 groups (4 sites per group). We then placed 3 of an available 12 RECONYX Silent Image ™ game cameras (Model PM35M13, Reconyx LLP, Holmen, WI) at each site of 1 of the 3 groups. After an initial 7-day pre-baiting period, we deployed cameras side-by-side at a distance of approximately 2.74 meters and a height of 1.07 meters facing, at a downward angle of approximately 15°, a cleared, 3.66 X 1.83 m field in which approximately 11.34 kilograms of dry, whole-kernel corn was evenly-distributed at the beginning of each survey. Cameras were mounted in this configuration in an attempt to maximize the vantage point and picture quality for this particular model of camera. One camera at each site was programmed for a 3-, 6-, or 9-minute time-lapse interval, respectively. We left the cameras at each site for a period of 3 nights as per the recommendation of Holtfreter et al. (2008) and then moved them to the next group of sites. Additionally, the position (left, center, or right) of the cameras with each particular time interval was changed upon each subsequent survey at each site to avoid any bias; otherwise, camera deployments were the same throughout the study. The process continued for approximately 5 weeks, from 26 May through 1 July 2008, until each site had been surveyed 4 times, yielding a total of 48, 3-day site surveys.

For the bait comparison, we randomly selected 36 additional sites which had not been baited within at least 30 days prior to camera deployment. This was intended to alleviate any potential bias associated with pigs revisiting known bait sites. Sites were not rejected based upon any hypothetical potential for external influence (e.g., proximity to roads, ranges, training facilities, etc.) on the initial site arrival times by wild pigs; randomization of site selection and sample size were assumed to mask any potential effects such external influences may have had. Each site was randomly assigned to 1 of 3 bait types: dry corn only, soured corn only, or an equal-but-separate mixture of dry and soured corn. Each site received approximately 11.34 kilograms of bait. Bait layout and camera positioning approximately followed that described previously; however, at mixed bait sites soured corn was placed in the half of the bait area nearer the camera and whole corn in the farther. Cameras were left in place for 1 week on a 3-minute time-lapse interval. Bait was refreshed, as needed, once during the middle of the survey week. Surveys were conducted between 29 July and 2 October 2008.

Analysis Methods

We examined each photograph collected during the time-lapse interval comparison for the presence of wild pigs. We recorded the first appearance of each individual pig (identifiable by size, sex, colors/patterns, and, in some cases, ear tags present from previous research efforts) during each 3-day site survey. Each of these instances was considered a "capture"; any individual could only be captured once during a 3-day site survey. Previous research by Holtfreter et al. (2008) established that the detection probabilities for pigs after 3 nights using a 3-minute interval were sufficiently high (>0.5) for use in population estimation. Therefore, we estimated the relative efficacy of time-lapse intervals by calculating the ratio of the number of individuals captured by cameras set at 6- and 9-minute intervals to the number captured by 3-minute time-lapse intervals. We recorded the number of times an individual pig was captured by a 3-minute time interval and "missed" by the 6- or 9-minute time interval. We noted any instance in which a capture was observed on a later night by the 6- or 9-minute cameras, since these occurrences represent instances in which a pig, although missed on its initial visit to a site, was captured later using 6- or 9-minute time intervals. We also noted any instance in which a pig was never captured by the 6- or 9- minute camera at any site over the course of the 4 surveys at each site. These occurrences represent instances in which a pig would have been completely missed during a survey, thus further reducing individual detection probability.

For the bait comparison, we examined each image to determine the date (in relation to deployment date) and time of the first visit, and the length of time each pig stayed at a site. We compared 95% confidence limits around the mean length of feeding bouts among bait types. We defined feeding bouts as the time, in minutes, a pig spent feeding at a site; bouts were considered separate if they occurred more than 30 minutes after a pig was last observed. Additionally, we compared the mean and 95% confidence limits for time from deployment to the first visit among bait types.

RESULTS

A total of 121,859 images were collected during 47 surveys (12 sites * 4 surveys at each site; one camera was not powered on for one survey). A total of 266 individual pigs were observed by the cameras set at 3-minute intervals. Of these “initial” visits (as observed by the cameras set at 3-minute intervals), 262 (98%) were observed by the cameras set on 6-minute intervals, and 245 (92%) were observed by the cameras set on 9-minute intervals. While these “misses” occurred on the initial visit to each site by a pig, only 1 individual (0.4%; *i.e.*, 99.6% similarity) using the 6-minute interval and 8 individuals (3.0%; *i.e.*, 97% similarity) using the 9-minute interval were missed on subsequent visits. However, since sites were sampled multiple times over the course of this study, it is also worth noting that, of the 134 individual pigs observed across 12 sites during 4 sampling periods, only 4 (3.0%; 97% of known pigs observed) were missed during all 47 surveys using the 9-minute interval. This never occurred when using 6-minute intervals (100% of known pigs were observed).

Of 36 sites baited with each of the described varieties of corn, 20 were visited by pigs. No difference was observed in the time to first detection among dry corn ($\bar{x}$ = 74.6 h; SE = 17.0), soured corn ($\bar{x}$ = 82.2 h; SE = 25.6), and mixed ($\bar{x}$ = 65.8 h; SE = 16.7) bait types (Table 1.1). No difference was observed between the average feeding bout length at sites baited with soured corn ($\bar{x}$ = 23.3 min; SE = 2.24) or a mixture of soured and dry corn ($\bar{x}$ = 23.6 min; SE = 2.09); however, pigs feeding at sites baited with whole corn ($\bar{x}$ = 33.5 min; SE = 2.06) tended to remain longer than pigs at sites baited with either of the other two bait types.

DISCUSSION

Population survey techniques relying on individual identifications are not plausible for all species. If many individuals in an abundant population are similar in appearance, distinguishing among individuals may become impractical, thereby rendering any estimates based on individual identifications suspect, if not worthless. However, we had a high degree of confidence in our ability to uniquely identify individuals in the Fort Benning population of wild pigs, because they exhibit a variety of colors, color patterns, and other pelage characteristics, and some individuals were marked with ear tags. Ancillary information including group composition and location within the study area also increased our confidence when identifying pigs. Since wild pigs at Fort Benning could be individually identified with relative confidence and ease, and considering the abundance of pigs on Fort Benning and their frequent habit of visiting bait sites for extended periods (~30 minutes per feeding bout), cameras set at a 3-minute interval captured many more pictures than were needed to confidently identify all individuals visiting each site. Indeed, cameras set at a 9-minute interval usually provided a sufficient number of pictures ($\bar{x}$ = 6.7 images/pig) at each site ensuring that all the individual pigs visiting that site could be identified.

There are numerous benefits garnered by reducing the amount of data collected by two-thirds while reducing the number of individuals captured by only 3%. Specifically, the required digital storage space (potentially a considerably expensive necessity) is reduced; camera battery life is increased; and image interpretation time is decreased significantly. Additionally, the likely reduction in the number of site visits necessary for camera maintenance associated with longer time-lapse intervals may also help reduce any effects the presence of human disturbance or scent at a camera site may have on the arrival or persistence of any species of interest (Whelan et al. 1994, Larrucea et al. 2007).

Camera-based surveys rely on an animal appearing within a certain area during a finite time period; therefore, the ability to entice those individuals living within a certain distance of any particular camera to appear as quickly and then linger at the camera site for as long as possible serves to increase the efficiency with which such camera-based surveys are conducted. Previous pig trapping efforts at Fort Benning utilized soured corn under the assumption that, via its strong odor, it attracted pigs to a site while potentially discouraging bait consumption by non-target species. However, our results suggest that, not only does soured corn appear to have no additional attractive quality over dry, whole-kernel corn, but pigs did not remain at the sites baited with soured corn as long in comparison to sites baited with dry corn. While any number of factors may contribute to a site's initial discovery by pigs, it seems probable that a site's initial placement in proximity to pigs may be the single most important factor when a quick site discovery time is desired. We posit that an initial effort to roughly locate the current location of a group of pigs will increase the effectiveness of future control efforts when compared to random or haphazard establishment of bait or trap sites hoping to attract pigs to that site from any distance. Furthermore, our data suggest that keeping a site baited with dry, whole-kernel corn is likely a more effective way to keep pigs at a site in the short term, considering individual feeding bouts, and in the long term, considering a period of days, than attempting to mix in or use only soured corn at a site. While pigs will certainly consume soured corn, our data suggest a preference for dry corn.

When time-lapse interval and bait type are considered in concert, and when survey efficiency of wild pigs is the goal, our results suggest the efficiency of using time-lapse cameras set at 9-minute intervals over sites baited with dry, whole-kernel corn. While other intervals might be found to be more efficient for populations with different demographics, this approach met our needs well, especially in comparison to the much shorter 3-minute interval. Additionally, while a number of proven pig attractants exist and are commercially available, we contend that the temporal and monetary resources saved in using such a simple, readily-available bait as whole-kernel corn likely offsets any decreases in initial site discovery times that might be generated by another attractant. Corn was, for our project, the cheapest bulk bait option available; our data suggest that when this is the case, dry corn likely remains the most effective, efficient bait when wishing to attract pigs and provide them an incentive to linger at a site for extended periods. Even further, when surveys are to be conducted across large tracts of land, the cheap, quick, simple process of using plain whole-kernel corn to bait sites is likely more time- and cost-effective than potentially more complicated baiting methods. When conducting large-scale surveys utilizing a number of sites across a large area, the simplest option is often the best option.

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Table 1.1. Comparison of initial wild pig arrival times to, and feeding bout lengths at, sites baited with soured corn only, a mixture of soured and whole corn, and whole corn only at Fort Benning, Georgia, 29 July through 2 October 2008.

	Initial arrival time (hours)					Feeding bout length (minutes)				
				95% CI					95% CI	
Parameter	*n*	$\bar{x}$	SE	Lower	Upper	*n*	$\bar{x}$	SE	Lower	Upper
Soured corn	5	82.2	25.6	11.0	153.4	77	23.3	2.24	18.9	27.8
Mixed	7	65.8	16.7	24.9	106.7	130	23.6	2.09	19.5	27.7
Whole corn	8	74.6	17.0	34.5	114.7	168	33.5	2.06	29.4	37.5

II. TRAP STYLE INFLUENCES WILD PIG BEHAVIOR AND TRAPPING SUCCESS

ABSTRACT

Despite the best efforts of natural resource professionals, wild pig (*Sus scrofa*) populations are expanding in many areas of the world. While many creative techniques for controlling pig populations are being explored, trapping has been and still is the most commonly used method of population control for many public and private land managers. We conducted a survey to examine the efficiency of two frequently-used trap styles: a small, portable box-style trap and a larger, semi-permanent, corral-style trap. Game cameras were used to examine patterns of trap entry of wild pigs around each style of trap, and a trapping session was conducted to compare trapping success between trap styles. Adult female and juvenile wild pigs entered both styles of trap more readily than adult males, and adult males seemed particularly averse to entering box traps. Less than 10% of adult male visits to box traps resulted in entries, easily the least percentage of any class at any style of trap. Adult females entered corral traps approximately 120% more often per visit than box traps and re-entered corral traps over 100% more frequently. Juveniles entered and re-entered both box and corral traps at similar rates. Overall (all-class) entry-per-visit rates at corral traps (0.71) were nearly double that of box traps (0.37). Subsequent trapping data supported these preliminary entry data: the capture rate for corral traps was over four times that of box traps. Our data suggest that corral traps are temporally and economically superior to box traps with respect to efficiency; that is,

corral traps effectively trap more pigs per trap night at a lower cost per pig than do box traps.

INTRODUCTION

The steadily rising numbers of wild pigs (*Sus scrofa*) in many parts of the world have triggered a flood of formal research (see, for example, Choquenot et al. 1996, McCann and Garcelon 2008, Hanson et al. 2009) and informal experimentation aimed at curbing population growth or reducing numbers. The potential detrimental effects of wild pigs upon ecosystems not adapted to their presence are well documented, ranging from alteration of soil chemistry and inhibition of forest regeneration (Singer et al. 1984) to competition with, and even consumption of, native species (Taylor and Hellgren 1997, Loggins et al. 2002, Jolley et al. 2010). However, despite the increased attention and the myriad stratagems employed, neither researchers nor managers have developed effective long-term control strategies for free-ranging populations of wild pigs (Oliver and Brisbin 1993, Choquenot et al. 1996, Engeman et al. 2003). Although some toxicants have shown promise at reducing wild swine numbers in, for example, Australia (Cowled et al. 2006), difficulty developing a species-specific delivery system in the United States (Campbell et al. 2006) currently limits managers to other means of control, typically involving some form of trapping, perhaps in combination with active hunting or shooting. While we leave it to other authors to discuss in detail the variety of negative impacts wild pigs may have on areas which they invade, thereby justifying the need for population control, suffice it to say the need for an effective, efficient plan for controlling and managing, if not eradicating, wild pigs in those areas in which they are an invasive species remains obvious, if not imperative.

Trapping, in some form or another, is one of the most commonly used control measures for many invasive animal species, including wild pigs (Choquenot et al. 1993, Choquenot et al. 1996, Sweitzer et al. 1997). However, as wild pigs are a relatively large, rapidly-reproducing species (Wood and Barrett 1979, Ditchkoff and West 2007), the economic and temporal investment associated with trapping wild pigs can be extraordinary. Furthermore, many of these efforts do not approach the scale necessary to have a significant, long-term impact on wild pig populations across a relatively large tract of land. While current trapping/removal strategies may not be as effective at reducing long-term wild pig populations as managers might wish (Dzieciolowski et al. 1992, Engeman et al. 2001, Engeman et al. 2003), the purchase/construction and monitoring of traps still presents a more economically viable alternative than other proposed control techniques (Choquenot et al. 1993, Bomford and O'Brien 1995). While a combination of control techniques will likely provide the final solution, it seems likely that trapping will be included in future wild pig research and control efforts. Therefore, the need for increased effectiveness and efficiency of trapping is apparent.

Two general styles of trap have long been popular for capturing wild pigs: a relatively small and portable trap often called a box trap and a larger, semi-permanent trap often referred to as a corral trap (Wood et al. 1992). Box-style traps may be moved quickly to new areas, but their size significantly limits the number of individual pigs that can be captured at any one time. Corral-style traps, alternatively, while more time consuming to construct, may be more effective at targeting groups of pigs, which may actually decrease the amount of time and per-pig cost necessary to remove the majority of pigs from an area. This research attempted to objectively compare these two trap styles and determine which, if either, was more economically and temporally efficient. We predicted that corral traps would trap more pigs per trap night and per dollar than box traps.

In furtherance of increasing trap efficiency, it also seems logical to understand if trap style influences the number, age, and sex of individuals captured. Management efforts aimed at removing individuals will likely attempt to maximize the total number of individuals trapped, and, therefore, this research was centered on the concept of capturing as many individuals as possible in the shortest amount of time in part by examining how two different styles of traps affected behavior of wild pigs when presented with a trap. Years of observations on behavior of pigs around traps led us to suspect that wild pigs may avoid entering smaller, box-style traps for a period of days, if they enter at all. Elements including a roof often only slightly higher than the shoulders of an adult pig, a door often only slightly wider than the width of an adult pig, and a wire mesh floor may all contribute to a decrease in the potential effectiveness of trapping efforts using box-style traps. To investigate these concepts, we examined whether wild pigs enter larger, corral-style traps more frequently than smaller, box-style traps. Previous research and observation also suggested that juvenile and adult female wild pigs are quicker to enter a trap than adult males (Choquenot et al. 1993, Kaminski et al. 2005). Therefore, we also examined whether or not juvenile and/or adult female wild pigs enter traps more readily than adult male wild pigs.

METHODS AND MATERIALS

Study Area

The research for this project took place on the ~737 km^2 Fort Benning military installation, located along the Chattahoochee River just outside of Columbus, Georgia, and an adjoining few square kilometers across the river in Alabama [32° 21′ N, 84° 58′ W]. Terrain at Fort Benning consisted mainly of low, sandy hills, many of which were planted stands of longleaf pine (*Pinus palustris*), separated by stretches of hardwood bottomland. Blackjack oak (*Quercus marilandica*), bluejack oak (*Q. incana*), and common persimmon (*Diospyros virginiana*) were also common. Oak and hickory (*Carya* spp.) species, along with yellow poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), flowering dogwood (*Cornus florida*), and American beech (*Fagus grandifolia*) were prevalent throughout the bottomlands. Floral descriptions of Fort Benning have been taken largely from previous research (King et al. 1998, Dilustro et al. 2002, Holtfreter et al. 2008, Hanson et al. 2009, Jolley et al. 2010). This study took place in two separate study areas, one measuring ~100km^2 and the other ~35 km^2, designated for wild pig research by the Fort Benning Natural Resources Branch. Wild pigs were at an approximate density of 1.15 pigs/km^2 on Fort Benning near the time of this study (Holtfreter, unpublished data). This estimate was comparable to previous estimates of the population of wild pigs on Fort Benning (Hanson et al. 2008).

Field Methods

We evaluated behavior patterns of wild pigs related to entry of box- and corral-style traps by randomly selecting a total of 24 sites from a larger pool of previously-located sites exhibiting pig sign (wallows, scat, tree rubs, etc.). Upon selection, each of the 24 sites was randomly assigned to 1 of 2 groups. One group was designated for corral-style traps and the other for box-style traps. As traps, which were in use during this time for research in other areas of Fort Benning, became available, each was moved to a site within its group (one trap per site). A selection of sites within each group was pre-baited at least one week prior to trap placement so that traps could be moved to sites with known recent pig activity. Upon placement of a trap, a camera, at a height of 1.8 meters and downward angle of 15°, was placed at the front and rear of each trap, facing toward the trap (a detailed description of trap designs will be found below). For box traps, the rear camera was placed approximately 2.7 meters from the rear of the trap, and the front camera was placed diagonally approximately 7.3 meters from the door-side corner of the trap. For corral traps, the rear camera was placed approximately 0.9 meters from the rear panel of the trap, and the front camera was placed approximately 7.3 meters from the door. Considering the added distances involved due to the greater size of corral traps, an additional camera was placed at one corner of the door, facing into the trap, in an attempt to ensure photographing any pig inside the trap. All heights and distances of cameras were previously determined in an effort to maximize viewing area and clarity of picture of the cameras (RECONYX Silent Image ™ game cameras, Model PM35M13, Reconyx LLP, Holmen, WI) used in this study. Upon initial trap and camera placement, each site was evenly baited with approximately 11.34 pounds of dry whole-kernel corn. Cameras were left on site set at 3-minute time-lapse intervals for 7 days. Using the same interval for the same length of time, Holtfreter et al. (2008) found pig detections probabilities in excess of 0.8; we assumed, with at least two cameras at each site, that very few pigs visited a site while escaping observation on at least one camera. Observations were made between 21 July and 25 September 2008.

In an attempt to examine, by comparison, the efficiency of each style of trap, we deployed 24 traps, 12 of each style, and worked them, as our schedules allowed, from 29 February 2008 through 29 April 2008. Six box traps and 6 corral traps were assigned to each of the two study areas, and all 24 traps were randomly assigned to sites previously identified as containing pig sign. Once trap sites were chosen and traps placed (one trap per site), pre-baiting with dry whole-kernel corn commenced and continued for approximately 1 week until active trapping began. Trigger mechanisms were set on all traps during pre-baiting, but all doors were tied open so that pigs could become acclimated to the sensation of tripping the trigger without the door actually closing. All pigs captured during this trapping session were ear-tagged and released. Any recaptures were recorded and released.

Trap design – Corral-style traps consisted of an angle-iron- or wood-framed door section connected on both sides to an angle-iron-framed 1.5 * 2.4 m, heavy-gauge wire-mesh-filled panel, which were each in turn connected to a 1.5 * 4.9 m section of portable utility panel fencing. The two utility panels were brought together and secured to form the rear apex of the trap. The door frame sections measured approximately 0.9 * 1.8 m, with the vertically-hinged door occupying the bottom half of the frame. Sections of panel were wired together and supported with t-posts at any potential weak spots. Sections of fence left off the ground were either staked down or the empty space filled in with debris. Traps were set by leading a rope tied to the bottom of the lifted door over the top of the frame, over the top of the trap, down the outside to the bottom of the rear section of fence, and across a back corner to a trigger mechanism. Triggers consisted of a twig balanced in an opening of fence panel. The last ~1 m of rope (the section most likely to be encountered by pigs) was substituted with monofilament fishing line in an effort to decrease trigger detection. Box-style traps consisted of 2.4 * 1.2 * 0.9 m (length * width * height) angle-iron frames filled on all sides with hog fencing. The door mechanism occupied one half of one of the 1.2 * 0.9 m sections of the box. The door and trigger mechanism were similar to the corral-style trap, except that both were oriented horizontally instead of vertically.

Analysis Methods

All photographic data were examined, each pig was identified at each site, and any entries each pig made into a trap were noted. All individuals were classified by age (juvenile vs. adult) and, among adults, sex. Age distinctions were made based on individual body size and group characteristics (e.g., small pigs found in groups with larger adult females present were generally considered juvenile; solitary or "bachelor groups" of male pigs were generally considered adult; pigs visually estimated at weights below 50 pounds were always considered juvenile, regardless of group characteristics). The number of entries by each class of pig were compared using contingency tables to determine whether the ratios of entries-to-visits were the same between box and corral traps. Since a pig could potentially enter, exit, and re-enter a trap numerous times during a single visit, rates of entries per visit were also calculated for each class of pig. Additionally, since repeated re-entries by a single pig during a single visit could have potentially inflated overall entry numbers, we also calculated a rate of entries per individual for each class of pig.

To compare the temporal and economic trapping efficiency of box-style versus corral-style traps, all time spent transporting, constructing/setting, baiting, maintaining, and travelling to traps/trap sites was recorded; and all costs associated with the purchase, setup, baiting, and maintenance of all traps were documented. Since the trap styles were mixed within the study areas and were therefore visited in no particular order, the costs associated with the total time, mileage, and bait spent/used preparing to trap and trapping were halved; one of the resulting halves of these costs was used for the calculation of the per-pig cost for each style of trap. The total cost of trapping associated with each style of trap was calculated and divided by the total number of individual pigs trapped in each style of trap.

RESULTS

A total of 213,761 pictures were taken at 24 traps. Ten traps of each style were visited at least once. One corral trap malfunctioned during the observation period and was not included in any visit/entry totals. Six of the 10 visited box traps (6 of 12 total) were entered, while 8 of the 10 visited corral traps (8 of 12 total) were entered. While more visits occurred at box traps (141; 109 in corral traps), more entries occurred in corral traps (77; 52 in box traps), yielding an overall entry-per-visit ratio in corral traps (0.71) nearly double that of box traps (0.37). No differences in trap visit-to-entry ratios were observed between the traps styles among either adult females ($\chi^2 = 0.17$, $p = 0.68$; Table 2.1) or juveniles ($\chi^2 = 2.32$, $p = 0.13$); however, adult males entered box traps significantly less often than corral traps ($\chi^2 = 6.08$, $p = 0.01$). Although values were slightly greater for corral traps, overall, adult males entered both styles of trap less frequently per visit and were less apt to re-enter either style than were adult females or juveniles. Juveniles entered both styles of trap at similar per-visit rates, and were also similarly likely to re-enter either style of trap. Adult females, however, were 120% more likely to enter a corral trap than a box trap during a visit, and over 100% more likely to re-enter a corral trap than a box trap.

Twenty one nights of trapping produced 504 trap-nights, 252 for each style of trap. Seventy-one individual pigs were trapped, 59 in corral traps and 12 in box traps (Figure 2.1). These numbers resulted in capture rates of 0.23 new pigs per trap-night and 0.05 new pigs per trap-night for corral and box traps, respectively. Thirty-nine recaptures occurred in corral traps, while only 8 occurred in box traps. Once all approximate costs were accounted for (Table 2.2), pigs trapped in box traps cost, on a per-pig basis, approximately 5.5 times as much as pigs trapped in corral traps (Table 2.3).

DISCUSSION

Our data suggest that larger traps consistently out-perform smaller traps when trapping the greatest number of pigs in the shortest amount of time is the goal. Photographic data suggest adult pigs entered corral traps more readily than box traps and made repeat entries into corral traps more frequently than into box traps. Subsequent data collected from active traps (Holtfreter, unpublished data) further support this concept, as the capture rate for corral traps was over four times that of box traps. Although we feel these data, especially the photographic data, suggest that the absence of a floor in the corral traps (Diong 1980) in addition to a much larger opening for a doorway both play a role in the increased effectiveness of the corral traps, we cannot assert these concepts more definitely without further experimentation.

Photographic evidence of open traps and data collected from live traps suggest that large adult male wild pigs tend not to enter traps as readily as either juveniles or adult females. While previous studies have reported high rates of juvenile capture (>50% of animals captured; e.g., McCann and Garcelon 2008, Hanson et al. 2009), this finding may be due in large part to the proportion of juveniles within the population. Our findings suggest that adult male wild pigs at Fort Benning are captured much less than their abundance (Holtreter et al. 2008) would suggest if trapping results are based purely upon population sex and age ratios. These findings support those of, for example, Choquenot et al. (1993) in which the authors reported that a roughly equal sex ratio prior to trapping was skewed heavily in favor of males subsequent to trapping. However, whether this tendency arises solely from the larger average size of adult males in comparison to a trap or trap door, from a greater degree of wariness (Diong 1980) gathered over a lifetime spent in a hazardous area frequented by hog hunters, or from a combination of these and other factors remains unknown. If total eradication is the target of a landowner or manager, additional removal techniques may be needed to eliminate any large adult boars remaining in an area following intense trapping; however, the presence of a small, remnant number of adult boars in an area should not affect the rebound potential of a population nearly as much as if juvenile or adult females were allowed to remain (Dzieciolowski 1992, Hanson et al. 2009).

The overall economic viability and efficiency of any removal strategy is largely dependent upon the environmental and legal factors affecting a given area. Aerial culling via helicopter has proven effective in open, flat lands not easily accessible by other methods (Saunders 1993, Mitchell and Kanowski 2003); the use of species-specific baits to deliver toxicants has shown promise in environments where such species specificity exists and where such baits are legal (Choquenot et al. 1996, Cowled et al. 2006); and, in areas where other removal techniques may prove impractical or even illegal, intense trapping can reduce pig populations, at least in the short term (Wood et al. 1992, Mitchell and Kanowski 2003, McCann and Garcelon 2008). Since no toxicants have been approved for use on wild pigs in the United States, and since much of the range of wild pigs is forested (thereby severely limiting any chances of spotting, tracking, and shooting wild pigs from the air), trapping, in its most efficient form, remains the most economically logical choice to capture as many pigs as quickly as possible. While such trapping is very labor intensive, the purchase of pre-built traps or trap-building materials represents a potentially sizeable initial investment, and the bait necessary to keep traps active over a large area may represent hundreds of dollars. Our data suggest the long-term benefits, in terms of cost-per-pig, accrued by targeting multiple pigs with corral traps placed in areas known to contain unique sounders are likely to counteract these costs (McCann and Garcelon 2008). It should also be noted that our per-pig costs were inflated by the inclusion of non-recurring costs such as the initial purchase price of all traps and trap constructing materials; salaries implicitly designated for wild pig removal; and travel costs associated with daily Auburn-to-Fort Benning trips. Since many landowners or managers may not encounter any one (if any) of these costs, we also include here the costs without these additional variables: $142.12/pig for box traps and $28.91/pig for corral traps. While these figures are similar to others previously reported (Wood et al. 1992, McCann and Garcelon 2008), we wish to highlight more the difference between the two styles of traps, and thereby the relative efficiency of each compared to the other, than any specific values.

While our data do not provide any direct insights into the causes of the observed differences between corral traps and box traps, we feel that trap area (i.e., trap "openness") is likely the single most important factor in trap design influencing rapid success in trapping wild pigs. Although the on-site construction of corral-style traps may represent a greater investment of time and effort in the preliminary stages of trapping, we hold that the long-term benefits, i.e., the increases in temporal and economic trapping efficiency accrued while using large, open traps, far outweigh the relative portability offered by smaller box-style traps. While wild pigs may be captured in either style of trap, our data suggest that corral traps are more efficient than box traps in terms of time, money, and effort spent trapping.

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Table 2.1. Comparison of wild pig trap entry behavior at box traps and corral traps at Fort Benning, Georgia, 21 July through 25 September 2008.

	Box traps					Corral traps						
	Visits[1]	Entries[2]	Visits with entry[3]	Entries per visit[4]	Entries per entry[5]	Visits	Entries	Visits with entry	Entries per visit	Entries per entry	Chi-square[6]	*P*
Adult males	31	3	3	0.10	1.00	37	21	13	0.57	1.60	6.08	0.014
Adult females	44	22	12	0.50	1.80	25	30	8	1.20	3.80	0.17	0.677
Juveniles	66	27	14	0.40	1.90	47	26	16	0.60	1.60	2.32	0.128

[1] Individual pigs observed each night summed across 7 nights

[2] Total number of unique times a pig was observed completely within the entrance of a trap (including re-entries during a visit)

[3] Number of visits that resulted in at least one entry (total excluding re-entries)

Table 2.1. Continued.

[4] Entries/Visits

[5] Entries/Visits with entry (likelihood of re-entry, 1.00 = no re-entries)

[6] Assumes entry observations are equal for both styles of trap; expected values calculated as (AM box entries used for example): ((box visits with entries + corral visits with entries)/total combined entries) * total box visits

Table 2.2. Approximate costs of all non-trap-related investments associated with wild pig trapping at Fort Benning, Georgia, 29 February through 29 April 2008.

Description of cost	Approximate amount
Labor	
Man hours	462.00
Rate per hour	$10.00
Total	$4,620.00
Travel	
Commute miles	2520.00
On-site miles	1328.00
Total mileage	3848.00
Rate per mile	$0.55
Total	$2,116.40
Bait	
Corn used (kilograms)	680.40
Rate per palette (453.6 kilograms)	$650.00
Total	$975.00
Total non-trap-related costs	$7,711.40

Table 2.3. Approximate per-pig costs associated with wild pig trapping at Fort Benning, 29 February through 29 April 2008.

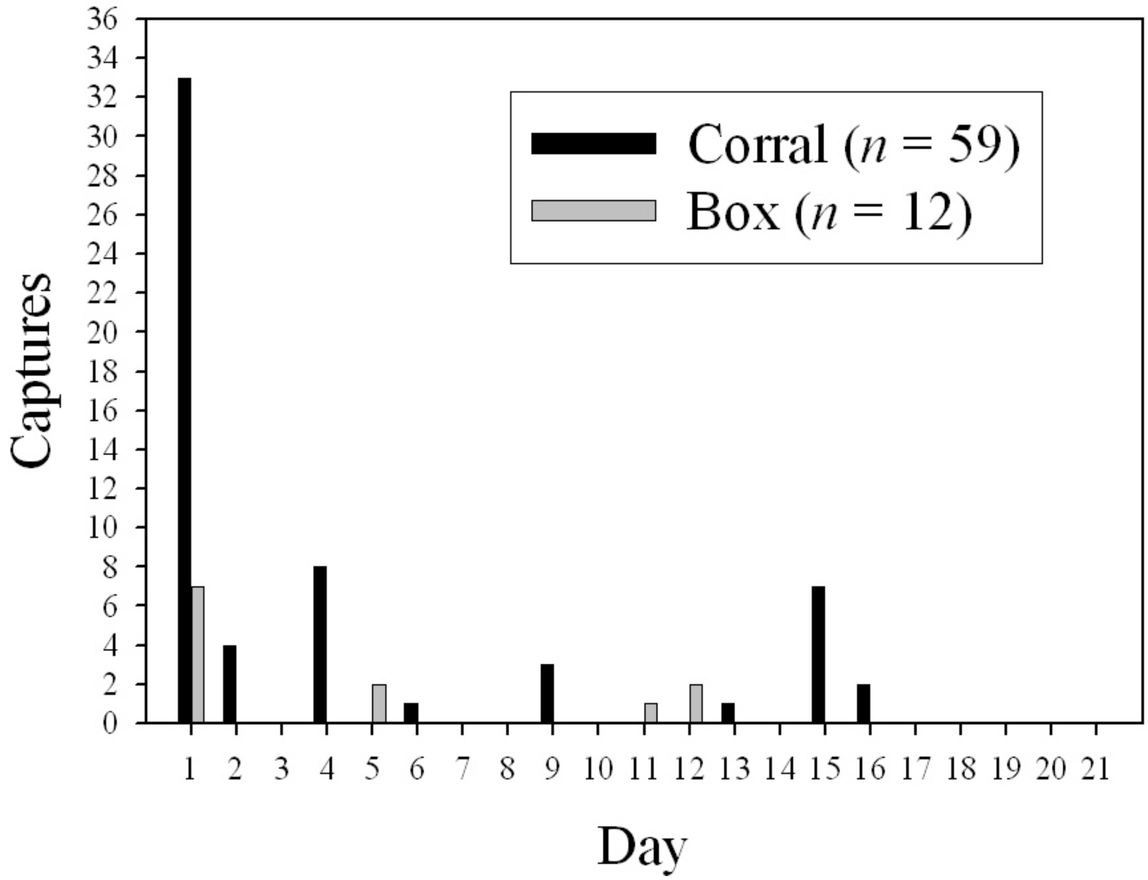
Trap style	Trap nights[1]	New captures[2]	Trap costs	Half additional costs[3]	Total approximate costs	Cost per pig
Box	252	12	$4,200.00	$3,855.70	$8,055.70	$671.31
Corral	252	59	$3,300.00	$3,855.70	$7,155.70	$121.28

[1] Twenty one nights of trapping * 12 traps of each style

[2] Unique individuals only; recaptures not included

[3] Total non-trap-related costs ($7,711.40; includes labor, travel, and bait expenses)/2; assumes approximately equal labor and travel expenditures for each style of trap since traps were placed/constructed/visited arbitrarily each day of preparation and trapping

Figure 2.1. Unique wild pig captures, by trap day and style, on Fort Benning, Georgia, between 29 February and 29 April 2008.


Corral (n = 59)
Box (n = 12)
Captures
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
Day
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21