# Efficiency of Time-Lapse Intervals and Simple Baits for Camera Surveys of Wild Pigs

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*Research Article*

# Efficiency of Time-Lapse Intervals and Simple Baits for Camera Surveys of Wild Pigs

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**ABSTRACT** Growing concerns surrounding established and expanding populations of wild pigs (*Sus scrofa*) have created the need for rapid and accurate surveys of these populations. We conducted surveys of a portion of the wild pig population on Fort Benning, Georgia, to determine if a longer time-lapse interval than had been previously used in surveys of wild pigs would generate similar detection results. We concurrently examined whether use of soured corn at camera sites affected the time necessary for pigs to locate a new camera site or the time pigs remained at a site. Our results suggest that a 9-min time-lapse interval generated dependable detection results for pigs and that soured corn neither attracted pigs to a site any quicker than plain, dry, whole-kernel corn, nor held them at a site longer. Maximization of time-lapse interval should decrease data and processing loads, and use of a simple, available bait should decrease cost and effort associated with more complicated baits; combination of these concepts should increase efficiency of wild pig surveys. © 2011 The Wildlife Society.

**KEY WORDS** bait, camera surveys, Fort Benning, Georgia, *Sus scrofa*, wild pigs.

Recently, the ability to accurately and efficiently monitor invading and expanding populations of wild pigs (*Sus scrofa*) has become a priority among managers in several countries around the world. Whereas techniques utilizing game cameras have been used with some success to quantify and describe the makeup of isolated wild pig populations, the process of collecting and processing 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). For example, although the use of motion- or infra-red-activated cameras has become popular for such surveys, when photographing wild pigs (a species likely to remain at a food source during a feeding event for >1–2 min), motion- or infra-red-activated programs can result in hundreds or thousands of pictures of the same individual(s), expanding the data load without providing much additional information of value. Conversely, whereas it is usually possible to program modern cameras not to capture images (i.e., motion- or infra-red-trigger) until a certain amount of time has elapsed between trigger events, this effectively changes the camera to a time-lapse interval while still depending upon a presence-based sensor to trigger the capture of an image or series of images. Most time-lapse settings, however, do not rely on any external influences to record an image, and many modern game cameras may be programmed to dependably record an image at a wide variety of possible intervals.

Because only a few images (as few as one) are needed to determine presence of an individual at a given survey site, and therefore fulfill the requirements of an individual-presence-based survey technique, it seems logical to decrease the necessary data load by decreasing the number of images taken at a site, while maintaining confidence that any animal present at the site will still be detected. Indeed, determination and use of a time-lapse interval sufficient to meet these demands for any given species would be a time-saving, worthwhile goal. Although studies conducted using a 3-min time-lapse interval have produced accurate assessments of wild pig populations, the data generated from these studies required large amounts of digital storage space and dozens of hours of human processing time to arrive at these assessments (Holtfreter et al. 2008). The ability to increase this time-lapse interval while collecting the data necessary for an accurate assessment would be beneficial.

In addition to the ability to maximize the time-lapse interval associated with generating 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 the effectiveness of time-lapse surveys set at longer intervals. Logically, the effectiveness of any survey utilizing time-lapse photographic equipment or techniques is affected by the length of time an animal remains within a camera's field of view; 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 often be aided by >1 image of any particular individual. Therefore, the ability to quickly attract animals to a camera site and provide incentive for

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those animals to remain in view of a camera should further increase the effectiveness of such survey methods. An array of attractants and baits have been used to draw pigs into camera or trap sites (Campbell and Long 2008), and one of the most simple and commonly used in the southeastern United States is soured corn (Hanson et al. 2008), the malodorous result of the fermentation of corn. However, to our knowledge, its effectiveness as an attractant has not been objectively evaluated.

We evaluated 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 photographic capture even at intervals >3 min. We predicted that extending a previously-validated 3-min interval (Holtfreter et al. 2008) out to as long as 9 min would still yield images of the same number of individuals (i.e., data that would still be sufficient for use in individual-identification-based population estimations). Additionally, we compared 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 would 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.

## STUDY AREA

We conducted our study on the approximately 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 was situated. A more complete description of floral and land-use characteristics in the study area is provided by King et al. (1998), Dilustro et al. (2002), and Hanson et al. (2009). Within the military installation, we conducted our project within one approximately 100-km$^2$ contiguous tract of land that was physiographically characteristic of the installation as a whole and that had been delineated for wild pig research by the Natural Resources Branch at Fort Benning (Hanson et al. 2009, Sparklin et al. 2009, Jolley et al. 2010). Our study area was theoretically kept free of hunters and external bait sources during our study. Hanson et al. (2008) reported pig densities between 1.2 and 6.1 pigs/km$^2$ in a similar area of Fort Benning in 2004.

## METHODS

### Time-Lapse Interval Comparison

Field methods for comparing the efficacy of time-lapse intervals largely followed Holtfreter et al. (2008). Between January and May 2008, we established approximately 85 scout sites across the study area, one in each of the 1-km$^2$ grid cells found in our study area once we overlaid it with such a grid (we combined partial border cells amounting to <0.5 km$^2$ with an adjacent complete cell). These scout sites consisted of approximately 11.3 kg of dry, whole-kernel corn broadcast and trailed at and around (within an approx. 50-m radius) a site and left for between 3 and 5 days. Upon our return to the site, we examined each for potential presence of pigs (e.g., tree rubs, wallows, scat, rooting, lack of corn). We noted locations of scout sites with likely pig activity and then randomly selected 12 camera sites from this pool. Because we were availed of our cameras for this element of our project for only a short time (approx. 1 month), and because we wished to follow the repeated site survey procedure followed by Holtfreter et al. (2008), we were unable to include >12 sites in our rotation. However, because our foremost objective was to compare the efficacy of the different intervals at identifying individual pigs, we expected the data produced from the repeated surveys of these sites would be sufficient for us to reach a conclusion.

We randomly assigned each site to 1 of 3 groups (12 total sites, 4 sites per group) and pre-baited the first group of sites with approximately 11.3 kg of dry, whole-kernel corn for 7 days prior to initial camera placement. Once the first group of sites had been pre-baited for 7 days, we deployed 3 cameras (RECONYX Silent Image ™ game cameras, Model PM35M13, Reconyx LLP, Holmen, WI) for data collection at each site of the first group (no cameras were deployed at sites prior to this point). We placed 3 cameras side-by-side 2.7 m from the 3.7 × 1.8-m bait field, at a height of 1.1 m and at a downward angle of 15°. We mounted cameras in this configuration relative to the bait field to maximize the vantage point and picture quality for this particular model of camera. We also pre-baited the remaining sites using the same protocol once those sites were within 7 days of receiving a set of cameras. We programmed one camera at each site to a 3-, 6-, or 9-min time-lapse interval, respectively. We considered the 3-min camera interval of Holtfreter et al. (2008) to be our control and we tested the 6- and 9-min intervals for ease of comparison, as they were double and treble, respectively, the previously-validated 3-min interval and represented a reduction of 50% and 66%, respectively, the number of images collected during a given site survey compared to the 3-min interval. We considered testing longer intervals, but we had neither the camera availability nor the image analysis time needed to collect and process these additional data.

We provided approximately 11.3 kg of evenly distributed, dry, whole-kernel corn at the beginning of each survey, left the cameras at each site for 3 nights (as per the recommendation of Holtfreter et al. [2008]), and then moved them to the next group of sites. Additionally, we changed the position (left, center, or right) of the cameras with each particular time interval upon each subsequent survey at each site to avoid any bias; otherwise, camera deployments were the same for each of the 3 groups of camera sites. Once we sampled all 3 groups of sites, we repeated this process 3 more times from 26 May through 1 July 2008, until we had surveyed each site

4 times, yielding 48 3-day site surveys. We assumed detectability among cameras and sites was equal. Because our objective was to compare the efficacy of longer intervals (i.e., whether we identified an individual pig using these intervals) to the previously-validated 3-min interval, rather than to generate population estimates from our data, considerations of any assumption violations associated with population estimations, baiting of sites, effective sampling area, et cetera, were beyond the scope of our study.

Upon collection of all data, we examined each photograph for presence of wild pigs. We recorded the first appearance of each individual pig (identifiable by size, sex, pelage color pattern, and, in some cases, ear tags present from previous research efforts) during each 3-day site survey. We considered each of these instances a capture; any individual could only be captured once during a 3-day site survey. We estimated relative efficacy of time-lapse intervals by calculating the ratio of the number of individuals captured by cameras set at 6- and 9-min intervals to the number captured by 3-min time-lapse intervals. We recorded the number of times we captured an individual pig by a 3-min interval and missed it by the 6- or 9-min interval during the same visit. We noted any instance in which we observed a capture on a later night during a 3-day site survey by the 6-or 9-min cameras, as these occurrences represented instances in which a pig, although missed on its initial visit to a site, was still captured during the site survey. We also noted any instance in which a pig was not captured by the 6-or 9-min camera at a site during any of the 4 surveys at each site. These occurrences represented instances in which a pig would have been completely missed during a survey, thus further reducing individual detection probability.

**Bait Comparison**

From the pool of scout sites we randomly selected 36 additional sites independent of the previous 12 interval comparison sites. To alleviate any potential bias associated with pigs revisiting known bait sites, we chose only sites that had not been baited within 30 days of the start of our bait comparison. We selected these 36 sites in an attempt to sample our study area as thoroughly as possible given the available time. With between 6 and 12 cameras available at any given time during the approximately 2 months of sampling, needing 7 days of sampling at each site, and also needing a sufficient and equivalent number of sites with each bait type, we determined 36 sites, 12 with each bait type, was a feasible number. We did not reject sites based upon any hypothetical potential for external influence (e.g., proximity to roads, ranges, training facilities) on initial site arrival times by wild pigs. We assumed randomization of site selection and sample size masked any potential effects such external influences may have had, positive or negative, largely because our study area contained enough roads, ranges, training facilities, bivouac sites, construction zones, and logging, surveying, and prescribed burning operations that avoidance of external influence would have been difficult. Furthermore, although we submit that initial proximity to pigs is likely the most important variable in determining how quickly pigs locate a bait site, we knew no way of accounting for this potential source of bias, large though it may be.

We randomly assigned each site to 1 of 3 bait types: dry corn only, soured corn only, or an equal-but-separate mixture of dry and soured corn. We placed approximately 11.3 kg of bait at each site. Our bait layout and camera positioning followed that we described previously; however, at mixed bait sites we placed soured corn in the half of the bait area nearer the camera and whole corn in the farther. We left cameras in place for 1 week on a 3-min time-lapse interval and refreshed bait, as needed, once during the middle of the survey week. We conducted surveys between 29 July and 2 October 2008.

Upon collection of all data, 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. We considered a bout separate if it occurred >30 min after a pig was last observed. Although we based this cutoff point on preliminary estimates of the average feeding bout length of wild pigs at Fort Benning, it remains arbitrary; however, some cutoff point was necessary to prevent pigs appearing in images separated by hours or days from being considered within the same feeding bout. A cutoff also was necessary to prevent stopping the clock on a feeding bout when a pig simply stepped out of range of the camera for an image or two but returned to the frame shortly after exiting; during such occurrences it seemed a biologically valid assumption that pigs exhibiting such behavior were still actively associated with our bait sites (i.e., still actively feeding) and were simply just outside the range of our cameras. Finally, we compared the mean and 95% confidence limits for time from deployment to the first visit among bait types. All of our procedures were approved by the Institutional Animal Care and Use Committee at Auburn University (PRN 2007–1196).

## RESULTS

We collected 121,859 images during 47 site surveys (12 sites $\times$ 4 surveys at each site; one camera was not powered on for one survey). Cameras set at 3-min intervals observed 266 individual pigs during these 47 surveys. Of these initial visits captured by the 3-min cameras, cameras set on 6-min intervals observed 262 (98%), and cameras set on 9-min intervals observed 245 (92%). While these misses occurred on the initial (control) visit to each site by a pig (as observed by the cameras set on the 3-min interval), cameras using the 6-min interval missed only 1 individual (0.4%; i.e., 99.6% similarity), and cameras using the 9-min interval missed only 8 individuals (3.0%; i.e., 97% similarity) when we considered each 3-day site survey as a whole. However, because we sampled sites multiple times during our study, it is also worth noting that, of the 134 individual pigs observed across 12 sites during 4 sampling periods, cameras using the 9-min interval missed only 4 pigs (3.0%) during all 47 surveys combined. Cameras using 6-min intervals did not miss any pigs (100% of 134 known pigs were observed).

**Table 1.** 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 (hr) | | | | | Feeding bout length (min) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 95% CI[a] | | | | | 95% CI[b] | |
| Parameter | $n$[c] | $\bar{x}$ | SE | Lower | Upper | $n$[d] | $\bar{x}$ | SE | Lower | Upper |
| Soured corn | 5 | 82.2 | 25.6 | 32.0 | 132.4 | 77 | 23.3 | 2.24 | 18.9 | 27.7 |
| Mixed | 7 | 65.8 | 16.7 | 33.1 | 98.6 | 130 | 23.6 | 2.09 | 19.5 | 27.7 |
| Whole corn | 8 | 74.6 | 17.0 | 41.2 | 107.8 | 168 | 33.5 | 2.06 | 29.4 | 37.5 |

[a] Calculated for soured corn, mixed, and whole corn as: $\bar{x} \pm 1.960 \times$ SE.
[b] Calculated for soured corn, mixed, and whole corn as: $\bar{x} \pm 1.960 \times$ SE.
[c] Number of sites visited.
[d] Number of feeding bouts.

Of 36 sites baited with each of the described varieties of corn, 20 were visited by pigs. Based on the associated 95% confidence intervals (Table 1), we observed no difference in the time to first detection among dry corn ($n = 8$, $\bar{x} = 74.6$ hr), soured corn ($n = 5$, $\bar{x} = 82.2$ hr), and mixed ($n = 7$, $\bar{x} = 65.8$ hr) bait types. We observed no difference (based on associated 95% CIs) between the average feeding bout length at sites baited with soured corn ($n = 77$, $\bar{x} = 23.3$ min) or a mixture of soured and dry corn ($n = 130$, $\bar{x} = 23.6$ min); however, pigs feeding at sites baited with whole corn ($n = 168$, $\bar{x} = 33.5$ min) remained longer than pigs at sites baited with either of the other 2 bait types (Table 1).

## DISCUSSION

We were confident in our ability to uniquely identify individuals in the Fort Benning population of wild pigs. Wild pigs exhibit a variety of colors, color patterns, and other pelage characteristics, and some individuals were marked with ear tags from previous wild pig work at Fort Benning. Ancillary information including group composition and location within the study area also increased our confidence when identifying pigs. Because we could individually identify wild pigs at Fort Benning 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 (approx. 30 min/feeding bout), cameras set at a 3-min interval captured many more pictures than were needed to confidently identify all individuals visiting each site. Indeed, cameras set at a 9-min interval usually provided enough pictures ($\bar{x} = 6.7$ images/pig) at each site to ensure that we could identify all individual pigs visiting that site.

When using a photographic survey technique, numerous benefits are garnered by reducing the amount of data collected by 66% while reducing the number of individuals captured by only 3%. Required digital storage space is reduced, camera battery life is increased, and, perhaps most importantly, image processing and interpretation time is decreased substantially. Additionally, the likely reduction in the number of site visits necessary for camera maintenance associated with longer time-lapse intervals also may help reduce any effects of human disturbance or scent at a camera site 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 as possible and then remain at the camera site for as long as possible serves to increase the efficiency with which such camera-based surveys are conducted. Previous pig surveying and 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 suggested that soured corn appears to have no additional attractive quality over dry, whole-kernel corn. Any number of factors may contribute to a site's initial discovery by pigs, and although our data did not provide direct evidence in support of such an assertion, it seems probable that, beyond the influence of an olfactory attractant, a site's initial placement near pigs may be the most important factor when a quick site discovery time is desired. We suggest that an initial effort to roughly determine the current location of a group of pigs may result in the appearance of pigs at a site more quickly than random or haphazard establishment of bait or trap sites under the assumption that pigs will be attracted to that site from a distance. Although subsequent utilization of this concept at Fort Benning has shown promise, formal testing is needed to further elucidate the factors influencing site discovery by wild pigs. Additionally, our data revealed that pigs did not remain at sites baited with soured corn as long as sites baited with dry corn. This result suggests keeping a site baited with dry, whole-kernel corn is likely a more effective way to keep pigs at a site at least in the short term, considering individual feeding bouts, than attempting to mix in or use only soured corn at a site. Although pigs will certainly consume soured corn, our data suggested no preference for it over dry corn.

## MANAGEMENT IMPLICATIONS

Our findings should be taken as general suggestions recommending the benefits accrued when survey efficiency is maximized. Our conclusion that a 9-min time-lapse interval yielded the necessary data is specific to wild pigs at Fort Benning, but the concept of interval maximization should be applicable to a wide variety of species. Similarly, whereas our bait study focused specifically on corn, and whereas corn worked well for us, we suggest the generalization of our findings is more important. Especially if care is taken to locate likely pig habitat before a survey is conducted, the use of any simple, bulk bait may prove more cost- and effort-effective over time that the use of other more expensive or more complicated baits.

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