Size and Composition as a Proxy for Identification of Wild Pig Sounders

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Abstract: Management of wild pigs (*Sus scrofa*) typically employs some form of population survey methodology, and trail cameras are the most common tool for conducting these surveys. Identification of individual sounders is generally at the foundation of these population surveys. Pelage characteristics and relative age distribution of individuals within the sounder coupled with total sounder size are common characteristics used to identify unique sounders. However, in many populations, the pelage of many wild pigs is either black or wild/grizzled, making pelage characteristics unreliable for sounder identification. Consequently, our objective was to assess the potential of using sounder size and composition as a simple proxy for identification of individual sounders visiting a camera station. Specifically, we aimed to determine the probabilities of encountering two sounders of a specific size and composition at the same camera site. Our findings revealed that sounders comprised of two adult wild pigs were the most common to be found at the same camera site. Yet, sounders of unique size and composition with more than three adults had a very low frequency (<3.6%), and frequency showed a tendency to decrease as sounder size increased. Our data indicate that most sounder size/composition categories (88.8%) can be identified individually with high (>95%) confidence simply by counting the number of individuals and number of adults in the sounder. Only four sounder size/composition categories (sounder of two with zero adults, sounder of two with two adults, sounder of three with zero adults, and sounder of three with one adult) had probability of co-occurrence >0.10. Hence, our study suggests that using sounder size and composition as a proxy for sounder identification is suitable for population surveys and management purposes.

*Key words***:** camera survey, population survey, sounder size, sounder composition, *Sus scrofa*.

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Wild pigs (*Sus scrofa*) are known for their extensive geographic distribution (Lewis et al. 2017), and both native and invasive/introduced populations of this animal can cause extensive environmental damage (Mayer and Brisbin 2009, Barrios-Garcia and Ballari 2012). In the U.S., their populations have been rapidly expanding with damage estimates in the billions of dollars annually (Pimentel et al. 2005). Wild pigs are known for their destructive rooting and wallowing (Mayer and Brisbin 2009), ability to compete with native species for resources (Campbell and Long 2009, Barrios-Garcia and Ballari 2012, Fay et al. 2023), damage to crops (McKee et al. 2020, Carlisle et al. 2021), and transmission of diseases (Gortázar et al. 2007, Gaudreault et al. 2020). Wild pigs cause increased soil erosion (Gray et al. 2020), reduced water quality (Brooks et al. 2020, Bolds et al. 2021), and destruction to natural areas (Sweitzer and Van Vuren 2002, Mitchell et al. 2007). Ultimately, wild pigs have substantial negative impacts on biodiversity, ecosystem structure, and anthropogenic environments. With their expanding populations and increased societal awareness perpetuated by their impacts, greater emphasis has been placed on reduction or eradication of wild pig populations. However, despite recent advancements in wild pig management and research, robust methods for estimating population size are needed to guide management strategies and to assess outcomes of control operations.

Although a variety of approaches have been developed to estimate population size of wild pigs (Engeman et al. 2013), most methods rely upon data collected using trail cameras (Holtfreter et al. 2008, ENETWILD 2018, Massei et al. 2018, Schlichting et al. 2020). However, most developed techniques do not consider that wild pigs are highly social animals and generally found in groups (sounders), causing them to exist on the landscape in a clumped distribution. Some recent advances in population estimation (Emmet et al. 2022) suggest social dynamics of species such as wild pigs should be accounted for when estimating population size, and thus, identification of individual sounders should be incorporated into these estimates. Additionally, identification of individual sounders lies at the foundation of whole sounder removal (Lewis

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et al. 2022) and has been an important component of trapping approaches for quite some time (Sweitzer et al. 2000, Hanson et al. 2008, Hebeisen et al. 2008). Total number of individuals and the relative age distributions of members within a sounder (i.e., number of adults relative to juveniles) are measurable characteristics commonly used to uniquely identify a sounder. Additionally, variation in pelage coloration and pattern within a sounder can be considered when identifying unique sounders (Holtfreter et al. 2008, Fang et al. 2009, Keiter et al. 2017, Davis et al. 2020, Schlichting et al. 2020). However, in many areas of their range, a high percentage of individuals within a population have either black or wild/grizzled pelage (Mayer and Brisbin 2008, 2009). Thus, pelage coloration and pattern are sometimes unreliable for identifying unique sounders. To account for this limitation, some studies have incorporated assumptions to identify sounders by only counting images taken <10 min apart (Massei et al. 2018). However, these approaches are less than ideal and likely to introduce bias, leading to greater confidence intervals around density estimates.

Building upon our past experience using trail cameras to monitor wild pigs (Hanson et al. 2008, Holtfreter et al. 2008, Williams et al. 2011) and other wildlife (Mccoy et al. 2011, Price Tack et al. 2016, Elliott et al. 2022), we hypothesized wild pig sounders could be uniquely identified through certain aspects of their biology rather than with the use of pelage characteristics. Wild pig sounders are social groups comprised of related females and their offspring (Kaminski et al. 2005), and the individuals within these groups are fairly stable (Mayer and Brisbin 2008, Titus et al. 2022) during the short durations of camera surveys (usually less than 2 wk; Holtfreter et al. 2008, Kays et al. 2020). Additionally, wild pigs tend to show high site fidelity (Oliveira-Santos et al. 2016, Bastille-Rousseau et al. 2021), and in some cases exhibit territoriality (Gabor et al. 1999, Sparklin et al. 2009), so their spatial location is generally predictable. Based on these behavioral characteristics, we used the binomial distribution function to evaluate the potential for using sounder size as a simple proxy for identification of individual sounders, as well as sounder size and composition (number of adults and juveniles) in tandem. Specifically, we used data on sounder size and composition collected from several studies among four states to calculate the probabilities of two sounders of the same size and composition being found at the same camera site.

Methods

We estimated the relative frequency of wild pig sounders of variable size and composition across the landscape using data previously collected during other studies (Mayer 2021, McDonough 2023). These data were collected in Alabama, Florida, Georgia, and South Carolina. Land covers of the properties where these data were collected were common in the southeastern United States, including mixes of upland pine (*Pinus* spp.) interspersed with hardwood drains at interior sites, and both forested and non-forested wetlands for coastal sites.

Both Mayer (2021) and McDonough (2023) identified individual sounder sizes and compositions using different survey approaches (Table 1), and we combined both datasets for use in this study. Data generated in Florida, Georgia, and South Carolina were collected during all seasons (1982–2001) by Mayer (2021) using a simple count observational approach via vehicular and pedestrian diurnal surveys by a single observer. The numbers of adults and juveniles in each group were recorded. Mayer (2021) classified individuals as adults or juveniles based on body size (i.e., wild pigs estimated to be greater than 25–30 kg were classified as adults). Data generated in Alabama (2019–2021) were also collected during all seasons as part of ongoing research (Bolds et al. 2021, McDonough 2023) using Reconyx™ PC800 Hyperfire Professional IR Cameras (Reconyx Inc., Holmen, WI, USA), as described elsewhere (Lewis et al. 2022, McDonough 2023). Cameras were deployed across the study areas within a 1-km^2 grid and set in strategic areas with the greatest amount of wild pig signs. Cameras were programmed to take time lapse pictures every 4 min as well as in three-picture bursts 2 sec apart when triggered by motion with a 30-sec delay between motion activations. Once datasets were combined, we determined the total number of individuals in each sounder and classified each animal as either juvenile or adult based on body size similar to Mayer (2021). Any observations with uncertain counts or uncertain identification of all individuals present in the sounder were excluded from this study. The objective in combining these datasets was to generate a sample of sounder sizes and compositions that was generally representative of what is found on the landscape, rather than a sample that was representative of one area, and which could be influenced by habitat resources, management (e.g., trapping, etc.), or other factors.

The combined dataset from the above studies was used to develop a frequency matrix of sounder size (total number of wild pigs in the sounder) and composition (number of adults and juveniles) categories. Because occurrences of sounders with >10 adults were infrequent, we merged all instances of 10 or more adults into a single composition category. Because sounders are defined as a group of related females and their offspring (Kaminski et al. 2005, Titus et al. 2022), we considered the minimum sounder size to be two individuals. Because sounder sizes >20 were infrequent, all instances of sounders with ≥20 individuals were merged into a single sounder size category. To populate the matrix, we calculated the relative frequency of each combination of sounder size

Table 1. Summary of the sounder size/composition datasets gather from Mayer (2021) and McDonough (2023).

State	Study site	Sounder size metrics		Survey method	Number of unique sounders identified	Reference
		Mean ± SE	Range			
Florida	Immokalee Ranch	4.7 ± 0.1	2–19	Vehicular and pedestrian	219	Mayer 2021
Georgia	Ossabaw Island	3.8 ± 0.1	2–19	Vehicular and pedestrian	221	Mayer 2021
South Carolina	Savannah River Site	4.9 ± 0.2	2–22	Vehicular and pedestrian	209	Mayer 2021
Alabama	Control	8.6 ± 1.2	2–24	Camera	27	McDonough 2023
Alabama	Treatment 1	7.4 ± 0.6	2–41	Camera	92	McDonough 2023
Alabama	Treatment 2	6.6 ± 0.4	2–21	Camera	111	McDonough 2023
Alabama	Treatment 3	8.6 ± 0.7	2–23	Camera	49	McDonough 2023

and composition (i.e., number of adults) by dividing the number in each sounder size/composition category by the total number of sounders that were included in the combined dataset.

To determine the maximum number of sounders that have been found to overlap in space and time, we searched the literature for information on overlap of sounder home ranges. Using Web of Science and Google Scholar, we used combinations of "Sus scrofa" OR "wild boar" OR "wild hog" OR "wild pig" OR "feral pig" OR "feral swine" as interchangeable nomenclature with "overlap*" AND "sounder" to look for all available research that reported sounders overlapping in the same area. Based on information gathered from the literature review, the greatest number of sounders overlapping generally ranged from two to three (Boitani et al. 1994, Gabor et al. 1999, Sparklin et al. 2009, Kilgo et al. 2021, Lewis et al. 2022); therefore, we assumed that the maximum number of sounders that could overlap in space, and hence have the potential to be photographed at the same bait site, was three. Although on a few occasions Kilgo et al. (2021) identified more than three sounders overlapping in space, these observations occurred under unique circumstances (at a landfill). Thus, we felt these observations were generally anomalous for wild pigs in natural areas. To calculate the probability of at least two sounders of the same size and composition having the potential to be photographed at the same location, assuming that three sounders are using the same space at any particular time, we used the binomial distribution function: $1-(1-P)^x$; where P is the relative frequency of a sounder of a certain size and composition (i.e., the relative frequency calculated for each sounder size and composition), and x is the number of additional sounders overlapping with a given sounder (i.e., if three sounders are co-occurring, then $x = 2$).

Table 2. Relative frequency of finding a wild pig sounder of a particular size and composition on the landscape. Numbers in bold indicate those sounder size/compositions that had relative frequencies ≥0.05.

Sounder size	Number of adults										
	0	1	2	3	4	5	6	7	8	9	10+
2	**0.080**	0.038	**0.110**								
3	**0.075**	**0.052**	0.022	0.041							
4	0.039	**0.050**	0.020	0.010	0.018						
5	0.011	**0.050**	0.026	0.005	0.001	0.011					
6	0.012	0.033	0.017	0.002	0.006	0.002	0.004				
7	0.003	0.020	0.016	0.006	0.002	0.002		0.003			
8	0.011	0.028	0.008	0.005	0.003	0.001	0.001	0.001	0.005		
9	0.002	0.013	0.008	0.001		0.002		0.001		0.002	
10	0.003	0.004	0.008	0.003	0.001	0.001	0.002	0.001			0.001
11	0.003	0.005	0.009	0.004	0.001	0.001	0.002				0.003
12	0.002		0.001	0.001	0.001	0.001			0.001		0.002
13	0.002		0.002	0.002				0.001		0.001	
14		0.002	0.002		0.002	0.001					
15	0.002		0.001	0.001	0.001		0.002	0.001	0.001		
16				0.001	0.001		0.002				
17			0.001	0.002							
18				0.001		0.001	0.002				
19				0.001	0.001	0.001	0.001	0.002			0.001
20+				0.004	0.002	0.001	0.001				0.001

Results

We were able to identify 928 sounders (comprising 4942 individual wild pigs) within our combined datasets and determine size and composition for each. Sounder sizes ranged from 2–41 with a mean of 5.3 ± 0.1 (SE) wild pigs. Composition of sounders ranged from all adults to all juveniles (Table 2). The sounder size/composition category that was most frequently detected contained two adult wild pigs (11.0%), followed by a sounder of two (8.0%) or three (7.5%) juveniles. In addition, sounders of three to five individuals with one adult (15.1%) had a frequency ≥5.0%. Sounders with greater than six individuals with at least three adults were the least common (each category >2.0%). Overall, most sounder sizes and compositions (83%) had a low probability (<0.02) of there being at least two of the same size and composition using the same site (Table 3). However, sounders that had less than five individuals with less than three adults had greater probabilities of co-occurrence (>0.05).

Table 3. Probability that, given three wild pig sounders have overlapping home ranges, at least two of them have the same size and composition. Numbers in bold indicate those sounder/size compositions that had probability of occurrence ≥0.05.

Sounder size	Number of adults										
	0	1	2	3	4	5	6	7	8	9	10+
2	**0.153**	**0.074**	**0.208**								
3	**0.145**	**0.101**	0.043	**0.080**							
4	**0.076**	**0.097**	0.041	0.019	0.036						
5	0.021	**0.097**	**0.051**	0.011	0.002	0.021					
6	0.024	**0.066**	0.034	0.004	0.013	0.004	0.009				
7	0.006	0.041	0.032	0.013	0.004	0.004		0.006			
8	0.021	**0.055**	0.015	0.011	0.006	0.002	0.002	0.002	0.011		
9	0.004	0.026	0.015	0.002		0.004		0.002		0.004	
10	0.006	0.009	0.015	0.006	0.002	0.002	0.004	0.002			0.002
11	0.006	0.011	0.017	0.009	0.002	0.002	0.004				0.006
12	0.004		0.002	0.002	0.002	0.002			0.002		0.004
13	0.004		0.004	0.004				0.002		0.002	
14		0.004	0.004		0.004	0.002					
15	0.004		0.002	0.002	0.002		0.004	0.002	0.002		
16				0.002	0.002		0.004				
17			0.002	0.004							
18				0.002		0.002	0.004				
19				0.002	0.002	0.002	0.002	0.004			0.002
20+				0.009	0.004	0.002	0.002				0.002

Discussion

Our data suggest that when wild pig sounder size is greater than four with at least one adult, sounder identification using size and composition is a technique that can be employed with high confidence when conducting camera surveys for wild pigs. Most sounder size/composition combinations had very low probability of co-occurrence at the same camera location; only 12 size/composition categories (11.2% of represented categories) had co-occurrence probabilities >0.05. We would additionally argue that when sounder size is greater than two and at least one adult is present, excluding the unique category of a sounder composed of only two adults, this technique still has strong utility as almost all sounder/size compositions have probability of co-occurrence of less than 0.10. Finally, we emphasize that our calculated probabilities already assume that there are three sounders that co-occur at a site. Based on the information gathered from the literature review, the instances when three sounders co-occurred in the same area have been relatively low. Thus, the true probability that two or more sounders occupy the same area and have the same size and composition, is even less.

Our probability calculations are based solely on the size and composition of a sounder. However, there are several aspects of the biology of wild pigs that make this method even more reliable. Firstly, some populations of wild pigs are territorial (Gabor et al. 1999, Sparklin et al. 2009, Kilgo et al. 2021), indicating that the probability of overlap with any other sounder is often low. Thus, sounders can sometimes be identified simply based on location. Secondly, wild pigs are known to demonstrate high site fidelity (Oliveira-Santos et al. 2016, Bastille-Rousseau et al. 2021) and infrequently move outside of their established home range or territory. This, in turn, results in limited overlap between sounders of wild pigs (Boitani et al. 1994, Gabor et al. 1999, Sparklin et al. 2009, Lewis et al. 2022). Additionally, the presence of genetically related individuals within sounders reinforces their cohesive movement (Poteaux et al. 2009) and grouping behavior. Furthermore, effective baiting and conditioning have been shown to condition wild pigs to visit the same bait site at consistent times of the day (Snow et al. 2016, Snow and VerCauteren 2019, McRae et al. 2020, Snow et al. 2021). As a result, if multiple sounders inhabit a given area, they are likely to arrive at different times, further aiding in differentiation and identification of distinct groups. In sum, the combination of territorial behavior, high site fidelity, genetic relatedness, and movement behavior collectively fortify the effectiveness of our probability calculations, providing a robust framework for sounder identification.

Despite several behavioral characteristics of wild pigs enhancing the use of sounder size and composition as a proxy for unique identification of sounders, there are also a few behavioral aspects that weaken its potential utility. First, sounder size and composition can change during the farrowing period. When females approach parturition, they typically leave the sounder to give birth, and it is about 2–3 wk before they return with their offspring to re-join the sounder (Mauget 1982, Jensen 1986, Andersson et al. 2011). Additionally, sounders sometimes can experience dramatic changes in group composition due to merging or splitting (fission-fusion) of sounders (Ilse and Hellgren 1995, Gabor et al. 1999, Kaminski et al. 2005). Individual sounders can sometimes grow in numbers to the point where they split and form sub-groups, and it has been documented where small sounders or sub-groups of wild pigs have merged to form a larger sounder (Gabor et al. 1999). Although these behaviors do occur and have the potential to modify sounder size and composition, they have been reported more often during long-term studies (Truvé and Lemel 2003, Iacolina et al. 2009, Poteaux et al. 2009, McIlraith 2021) and most camera surveys for wild pigs last only 1–2 wk (Holtfreter et al. 2008, Williams et al. 2011, Risch et al. 2020). Thus, we can generally assume that sounders would be more stable within that time period.

We acknowledge that there are some sounder size/compositions that cannot be identified with the level of confidence (i.e., <0.05 probability of misidentification) that may be desired. Nevertheless, this tool can generally be applied with reasonably strong certainty. In those cases where sounder size and composition alone may not suffice for confident identification, physical characteristics such as pelage patterns, encompassing variation in color (i.e., black, red-brown, or white) and pattern (i.e., solid, spotted or mottled, belted, wild/grizzled, and combinations of these) can further aid in classifying and distinguishing individual sounders (Teton et al. 2020). Moreover, identifying sounders using other characteristics such as body mass, external dimensions, and hair morphology (Mayer and Brisbin 2008, 2009) would significantly enhance identification of individual sounders, particularly when dealing with smaller sounder sizes. Our study demonstrated the reliability of using sounder size and composition to identify individual sounders and provided the assurance that if one encounters a sounder with the same size/composition constantly in the same location, it will indeed be the same one. However, the possibility of incomplete observations, such as some individuals appearing in front of the camera while the rest of the sounder remains unseen, prompts the need for further investigation.

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