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Distribution, Habitat Use, and Morphotypes of Feral Hogs (*Sus scrofa*) in Illinois

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ABSTRACT

Feral hogs (*Sus scrofa*) recently have been introduced to Illinois. They are important to resource managers because of their potentially negative ecological and economic impacts. We assessed the distribution, habitat use, and body morphology of feral hogs in Illinois. We confirmed the occurrence of feral hogs in Fulton, Hardin, Johnson, Lawrence, Massac, Pope, Randolph, and Union counties. Forest and croplands probably are the most important habitats for feral hogs in Illinois. We found free-ranging hogs in Illinois included four previously described morphotypes with distinguishable physical/cranial characteristics: domestic hogs, feral hogs, hybrids, and Eurasian wild hogs. However, 32.6% of individuals were outside of these previously described morphotypes. External morphology and pelage usually were consistent with cranial analysis in determining morphotypes. Whole and dressed body weight regression indicated that dressed weight was about 85% of whole weight. We suggest that the goal of resource managers in Illinois should be to contain or eradicate existing feral hog populations. This should be addressed while populations are small and relatively isolated. If current practices continue, feral hogs have the potential to eventually increase in density and distribution throughout much of Illinois.

Key words: exotic, feral hogs, introductions, *Sus scrofa*

INTRODUCTION

Feral hogs (*Sus scrofa*) have been introduced repeatedly to North America during the last 500 years (Mayer and Brisbin, 1991). Hernando De Soto and other explorers brought hogs with them to supply fresh meat on their journeys from the 1500s onward. Some of these animals escaped and initiated feral hog populations (Towne and Wentworth, 1950). Hundreds of subsequent introductions have been made and continue to the present day. Feral hogs now exist in at least 23 continental states and Hawaii (Sweeney et al., 2003), but only recently have been introduced to Illinois (Gipson et al., 1998). Feral hogs were first reported in Union County, Illinois, in 1993 (Grund et al., 2000). Since then, they have been documented in at least 10 Illinois counties (Esker, 2001), as well as the bordering states of Missouri and Indiana. Feral hog introductions to Illinois result primarily from deliberate attempts by private individuals to establish populations for hunting, and rarely are the result of escaped domestic animals. Unfortunately, feral hogs damage crops and pastures by rooting, trampling, and direct consumption. They compete with native wildlife, damage native plants, and expose domestic livestock to diseases. Pimentel et al. (2000) estimated that feral hogs cause $800 million of loss and damages annually in the United States. An additional $500,000 is spent to control or remove pigs from private, state, and federal lands.

Our objectives were to: 1) determine the current distribution and habitat use of feral hogs in Illinois; 2) determine the occurrence of different morphotypes in the state based on cranial and pelage characteristics, and external body measurements; and 3) determine whole and dressed body weight relationships.

METHODS AND MATERIALS

Distribution

We assessed distribution of hogs throughout Illinois by contacting hunters, landowners, and representatives of state and federal management agencies. We also hunted and trapped hogs to collect specimens. Sliding door box traps (1.6 x 1 x 2 m) were baited with corn, commercial hog feed, and various attractants. From one to three traps were operated for a total of 49 nights, but were unsuccessful at collecting any feral hogs. A combination of stand and still-hunting techniques was employed in daylight and night-time conditions in an attempt to collect feral hogs. We spent a total of 168 field days scouting, hunting, trapping, and collecting information on feral hogs. Skulls or carcasses of hogs killed in Illinois by others also where collected when available.

Habitat Analyses

Known feral hog kill sites recorded during this study, and from Grund et al. (2000), were plotted on United States Geological Survey (USGS) digital topographic 7.5' quadrangles from the Illinois Natural Resources Geospatial Data Clearinghouse. There was one site per animal, except in the case of seven neonates collected in the same location, which were represented by only one point in analyses. The plotted locations were then overlaid on USGS National Land Cover Data using Arcview GIS 3.2. Landcover data were reclassified as: open water, forest, grassland/herbaceous, pasture, wetland, crops, developed, and other. Locations of feral hog kills were buffered to a 1000-m radius. Landcover was then tabulated for each buffer, divided by total area of the buffer, and recorded as a percent covertype for each of the eight categories. Feral hog kill site locations in Southern Illinois (SIL; $n = 18$) were grouped for comparison to kill sites in Fulton County, Illinois (FCIL; $n = 15$). Two random sample datasets, representing sites without feral hogs ($n = 17$ grouped individual locations for each) were tabulated through the Animal Movements extension of Arcview GIS 3.2 to sample all landcover south of Peoria, Illinois. These were buffered, and percent covertypes were tabulated for each composite random location. Habitat characteristics of the four datasets (SIL and FCIL with feral hogs; random data sets RD1 and RD2 without hogs) were compared using an analysis of variance model (SPSS 11.5) and Tukey post hoc analysis.

Body and Cranial Morphology

Morphotype of each hog collected was determined from a combination of cranial measurements, external body measurements, and pelage/coat color patterns. Mayer and Brisbin (1991) described four general morphotypes for *Sus scrofa*: domestic, feral, hybrid European x feral, and European wild hog. Morphotypes were based on 52 skull measurements using stepwise discriminant function analysis for each of five age classes (neonate, juvenile, yearling, subadult, adult) and sex. Using the first two discriminant functions, sets of predictive variables for neonates, juveniles, and yearlings, and for male and female subadults and adults were developed. The 15 cranial measurements (Appendix 1) described by Mayer and Brisbin (1991) that differentiate age-specific morphotypes were applied to the specimens collected to determine morphotype. We took all measurements with a 300-mm dial caliper to the nearest 0.1 mm. We estimated age of feral hogs by tooth eruption patterns described by Mayer and Brisbin (1991). Pelage color and pattern, when available, also were used to assess morphotype of animals.

Seven external body measurements were taken on the hogs collected: total length, head-body length, tail length, hind foot length, ear length, shoulder height, and snout length. These aided in differentiation of presumptive morphotypes. Measurements were taken with a steel tape to the nearest 0.125 in, then converted to millimeters for analyses.

Whole and dressed body weights were collected with a 136-kg spring scale. In this study we define whole weight as the intact carcass, and dressed weight as the carcass minus all entrails, including the heart and lungs. A regression of whole and dressed body weights was performed using JMP 5.0.1 computer software.

Disease Testing

Blood samples from the heart or body cavity of feral hogs we collected were sent to the Illinois Department of Agriculture Bureau of Animal Disease laboratories in Centralia and Galesburg, Illinois. Blood was tested for disease as follows: brucellosis by buffered antigen plate agglutination, pseudorabies by 1:4 dilution ratio serum neutralization, porcine respiratory and reproductive syndrome with enzyme-linked immunosorbent assay, and leptospirosis by microtiter agglutination test.

RESULTS

Distribution

We collected the crania of 39 feral hogs from Fulton, Hardin, Johnson, Lawrence, Massac, Pope, and Union counties. An additional four complete crania and mandibles were collected from an enclosed hunting operation in Edgar County. A free-ranging feral hog belonging to a private landowner in Randolph County was observed, as well as another 30 animals housed in a breeding facility at this site. Additionally, we obtained a hog mandible from Moultrie County that was found by a local sportsman. We received reports of feral hogs in five other counties (Alexander, Gallatin, Jackson, Monroe, Pulaski) but they could not be confirmed.

Habitat Use

There were no significant differences between the random data sets RD1 and RD2 for any cover type. There was a significant difference in the amount of forest cover between the Fulton County (58.9%) and Southern Illinois (39.6%) study areas (F = 13.10; d.f. = 1, 32; P = 0.001). Both were significantly more forested than either of the random data sets (SIL/RD1: F = 19.36; d.f. = 1, 34; P = 0.000; SIL/RD2: F = 9.72; d.f. = 1, 34; P = 0.004; FCIL/RD1: F = 118.24; d.f. = 1, 31; P = 0.000; FCIL/RD2: F = 58.12; d.f. = 1, 31; P = 0.000). There was no significant difference in the amount of cropland between FCIL (25.1%) and SIL (16.1%). Both had significantly less cropland than either of the random data sets (FCIL/RD1: F = 23.28; d.f. = 1, 31; P = 0.000; FCIL/RD2: F = 7.94; d.f. = 1, 31; P = 0.008; SIL/RD1: F = 45.71; d.f. = 1, 34; P = 0.000; SIL/RD2: F = 19.56; d.f. = 1, 34; P = 0.000;). Percent grass/herb was significantly different only for SIL and RD1 (F = 12.26; d.f. = 1, 34; P = 0.001). Percent pasture was significantly different between FCIL and SIL (F = 20.03; d.f. = 1, 32; P = 0.000), and FCIL and RD2 (F = 14.47; d.f. = 1, 31; P = 0.001). Percent wetland was significantly different between SIL and all other data sets: SIL/FCIL (F = 8.36; d.f. = 1, 32; P = 0.007), SIL/RD1 (F = 10.71; d.f. = 1, 34; P = 0.003), and SIL/RD2 (F = 6.44; d.f. = 1, 34; P = 0.016).

Body and Cranial Morphology

Based on the discriminant functions of Mayer and Brisbin (1991), three of seven neonatal crania collected in Illinois were classified as feral hogs. One fell in an area of overlap between feral hogs and hybrids. The other three were outside of the described areas for all morphotypes, but were closest to domestic hogs. Of the 14 juvenile crania we collected, there were 4 domestic hogs, 1 Eurasian wild hog, 2 feral, and 4 were in an area of overlap for feral hogs and domestic swine. Three juveniles were outside all described areas: one was closest to domestic swine, one closest to Eurasian wild hog, and one closest to the hybrid area. Five of the 12 crania of yearlings fell within the area demarcated as hybrids. Two were feral hogs. Five specimens were outside all described morphotypes: three were closest to hybrids, one was closest to domestic swine, and one was closest to Eurasian wild hog.

Crania from three subadult males were obtained: one was a feral hog, one a hybrid, and the other a Eurasian wild hog. The Eurasian wild hog was from the breeding program in Paris, IL. We collected no subadult females. Of four adult female crania obtained, one was a domestic hog, but with characteristics close to feral hogs, one was a feral hog, and one was a Eurasian wild hog. The last was outside of all described morphotype areas, but was closest to Eurasian wild hog. We obtained three adult males; one in an area of overlap with hybrid and feral hogs. The other two animals fell outside of all described morphotypes. They were equidistant to the mean center of discriminant space for feral hogs and hybrids. Morphotypes of all hogs we collected were: 11.6% domestic, 20.9% feral, 13.9% hybrid, 7.0% Eurasian wild hog, 14.0% overlap between feral and hybrid, or feral and domestic, and 32.6% outside of all described morphotype areas.

We found seven coat color patterns among 27 feral hogs in Illinois. These included: all black (n = 8); all red/brown (n = 6); black and white spotted (n = 5); black with white shoulder belt (n = 4); wild/grizzled (n = 2); black with tan front legs (n = 1); and black and red/brown spotted (n = 1).

Mean values for whole weight and body measurements within each age class (sexes combined) are given in Table 1. Both whole and dressed body weights were obtained from 19 feral hogs, ranging in age from neonates to adults. Dressed weight generally was about

85% of whole weight. The least squares linear regression for sexes combined was: whole weight = 1.8525 + 1.1557 (dressed weight) with $R^2 = 0.998$.

Disease Testing

No evidence of brucellosis, pseudorabies, or PRRS was found in blood samples from 15 feral hogs tested. However, two samples had titers of 1:100 and 1:200, respectively, for one species of leptospirosis. This was most likely the result of vaccination (Illinois Bureau of Animal Disease Laboratory, pers. comm. 2002).

Reproduction

Seven sows collected were visibly pregnant. They were collected in December (n = 2), March (n = 2), April (n = 1), and May (n = 2). Of these, information on the number of fetuses was recorded for only two sows, which had 4 and 5 fetuses, respectively.

DISCUSSION

Distribution and Habitat

The two most important habitats for feral hogs in Illinois are forested and agricultural areas. Crops can provide needed nutrients at certain times of the year. Because reproduction is strongly linked to nutrition, agricultural areas may be important to the reproductive success of feral hogs. The Fulton County and Southern Illinois study areas were similar in that both were significantly less cultivated than random areas. Nonetheless, they provided sufficient agricultural resources for feral hogs. Forest provides both cover and food for hogs. Hard mast and herbaceous understory plants are important parts of the diets of feral hogs in many parts of the country (Henry and Conley, 1972; Howe et al., 1981). Because habitat is highly fragmented in Illinois, and crops are available throughout the state, hogs may select areas that have a balance of forested and agricultural habitats that provide optimum feeding opportunities and shelter throughout the year. There was no clear relationship that would suggest grass/herb or pasture habitats were important in hog distribution. Southern Illinois had a higher percentage of wetland than the other areas, but again we suggest that wetlands are not a primary determinant in the distribution of hogs. Finally, to a large extent, the current distribution of feral hogs in Illinois probably is less a function of habitat selection than a reflection of where they have been released. Because habitat conditions are appropriate, there currently is little incentive for the animals to widely disperse.

Morphology

External morphology and pelage were consistent with cranial analysis in determining morphotypes of hogs in all but 3 cases. Two specimens were considered feral animals based on cranial analysis, but had external body measurements representative of domestic hogs. The other specimen was a Eurasian wild hog based on cranial analysis. However, it had solid red/brown coat color, which is not found in Eurasian wild hogs, and external body measurements more representative of domestic hogs. These animals were 3 of 24 individuals (12.5%) in which cranial, pelage, and body measurement data were collected. Because cranial analysis was in agreement with external morphology and pelage coloration for 87.5% of our sample, morphological analysis of hogs based only on crania may be viewed with confidence.

The low number of domestic hogs (11.6%) in our sample indicates that animals we collected were not escapees from commercial hog farms. The presence of feral hogs (18.6%), hybrids (13.9%) and Eurasian wild boars (9.3%) is strong evidence of the importation and release of hogs in Illinois. The high proportion of samples (32.6%) that were outside discriminant space for all previously described morphotypes may be the result of extensive crossbreeding of feral or hybrid stock with the variety of domestic breeds common to Illinois. Mayer and Brisbin (1991) used skulls from known populations of domestic, feral, hybrid, and Eurasian wild hog to establish the cranial discriminant functions used in our analyses. Of the four described morphotypes, we expect domestic, feral, and Eurasian wild boar populations would have less genetic diversity than hybrid populations. The term "hybrid" implies a cross between animals wholly or partially representing European wild hogs genetically and any of the previously defined morphotypes. Thus, we expect skull morphology to encompass a wide spectrum of values in a discriminant function analysis.

We found that dressed weight was about 85% of whole body weight over the entire range of age groups sampled. This is somewhat higher than the ratio reported by Henry (1969) for Eurasian wild hogs in Tennessee. He found that dressed weight of males and females averaged about 78% of whole weight. Illinois represents a very productive environment for feral hogs. The abundance of crops and mast lead to very healthy, well-developed feral hogs. All hogs we collected had large amounts of both subcutaneous and visceral fat, and were in excellent condition.

The 15 blood samples we collected are not enough to assess the presence of disease in feral hogs in Illinois. Feral hogs in other states are known to carry many diseases (Hanson and Karstad, 1959; Wood et al., 1976; Zygmont et al., 1982; Clark et al., 1983; Corn et al., 1986; Van der Leek et al., 1993). Feral hogs in Illinois should be viewed as a threat to domestic stock. The two individuals that had low titers for leptospirosis apparently were vaccinated before release. One was a hybrid; the other was outside of all described morphotypes, but was closest to hybrids in cranial analysis. Thus, they were not simply escaped domestic hogs. Future releases of feral hogs certainly enhance the probability that swine diseases will be introduced to Illinois (if they are not already present) and could negatively impact disease eradication programs for domestic swine.

The two litters recorded (4 and 5 fetuses) were consistent with expected litter size for feral hogs (Barrett, 1978; Sweeny et al., 1979; Baber and Coblentz, 1986; Taylor et al., 1998). The time of year when we found pregnant sows, December through May, likely reflects the lack of collection during summer and early fall, rather than trends in breeding behavior in Illinois. Important factors in the reproductive success of hogs in other areas are nutrition, weather conditions, and water availability. Food and water are readily available in Illinois, and weather conditions are relatively mild and consistent from year to year in central and southern Illinois. As noted previously, the body condition of all feral hogs we collected was excellent. There is probably little limitation on the breeding potential of feral hogs in Illinois. In areas where hogs are at low densities, however, breeding opportunities may be the limiting factor. This "lag phase" of population growth eventually can become exponential growth, however.

Invasive (Exotic) Species

Kolar and Lodge (2001) identified three stages or "transitions" of exotics as transportation, release, and establishment. Feral hogs always are intentionally transported through prolific trapping, trading, and relocation throughout the United States. Upon release, non-native species must be able to meet their basic needs of food, water, and shelter in their new environment. As noted, the needs of feral hogs are clearly met in Illinois and numerous other areas throughout North America. Because of efficient and adaptable feeding strategies and social behaviors, feral hogs can compete well with native Illinois species including white-tailed deer (*Odocoileus virginianus*) and turkey (*Meleagris gallopavo*). Establishment of an exotic species can be invasive or noninvasive. Kolar and Lodge (2001) define noninvasive establishments as those where species become established but remain in a localized area close to the point of release. Invasive establishment includes wide dispersal throughout a new region. Although most populations currently are small and isolated in Illinois, feral hogs have the potential for rapid increase in density and distribution throughout much of the state. Once a species becomes established, eradication may be impossible, and control becomes increasingly expensive.

Feral hogs are among the most damaging exotic animals that have been introduced to the United States. They damage crops and pastures by rooting, trampling, or consumption; dams, watering areas, and roads are affected by wallowing and rooting; fences are torn or lifted; and livestock face competition and exposure to diseases. In addition to agricultural losses, feral hogs damage native plants and compete with wildlife. Alternatively, hunting feral hogs is a very popular activity. Magazines and web sites provide a forum for hog hunting enthusiasts across the United States to interact, which can result in the allocation of feral hogs for release into new areas. Small numbers of feral hogs can be transported very inconspicuously, which can easily mitigate against enforcement of laws that regulate interstate transport of livestock.

Management Recommendations and Control Options

We suggest that the immediate focus for resource managers in Illinois should be containment and eradication of current feral hog populations and the prevention of new releases. Many methods have been employed or proposed for controlling feral hog populations around the world (Tisdell, 1982). Still hunting, stand hunting, hunting with dogs, or spotlighting from vehicles are effective shooting methods. Katahira et al. (1993) successfully removed feral hogs by hunting, trapping, and snaring at Volcanoes National Park, Hawaii. Trapping is an effective means of control when food sources are limited (Saunders et al., 1993). Snares are more affordable, but should not be used in areas where non-target species may interfere. Poisoning is an effective means of hog removal, but can have direct and residual effects on non-target species (Tisdell, 1982). For control of the low-density feral hog population that currently exists in Illinois, a combination of removal techniques, such as shooting, hunting with dogs, and trapping probably is sufficient. Additionally, management agencies should augment active control of feral hog populations by:

- Regulating the import of feral hogs in Illinois through legislation;
- Closely monitoring hunting and breeding operations to ensure that animals are contained with adequate fencing and enforce current regulations against releasing hogs on unconfined areas;

- Interacting with private landowners, hunting outfitters, and exotic animal farmers to better monitor feral hog populations; and
- Contain and remove existing hogs from known areas.

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APPENDIX 1

Cranial variables (from Mayer and Brisbin 1991) measured on all complete hog skulls (n = 43) collected in Illinois, 2001-2002, and from previous samples when available.

1. Condylobasal length – from the anteriormost edge of the premaxillae to the posteriormost projection of the occipital condyles.
2. Occipitonasal length – from the anteriormost edge of the nasal bones to the posteriormost projection of the occipital condyles.
3. Nasal length – from the anteriormost point of the nasal bones to the posteriormost point at midline.
4. Length lacrimal notch to anterior nasal – from the uppermost lacrimal foramen to the anteriormost point of the nasal bones.
5. Rostral length – distance from the midpoint between the lacrimal notches to the anteriormost edge of the nasal bones.
6. Zygomatic width – the greatest distance between the outer margins of the zygomatic arches.
7. Braincase breadth – the greatest breadth of the lateral sides of the parietals, midway between the postorbital processes and the lambdoidal crest.
8. Supraoccipital constriction – the least distance between the lateral edges of the supraoccipital.
9. Greatest width of occipital ridge – the greatest width across the lateral ridges of the supraoccipital.
10. Parietal constriction – the least distance across the edges of the parietal crest.
11. Least interorbital breadth – the least distance between the dorsal margins of the orbits.
12. Palatal premaxillary constriction – the least breadth across the palate at the lateral junction of the premaxillae and maxillae.
13. Premaxillary rostral width – the greatest breadth across the premaxillae above the upper canine.
14. Palatal length – from the anteriormost ventral edge of the premaxillae to the posterior margin of the palate at midline.
15. Angle of the occipital wall – the angle between the midline of the occipital wall (midline point of the lambdoidal crest to the midline point of the dorsal edge of the foramen magnum) and midline of the plane of the palate adjacent and posterior to the third molars.

Table 1. Mean values (standard error) for six body measurements (cm) and whole and dressed body weights (kg) for five age classes, sexes combined, of feral hogs in Illinois.

Age Class	Total Length	Tail Length	Hind Foot Length	Ear Length	Snout length	Shoulder Height	Whole Weight	Dressed Weight
Neonate	92.65	13.97	16.46	8.39	11.51	40.61	17.86	13.38
(n=7)	(9.48)	(2.53)	(1.87)	(1.15)	(0.89)	(4.49)	(4.18)	(2.86)
Juvenile	140.02	23.50	25.74	13.65	18.25	63.95	61.70	52.16
(n=11)	(12.39)	(1.35)	(1.89)	(2.35)	(1.51)	(4.65)	(13.63)[a]	(11.93)
Yearling	154.15	21.05	26.13	13.65	21.58	70.15	89.61	86.36
(n=4)	(14.44)	(7.88)	(2.48)	(1.28)	(2.96)	(13.73)	(26.00)[b]	(10.00)[c]
Subadult	167.60	22.20	29.90	14.00	25.40	62.20	86.36	77.27
(n=1)								
Adult	184.50	26.35	31.12	19.85	30.80	83.85	147.73[d]	125.00[d]
(n=2)	(22.91)	(14.35)	(0.90)	(7.42)	(0.42)	(3.61)		

[a] sample size (n=8)
[b] sample size (n=3)
[c] sample size (n=2)
[d] sample size (n=1)