Reproductive Biology of European Wild Hogs in the Great Smoky Mountains National Park

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Abstract: Based on 162 European wild hogs (*Sus scrofa*) collected from 1971 to 1973 in the Great Smoky Mountains National Park, the male : female ratio was 52 : 48 and the age composition consisted of 52% of the hogs being <12 months, 21% 12–26 months, and 27% >26 months of age. No sex difference in collection by trapping and shooting occurred ($0.1 < P < 0.5$), but hogs <12 months old were more likely to be trapped (77.4%) than shot (22.6%) and hogs >26 months old were more likely to be shot (75.0%) than trapped (25.0%) ($P < 0.005$). Males attained puberty in 7 to 12 months and females in 5–8 months; both were physiologically capable of breeding year-round. Farrowing activity occurred year-round, but peaks occurred in late fall–early winter and late spring–early summer. Collection of 2 pregnant females accompanied by young 5 to 8 months old suggested the possibility of 2 litters per year following good mast yields. Litter sizes based on fetal counts (3.0), trapped litters (2.8), litters observed in the field (3.5), and the number of lactating teats (3.8) averaged 3.3 and ranged from 1–5. The high reproductive potential and lack of effective control techniques for hogs indicated that range expansions both through transplants and dispersal should be discouraged. A comprehensive, regional policy and management plan, agreed upon by natural resource scientists, would facilitate proper management and minimize public and professional conflicts concerning hogs.

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An estimated 60–100 European wild hogs were accidentally introduced into the Southern Appalachian region from a private shooting preserve on Hooper Bald, North Carolina, in the early 1920's (Conley et al. 1972:3). Free-ranging domestic and feral hogs were present in the area and readily interbred with the European wild hogs. McFee et al. (1966) found that European wild hogs have 36 chromosomes and domestic hogs have 38; wild and domestic crosses produce fertile offspring with a chromosome number of 37. Rary et al. (1968) reported that of 120 hogs sampled in 1966 and 1967 on the Tellico Wildlife Management Area, Tennessee (adjacent to Hooper Bald), 38 (31.6%), 65 (54.2%), and 17 (14.2%) had diploid chromosome numbers of 36, 37, and 38, respectively. Ancestry of the Tellico hog population was composed theoretically of 58.7% European wild stock and 41.3% domestic stock (Conley et al. 1972:60). Wood and Barrett (1979: 237) further stated that "few, if any, pure European wild boar exist in the U.S. today due to inter-breeding with feral stock."

Since the original introduction, the hog population has increased in number and expanded its range into adjacent areas of Tennessee and the Great Smoky Mountains National Park (GSMNP or Park) in spite of strong hunting pressure (Stegeman 1938, Bratton 1975), control actions (Fox and Pelton 1977), and an outbreak of hog cholera (Stegeman 1938, Shaw 1940). Hogs were promoted and managed as big game animals on national forestlands, and soon the tradition of hunting "Russian Boar" was established in the Southern Appalachian region. Hogs from this original population later were transplanted and established in Polk, Morgan, and Cumberland Counties, TN (Conley et al. 1972:5), Lauderdale County in the Mississippi River bottomlands of West Tennessee (Tenn. Wildl. Resour. Agency 1981:182), California and New Hampshire (Presnell 1958), West Virginia (Igo et al. 1979), and Texas (Wood and Barrett 1979). Feral swine were reported to range over about 375,000 km^2 (Hanson and Karstad 1957) and 108,000 km^2 (Wood and Barrett 1979) of the Coastal Plain region of the southeastern United States.

Invasion of the GSMNP, an International Biosphere Reserve, by wild hogs during the 1940's has presented continuing management problems (Bratton 1975). Hogs presently occupy approximately 75% of the Park and are contrary to National Park Service policy of maintaining and protecting native flora and fauna in their natural state (National Park Service 1982). "Negative impacts have been documented in forest nutrient cycling, direct flora and fauna habitat disruption by rooting and wallowing, flora and fauna population decreases by grazing or depredation, direct competition for available forest mast, and as a co-host and reservoir of wildlife diseases" (National Park Service 1982:3). Control measures (mainly shooting) have met strong public and political opposition from hunting interests in North Caro-

lina. A cooperative citizen-volunteer program to trap and relocate hogs in North Carolina has alleviated some hunter and state opposition but has not been an effective control measure (National Park Service 1982). The program also has increased public pressure to relocate hogs into unoccupied U.S. Forest Service lands in North Carolina.

Concurrent with control actions (Fox and Pelton 1977) and food habits studies (Scott and Pelton 1975), data were also collected on reproductive biology of hogs in the GSMNP. Reproductive information is basic to understanding population dynamics, evaluating management actions, and evaluating the implications of transplants to expand the range for hunting stock. Our objectives are to report on: (1) sex and age structure, (2) age of puberty and periods of breeding capabilities, (3) periods of farrowing activity and farrowing frequency, and (4) average litter sizes of hogs in the GSMNP.

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Methods

The GSMNP comprises 2,074 km^2 in Cocke, Sevier, and Blount Counties, Tennessee, and Swain and Haywood Counties, North Carolina. This study was conducted primarily in the northwestern quarter of the Park. Most of the area is characterized by rugged, mountainous terrain, limited road access, and dense and diverse vegetation. Bratton (1974) listed 118 genera of plants that are included as potential food items in Eurasian studies on hogs that are also present in the GSMNP. Elevations range from 271 m to 2025 m and account for marked variations in climate (Shanks 1954).

Reproductive data were obtained from hogs that were collected by live-trapping (Matschke 1962, Williamson and Pelton 1971) or hunting between February 1971 and July 1973. Group-type permanent trap structures were also utilized (Fox and Pelton 1977). Hunting methods included daytime hunting, night hunting from vehicles, and night hunting while walking. Each hog was sexed, weighed, measured, and aged into 3 classes (<12, 12–26, >26 months) based on tooth eruption (Matschke 1967); data also were recorded on color and external appearance, location, time, weather, and collection method.

Upon necropsy, both testes of males were collected and preserved in Mossman's AFA (50% distilled water, 30%–95% ethyl alcohol, 10% for-

malin, and 10% glacial acetic acid). Length, width, weight, and volume were taken for each testis. A sperm smear was made from the tail of the epididymis and stained with Wright's stain. Each smear was examined under a compound microscope for the presence of mature, viable spermatozoa and if no identifiable sperm were found from the epididymis of 1 testis, the epididymis of the other was examined. Sexual maturity of males was assumed when viable sperm were found in the tail of the epididymis. Other characteristics noted at the time of dissection included: (1) turgidity or flaccidity of testes, (2) presence of convolutions in the tail of the epididymis, (3) condition of the seminal vesicles, and (4) the presence of semen in the tail of the epididymis. The total testes weight for each adult male hog was expressed as a percentage of the total body weight and plotted against the month of the year to determine if there were seasonal peaks in breeding activity of adult male hogs.

Reproductive tracts were removed from each female hog and preserved in AFA. Parameters noted during dissection included: (1) presence or absence of corpora lutea, (2) the presence or absence of mammary tissues, (3) lactation, (4) teat numbers and spacing, and (5) location of fetuses in the case of pregnant females. Measurements were taken on the width of the uterus (uterine body) and the width, length, weight, and volume of each ovary.

Fetuses, when present, were removed from the uterine horns and preserved in AFA. Fetuses were counted, measured, sexed when possible, and aged (in days) according to crown-rump measurements (Henry 1968). These data were utilized to establish approximate dates of conception and farrowing.

Ovaries were preserved in AFA, sectioned with a razor blade at 1.5 mm intervals, and examined under a dissecting scope for follicles, corpora lutea, and corpora albicantia (Corner 1915, Sweeney 1970). Measurements were recorded for all ovarian structures. Only corpora albicantia that measured at least 3 to 5 mm in diameter were utilized in determining puberty. This practice was adhered to because of the difficulty encountered in distinguishing between corpora albicantia and atretic follicles <3 mm in diameter. Corpora albicantia, of the above mentioned size, and corpora lutea served as the criteria for determination of puberty. Back-dating ages of fetuses to determine the actual breeding age also was used to determine age of puberty for female hogs.

The following data on litters were collected: (1) number of fetuses, (2) size of trapped litters, (3) field observations of young per female, and (4) number of functional (swollen) teats on lactating females.

Data on farrowing activity were collected by: (1) aging and back-dating fetuses, (2) aging and back-dating trapped young, (3) aging and back-dating

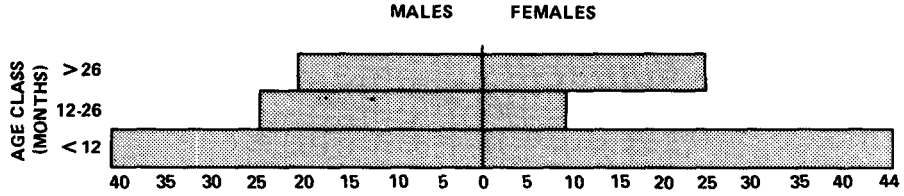

Figure 1. Sex and age composition of 161 European wild hogs in the Great Smoky Mountains National Park, 1971–1973.

adult hogs (<26 months old), and (4) field observations of young with females.

All hogs collected, with the exception of 6 fetuses, were sexed and this information, along with age, utilized in the sex and age analysis of the hog population in the Park.

Results and Discussion

Sex and Age Structure

One hundred sixty-two wild hogs were collected; 89 were live-trapped and 73 were shot. The male : female ratio for all age classes was 52 : 48, and the age composition consisted of 52% hogs <12 months old, 21% hogs 12–26 months old, and 27% hogs >26 months old (Fig. 1). Chi-square analysis indicated no sex difference in collection by trapping and shooting ($0.1 < P < 0.5$), but the R × C test of independence using the G-test (Sokal and Rohlf 1969:599) indicated that the collection method was not independent of age classes ($P < 0.005$). Hogs <12 months old were more likely to be trapped (77.4%) than shot (22.6%) and hogs >26 months old were more likely to be shot (75.0%) than trapped (25.0%). This difference may be partially attributed to multiple captures of young with females; a total of 45 hogs was captured together for an average of 2.8 hogs per multiple capture and a range of 2–5. Of the hogs 12–26 months old, 58% were trapped and 42% shot.

Fox and Pelton (1977) reported a similar trend for hogs collected in control actions in the Park from 1959–1972; the overall male : female ratio was 53 : 47 and the immature : adult ratio was 69 : 31 for trapped hogs and 34 : 66 for shot hogs. If the combination of trapping and shooting is considered to representatively sample the population, the overall immature : adult ratio of 62 : 38 (Fox and Pelton 1977) and the age composition from 1971–1973 (Fig. 1) may be indicative of an expanding population in the Park from 1959–1973. Additional data from 1976–1980 indicated a male : female

ratio of 53 : 47 and an age structure that also appeared indicative of an expanding population in the Park, but the number of hogs that were trapped and shot was not reported (Singer and Ackerman 1981:20).

Conley et al. (1972:118–123) reported a male : female ratio of 47 : 53 and an age composition of 31.6% hogs <12 months old, 33.6% hogs 12–26 months old, and 34.8% hogs >26 months old for hunter-harvested hogs on the Tellico Wildlife Management Area from 1961–1969. These data were similar to sex and age composition of hogs that were shot during control operations in the Park and indicated a possible bias in using only harvest data to monitor the status of hog populations.

Age of Puberty and Periods of Breeding Capabilities

Epididymal examinations of testes from 79 hogs indicated that maturation for male hogs occurred between 7.5 and 12 months. Nine of 12 hogs between the ages of 7.5 and 12 months were mature and all male hogs older than 12 months ($n = 42$) were sexually mature. Average testicular measurements were distinctly different between immature and mature male hogs (Table 1). Conley et al. (1972:82) reported that male wild hogs 8.5 months old successfully bred wild females in captivity. Sweeney (1970) found that male feral hogs reached sexual maturity between 5 and 7 months, and sperm were present in domestic hogs at 5 to 6 months of age (Day 1968).

Table 1. Average Testicular Measurements for Immature and Mature Male European Wild Hogs Collected in the Great Smoky Mountains National Park, 1971–1973

Age Class	Testis Length (cm.)	Testis Width (cm.)	Testis Volume (ml.)	Testis Weight (gm.)	Weight of Both Testes (gm.)
			Immature		
0– 6 days	1.61(2)[a]	1.12(2)	1.05(2)	1.09(2)	2.18(1)
6– 7 weeks	1.98(10)	1.28(10)	1.78(10)	1.84(10)	3.67(5)
7–19 weeks	2.49(16)	1.61(16)	3.73(16)	3.75(16)	7.50(8)
20–33 weeks	3.11(22)	1.95(22)	7.09(22)	7.02(22)	14.04(11)
30–51 weeks	3.98(6)	2.31(6)	14.50(6)	15.32(6)	30.63(3)
			Mature		
30–51 weeks	6.22(18)	4.20(18)	58.61(18)	56.76(18)	113.46(9)
12–15 months	7.09(14)	4.49(14)	86.25(14)	86.34(14)	172.67(7)
14–18 months	8.27(10)	5.82(10)	146.00(10)	139.31(10)	308.40(4)
18–22 months	8.03(10)	5.45(10)	129.50(10)	127.05(10)	254.09(5)
21–26 months	8.44(6)	5.55(6)	151.67(6)	148.96(6)	297.92(3)
26+ months	8.80(38)	6.02(38)	174.61(38)	169.75(38)	339.50(19)

[a] Sample size.

Spermatozoa were found during every month of the year and no seasonal differences were discernible when total testes weight, expressed as a percentage of the whole body weight, was plotted against the months of the year (Duncan 1974:27), further indicating year-round breeding capabilities for male hogs in the Park. Captive hogs from Tellico (Conley et al. 1972: 104), and feral (Sweeney 1970) and domestic (Day 1968) hogs also have been shown to be capable of breeding year-round.

Ovarian analyses of 72 reproductive tracts indicated that puberty in female wild hogs in the GSMNP was reached at approximately 6 months with a range of 5–8 months. The calculation of the age of puberty was made by differentiating between the age classes which showed no indications of ovarian activity and the earliest age class which did show signs of current or past ovulations. Sixteen (22.2%) of the 72 females were immature; 13 (81.2%) of these were <5 months of age. The 3 remaining immature hogs were 5 to 8 months of age. Forty-one (57.0%) of the 72 females were sexually mature with 17 (41.4%) in the 5 to 8 month age class and 24 (58.6%) older than 8 months. Fifteen (21.0%) of the 72 females were older than 8 months but exhibited no signs of ovarian activity; all were collected during the fall of 1972, a period of low oak mast production (Tenn. Wildl. Resour. Agency 1981:54) and utilization (Scott and Pelton 1975). Sorensen et al. (1961), Matschke (1964), Day (1968), and Singer and Ackerman (1981:25) discussed the complex relationships between the plane of nutrition and ovarian activity in hogs.

Conley et al. (1972:82) reported an average breeding age of 9.2 months (range 6.9–11.1 months) for 9 captive female hogs; 17 of 20 captive females, age 7.0 to 8.5 months, became pregnant when bred by 8.5 month old males. Sweeney (1970) reported 9 months to be the age of puberty in female free-ranging feral hogs in South Carolina and domestic hogs reach puberty between 5 and 8 months (Lasley 1968).

Although physiologically capable of conceiving at approximately 6 months, the extent that this young segment contributes to recruitment is unknown and varies in response to oak mast abundance (Matschke 1964, Singer and Ackerman 1981:25). Cases of 5- to 7-month-old females conceiving and farrowing in the wild have been reported (Conley et al. 1972:83, Pine and Gerdes 1973, Singer and Ackerman 1981:25), but Singer and Ackerman (1981:25) found the age of first conception of successful litters in 8 radio-collared or marked females to be 16.8 ± 0.8 months (range 7.5–24), suggesting that young females exhibited pseudo-estrous (Duncan and Lodge 1960) or were inhibited from breeding through other factors.

Once puberty is reached female wild hogs, like male wild hogs, are physiologically capable of breeding year-round.

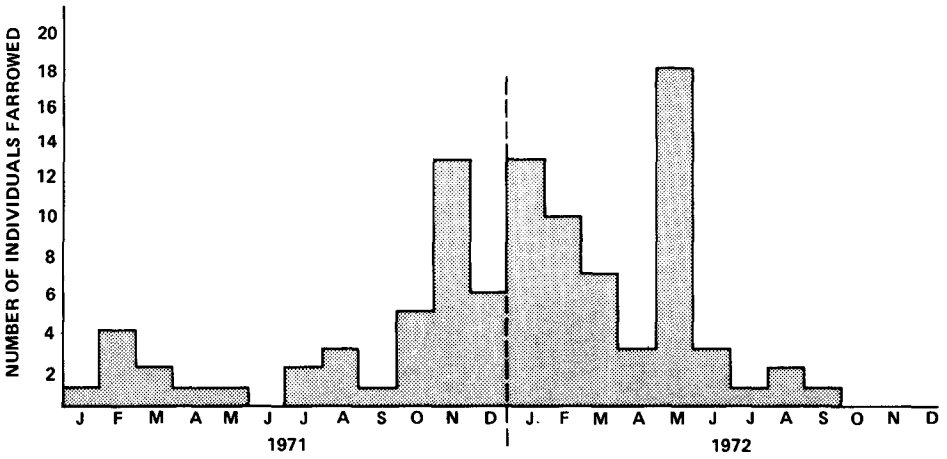

Figure 2. Farrowing activity of 97 European wild hogs in the Great Smoky Mountains National Park, 1971–1972.

Periods of Farrowing Activity and Farrowing Frequency

Approximate farrowing dates for 97 (<26 months old) of the 162 hogs collected in the GSMNP were calculated by back-dating tooth-eruption ages from collection dates. Farrowing activity occurred year-round but 2 peaks occurred, one in late fall-early winter (Nov., Dec., Jan.) and the other in May (Fig. 2).

Examination of 6 fetal litters revealed that 4 of 6 would have been farrowed during a late spring-early summer period from April to June. Of the remaining 2 litters, one would have been farrowed in March and the other during December.

Field observations included the sightings of 23 striped piglets, 21 of which were seen with 6 females. Young from the 3 female-young groups, from which no young were collected, were calculated to have been farrowed in May. The 2 solitary young were calculated to have been farrowed in July. Thus, the majority (15 of 20 uncollected young) were calculated to have been farrowed during the late spring-early summer farrowing season.

Conley et al. (1972:104–115) also reported that farrowing occurred in all seasons but 2 peaks occurred, predominantly in January and May. Pine and Gerdes (1973) found that some farrowing occurred during every month, but most occurred from October through June with March being the peak; little farrowing took place from July through September. Sweeney (1970) reported a January to February farrowing peak for feral hogs in South Carolina but could not determine if farrowing activity in April through July was a separate peak or simply a result of a gradual decrease in activity from the

mid-winter farrowing peak. Singer and Ackerman (1981:28) observed no distinct farrowing peaks, although general cessation of births was observed from August to November; 41% of young were born between March and May (Singer 1981).

Conley et al. (1972:115) attributed winter farrowing activity to the high nutritive value of oak mast which likely stimulated the reproductive and endocrine system because conception dates for fall breeding occurred soon after mast became available. Such winter farrowing is apparently not extensive on native ranges in Europe (Conley et al. 1972:115, Singer 1981). Conley et al. 1972:110) also reported that winter is the main farrowing season in good mast years, but spring contributes most to the population because of high mortality of winter-born litters. Females that lose their litters in winter may breed again and farrow in the late spring-summer farrowing season, as do some young females breeding for the first time (Conley et al. 1972:110).

Collection of 2 pregnant females accompanied by young (5 to 8 months old) indicated the possibility of 2 litters being produced in <1 year. Both observations followed good mast production in the fall of 1971. Production of 2 surviving litters in 1 year occurred in 3% (Singer and Ackerman 1981:25) to 5% (Singer 1981) of the females sampled in the GSMNP from 1976–80 and again was associated with good mast production. Conley et al. (1972:94, 103) reported that pen-reared hogs were physiologically capable of producing 2 litters annually but found no evidence that wild females produced more than 1 surviving litter per year.

Litter Size

Average litter size for 6 pregnant females based on fetal counts was 3.0 with a range of 2 to 4; 6 were females, 6 were males, and 6 were not sexed. This value was lower than the average litter size ($\bar{x} = 4.8$) reported for wild and captive European hogs (Henry 1966, Conley et al. 1972:100). Pine and Gerdes (1973) stated the number of fetuses for wild females in California averaged 5.0 with a range of 1 to 9. Sweeney (1970) reported that the average litter size of feral hogs in South Carolina was 7.4. Catchpole (1969) gave the litter size for domestic hogs as being between 8 and 12.

Sixteen multiple-captured groups, involving 41 animals that were judged to be partial or complete litters, yielded an average litter size of 2.8, with a range from 2 to 5.

Ninety hog sightings were made during the course of the study; 23 of the 90 sightings involved female and young groups. Six adults were seen with a total of 21 striped young for an average litter size of 3.5 and a range of 2 to 5. Pine and Gerdes (1973) reported 4.2 as the average litter size as determined by field observations for the California population of wild hogs.

The number of lactating teats also was used as an indirect indicator of

litter size. Observations on 7 lactating females collected during the study period indicated an average litter size of 3.8 with a range from 2 to 5. Conley at al. (1972:94) substantiated this technique by reporting that the number of functional teats of European wild hogs was highly correlated with litter size and that litter size recorded for trapped wild females averaged 4.2 and ranged from 1 to 8.

Average litter size based on all methods of determination [fetal counts (3.0), trapped litters (2.8), litters observed in the field (3.5), and number of lactating teats (3.8)] was 3.3 with a range from 1 to 5. Both the average litter size and ranges were fairly consistent among methods but generally were lower than published litter size reports cited by Wood and Barrett (1979). Reasons were unclear but may have involved small sample sizes, low mast production in the fall of 1972 and other habitat differences. Matschke (1964), Henry (1966) and Singer and Ackerman (1981:27) also reported smaller litter sizes in years of low mast production and documented the sensitivity of ovulation rates and general ovarian activity to mast yields in the Southern Apalachian region.

Litter size among domestic hogs varies considerably among individual animals, between successive farrowings by the same female, and in relation to age, parity, and inherent reproductive ability (Day 1968). The genetic composition of the hog population in the GSMNP has not been evaluated through cytogenetic studies but external examination indicated that 100 of 150 hogs (66.7%) exhibited the European phenotype (solid black or grizzled). The Tellico hog population was composed of 58.7% European wild stock and 41.3% domestic stock (Conley et al. 1972:60). The degree that interbreeding influences inherent reproductive ability is unknown, but these complex interactions may account for the observed variability in litter sizes.

Management Implications

The young age of puberty, year-round breeding capabilities, the polytocous nature, and the possibility of 2 litters per year indicated the high reproductive potential of hogs in the GSMNP. Although litter sizes in the present study were slightly smaller than reported from other populations, the productivity of hogs in the GSMNP was evident, particularly during years of good mast production. Wood and Barrett (1979:242) stated that wild pigs are "the most prolific large mammal in the U.S." Although other factors are involved in hog management in the Southern Appalachian region, reproductive biology contributes vital information to the issues of management and transplanting of hogs. The high biotic potential accompanied by high mobility (Singer et al. 1981) and a lack of effective control techniques (Fox and Pelton 1977) indicated that range expansions both through transplants and

dispersal should be discouraged because hogs cannot be contained exclusively within release areas. The Wildlife Society (1975) in its policy on introductions of exotic species states "that no state, provincial, or national agency shall introduce, or permit to be introduced, any exotic species into any area within its jurisdiction unless such species can be contained exclusively within that jurisdiction, or unless adjoining jurisdictions into which the species could spread have sanctioned the introduction officially."

Hogs present many negative ecological and sociological impacts (National Park Service 1982) in contrast to many positive benefits as a unique hunting opportunity (Conley et al. 1972:246). A thorough interdisciplinary analysis in accordance with evaluation criteria presented by The Wildlife Society (1975) should be conducted to formulate a consistent hog policy in the Southern Appalachian region. A comprehensive, regional management plan, agreed upon by natural resource scientists, would facilitate proper management and minimize public and professional conflicts concerning hogs.

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