

Original Article

The prenatal mortality rate of the wild boar (*Sus scrofa*) in Gunma Prefecture

ANEZAKI Tomoko

Gunma Museum of Natural History: 1674-1, Kamikuroiwa, Tomioka, Gunma 370-2345, Japan
(anezaki@gmnh.pref.gunma.jp)

Abstract: The reproductive status of wild boar (*Sus scrofa*) is evaluated based on the examination of ovaries, a number of corpus luteum, retrograded corpus luterum, and embryos or fetuses. These data are used to estimate number of ovulation, number of implantation and the rate of pregnancy. However, it is known from the studies of domesticated pigs that number of piglets per swine is highly influenced by not only the number of ovulation and implantation, but also the fetal mortality rate. Therefore, in this study, the reproductive performance of female wild boar is investigated based on their fetal mortality rate.

A total of 401 female wild boars collected from April 2007 to June 2011 were used in this study. Out of 401 samples, corpus luteum and embryo/fetus were found in 78 individuals. The average number of corpus luteum was 5.7, average number of embryo or fetus was 4.2, and overall prenatal mortality rate was 27.2%. The percentage of degenerated embryo or fetus was high at 60 and 100 days at pregnancy at 22.6% and 27.3%. The high survival rate of embryo or fetus indicates the successful reproduction of boars in Gunma Prefecture, which implies further increase in the number of boars in the region.

Key Words : *Sus scrofa*, prenatal mortality, corpus luteum, embryo, fetus, degeneration

Introduction

It is important to evaluate the reproductive status of boars throughout the year based on a long term survey in order to understand the population dynamic of boars and assess the impact of different management strategies. The wild boar (*Sus scrofa*) has adapted well to the natural environment of Gunma Prefecture. Their distribution has expanded to lowlands, and the frequent appearance of boars in the human habitat had increased the conflicts, such as damage to agricultural crops, in the past 10 years.

The reproductive status of wild boar (*Sus scrofa*) in Japan is mainly investigated during the hunting-season and the reproductive performance of boars differed among prefectures (Kanzaki, 1993; Nature Conservation Division of Chiba Prefecture and Boso Deer Research Group, 2001, 2002; Wildlife Management Office Inc., 2001; Japan Wildlife Research Center, 2002). The number of ovulation, number of implantation and the rate of pregnancy are evaluated based on the examination of ovaries, a number of corpus luteum, retrograded corpus luterum, and embryos or fetuses. However, it is known from the studies of domesticated pig that the number of piglets per swine is highly influenced by not only the number of ovulation and implantation, but also the fetal mortality rate (e.g. Tsutsumi, 1970a). The reproductive success of wild boar is known to be high compared to other ungulates (Kaminski *et al.*, 2005; Keuling, 2009), but there are no studies investigating the prenatal mortality rate of the Japanese wild boar as there are for *Sus scrofa* in other countries (e.g. Baber and Coblenz, 1986, Nahlik and Sandor, 2003), and it needs to be examined for understanding their reproductive

status. Therefore, the aim of this paper is to evaluate both the number of ovulation and the prenatal mortality rate of the wild boar in Gunma Prefecture.

Materials and methods

The ovaries and uteri of 401 female wild boars were collected from April, 2007 to June, 2011 in Gunma Prefecture (Fig.1). The ovaries were examined visually from the outside and then dissected to determine the presence of corpus luteum, follicles and corpus albicantia. The number of corpus luteum on left and right ovaries was counted. The presence of corpus luteum indicated the number of ovulation that had occurred for the individual implying the number of potential fetuses present. The uteri were cut off along with ovaries from the individual for close examination to check for pregnancy. The length of horns and tubes of the uterus were measured. The uterus was cut open along the antimesenterial line, the position of the embryos and fetuses was recorded to estimate the number of litters produced by females based on Andersen (1927), Warwick (1928), Patten (1948), Tsutsumi (1970a, 1970b), Matsumoto (1985), Rural Culture Association Japan (1986) and Bruzewicz (2000). The embryo or fetus located closest to the tube was numbered as L1 or R1; L and R corresponding to the left and right uterus horns, respectively. The number increases as the embryo or fetus is located closer to the ovaries. Embryos or fetuses were weighed and gender was determined in a fetus whenever sexual characteristics could be distinguished. In general, the gender could be determined in a fetus measuring more than 5cm (Patten, 1959). The crown-rump



Fig.1. Sampling locations of the wild boar in Gunma Prefecture. The line indicates the municipal boundaries. Sample numbers are shown in parentheses. Darker shaded areas indicate higher elevation. The darkest for altitude over 2,000m, dark for 1,000 to 2,000m, light dark for 500 to 1,000m, slight dark for 200 to 500, light gray for 100 to 200, white for 0 to 100m.

length was measured to estimate embryo or fetus age (Patten, 1959 ; Marrable and Ashdaown, 1967 ; Matsumoto *et al.*, 1985 ; Gethoffer *et al.*, 2007) . A gestation period of 114 days was used for estimating the age of embryo or fetus (Rural Culture Association Japan 1986; Niwa *et al.*, 1994) .

The rate of prenatal mortality and rate of degenerated embryo or fetus were calculated according to Hammond(1921) , Corner (1923) , Warwick(1928) , Pomeroy(1960) , Tsutsumi(1970a, 1970b) , Matsumoto(1985) , and Rural Culture Association Japan (1986) .

Result

Of the 401 individuals collected, 78 individuals had embryos or fetuses. All of these pregnant females were captured between the months of December to August (Fig.2) . We found 448 corpus luteum and 326 live embryos and fetuses. We estimated an over-all prenatal mortality as 27.2%(122/448, Table.1) . The mean number of corpus luteum was 5.7, mean number of the live embryo or fetus per female was 4.2 (Table.1) , and the sex of fetus was 130 male and 134 female (Table.2) . The initial ten days of the pregnancy had the highest prenatal mortality rate (75%) (Table.1) . At 60 days and 100 days of pregnancy, the percentages of degenerated embryo or fetus were 22.6% and 27.3% respectively, whereas the average of degenerated embryo or fetus was 10.2%.

(number of individuals)

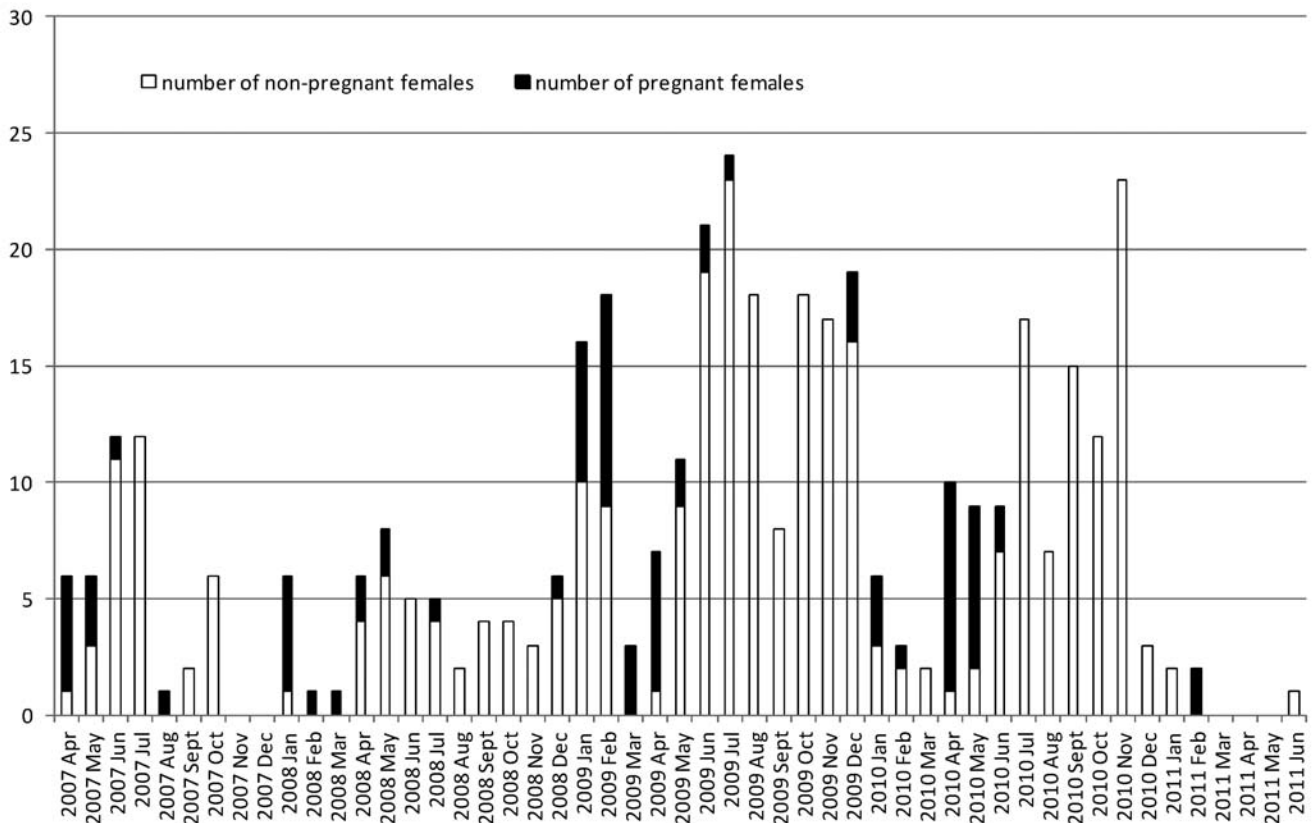


Fig.2. Seasonal changes in pregnancy rate of female wild boars collected from April, 2007 to June, 2011 in Gunma Prefecture.

stage of pregnancy (days)	number of uterus	number of corpus luteum			distribution of live embryo/fetus in the uterus												number of live embryo/fetus			distribution of degenerate embryo/fetus in the uterus												number of degeneration			% degenerate	corpus luteum	live embryo/fetus	number of lost ovum	prenatal mortality rate			
		L	R	Total	L						R						L	R	Total	L						R						L	R	Total	(%)	mean	mean	mean	(%)			
					1	2	3	4	5	6	1	2	3	4	5	6				1	2	3	4	5	6	1	2	3	4	5	6											
10	3	4	8	12	3													3	0	3												0	0	0	0.0%	4.0	1.0	3.0	75.0%			
20	6	19	19	38	5	4	4	1						5	5	2			14	12	26			1								1	0	1	3.7%	6.3	4.3	2.0	31.6%			
30	7	21	17	38	6	4	2	1	1					6	6	2			14	14	28			1				1					2	1	3	9.7%	5.4	4.0	1.4	26.3%		
40	1	2	5	7	1	1	1							1	1	1			3	3	6										0	0	0	0.0%	7.0	6.0	1.0	14.3%				
50	9	24	31	55	10	9	5	2						10	8	7	2			26	27	53				1	3	1	1			2	1	1	15.9%	6.1	5.9	0.2	3.6%			
60	5	14	19	33	5	4	3							3	5	1	3			12	12	24				1	1			2	2	1	22.6%	6.6	4.8	1.8	27.3%					
70	16	38	49	87	16	2	9							12	9	5				27	26	53							1				0	1	1	1.9%	5.4	3.3	2.1	39.1%		
80	12	33	37	70	11	11	3	3	1					11	6	4	2	2	2	29	27	56	1						1				2	2	4	6.7%	5.8	4.7	1.2	20.0%		
90	13	27	46	73	12	9	4	2						12	11	5	1			27	29	56	1				1	1	1					1	3	4	6.7%	5.6	4.3	1.3	23.3%	
100	5	16	13	29	3	2	3							4	3	1				8	8	16	1	1				1	1	1					2	4	6	27.3%	5.8	3.2	2.6	44.8%
110	1	2	4	6	1	1								1	1	1				2	3	5											1	0	1	16.7%	6.0	5.0	1.0	16.7%		
total/mean	78	200	248	448	73	47	34	9	2	0	65	55	29	8	2	2	2	165	161	326	4	4	5	2	1	1	6	4	6	3	1	0	17	20	37	10.2%	5.7	4.2	1.6	27.2%		

Table.1. Result of the analysis of corpus luteum and embryo or fetus of female wild boar in Gunma Prefecture. Prenatal mortality was calculated from the ratio of number of lost ovum/number of corpus luteum. Percentage of degeneration was calculated from the ratio of number of degenerated embryo or fetus/ total number of embryo or fetus identified. L and R correspond to left and right side of uterus.

stage of pregnancy (days)	male		female		unknown	
	L	R	L	R	L	R
10						3
20					14	12
30					14	12
40	1		2	3		
50	7	6	16	18		
60	7	6	5	5		
70	20	12	16	14		
80	13	17	16	10		
90	15	18	12	11		
100		5	1	3		
110	1	2	1	1		
total	64	66	69	65	31	24

Table.2. Sex of embryo or fetus. L and R correspond to left and right side of uterus.

Discussion

The number of ovulation, number of implantation, the rate of pregnancy and the rate of prenatal mortality are the important factors in understanding the reproductive status of wild boar. The reproductive rate of Japanese wild boar was said to be 100% (Japan Wildlife Research Center, 2001); however, our study show that we had 27.2% intrauterine loss in wild boar of Gunma Prefecture. This value is relatively close to the result of 30.6% loss reported by Abaigar (1992) and much higher than the result of 18% reported by Cellina (2008), 14% reported by Mauget (1972) or 12% reported by Nahlike and Sandor (2003). The most prenatal losses occurred at initial 10 day stage. According to Wu *et al.* (1989), when a number of ovulations exceeded the maximum capacity of uterine horns, number of embryo or fetuses was correlated highly with uterine length. Wu *et al.* (1989) also showed that by restricting uterine space available to each potential embryo or fetus at the initial stage, the embryo or fetus mortality rate became higher at 50 day stage, increasing the percentage of degenerated embryo or fetus after 20 day stage. The crowding of uterus with numerous embryos may be the cause of high prenatal mortality at initial stage of pregnancy. The marked rise in prenatal mortality at 60 day and 100 day

stage may due to body condition of the individual along with the uterine capacity. Pere *et al.* (1997) demonstrated that availability of energetic and gluconeogenic substrates was important for the survival of embryo or fetus at 110 day than 60 day stage in the domestic breeds, suggesting that metabolic adaptations were related to the development of embryo or fetus at the late stage of pregnancy and the final litter size. Considering the embryo or fetus losses occurring throughout the pregnancy period, the prenatal mortality rate needs to be taking into account in estimation of the reproductive status of wild boar.

The wild boars in Gunma Prefecture exhibited seasonal breeding patterns. The estimated season of birth was March to September, indicating their mating season to be November to May based on the gestation period of 114 days. The mono-modal pattern with peak at April to June was different from the result reported in Chiba Prefecture (Nature Conservation Division of Chiba Prefecture and Boso Deer Research Group 2002), where the pregnant individual were identified throughout the year. The winter mating and spring-summer birth patterns in Gunma Prefecture were similar to those reported by Kanzaki (1998) from Hyogo Prefecture, Japan. A similar pattern was also observed in from Germany (Briedermann, 1971), France (Mauget, 1982; Aumaitre *et al.*, 1984) and Pakistan (Ahmad *et al.*, 1995).

The mean live embryo or fetus number of 4.2 per female in Gunma Prefecture was a similar trend compared to 4.5 in Tochigi Prefecture and 4.6 in Ibaragi Prefecture (Nagata *et al.* 2006). Many estimates have been made for the birth rate of wild boar in different European countries as well; such as 3.58 in Villuercas (central-west of Spain) (Fernandez-Llario and Mateos-Quesada 1998), 4.1 in Almeria (east of Spain) (Abaigar 1992), 4.2 in Burgos (northern Spain) (Saez-Royuela 1987), 4.17 in Portugal (Fonceca *et al.* 2004), 4.62 in France (Mauget, 1972), 5.8 in Austria (Martys, 1982), and the majority of a litter size was 4 to 5 piglets (Nahlik and Sandor, 2003). The mean live embryo or fetus number of Gunma Prefecture and the surrounding prefectures falls within this majority.

According to Fonseca *et al.* (2004), the number of fetus per female was high in the areas of sustainable food availability, favorable climate, but it varied in particular with the quantities of acorn mast produced. However, Groot Bruinderink and Hazebroek (1994), and Nahlike and Sandor (2003) suggested that easy access to man-made resources, such as agricultural fields, in poor mast year during the winter season, will have similar effect as supplemental feeding maintaining their reproductive status to

be high. The analyses of stomach contents of wild boars from the east region of Gunma Prefecture suggest that wild boars had access to both natural and agricultural resources throughout the year (Anezaki *et al.*, 2011). The investigated population was mostly wild, and low in the degree of hybridization between wild boars and domestic breeds (Takahashi *et al.* 2009, 2010). The combination of good habitat quality and favorable climate may further increase the population density of wild boar in Gunma Prefecture in near future.

To conclude, this study evaluated the reproductive performance of wild boar in Gunma Prefecture. The season of birth was monophasic ranging from March to September. Their reproduction was successful with prenatal mortality of 27.2%, with sex ratio of 1 to 1 for male and female. The occurrence of degenerated embryo or fetus indicates that not only the rate of pregnancy, but also the prenatal mortality rate is an important factor in understanding the reproductive status of the wild boar.

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群馬県におけるニホンイノシシ (*Sus scrofa*) の出生前死亡率

姉崎智子

〒370-2345 群馬県富岡市上黒岩1674-1 群馬県立自然史博物館

要旨: 捕殺個体を利用したイノシシの繁殖状況の評価方法として、卵巣の観察による黄体と黄体退縮物の検出、子宮内の観察による胎児の検出、卵巣の組織観察がある。これらのデータは、排卵数、着床数、妊娠率の推定に用いられることが多い。しかしながら、イノシシにおける1腹あたりの出産頭数は、排卵数、着床数に加え、胎児の発育が進み娩出されるまでの間において死亡し退化する卵子、あるいは、胎児数によって大きく左右される。本研究では、イノシシの排卵数、胚胎の子宮内分布とその死亡状況をモニタリングすることで、出生前死亡率について検討することを目的とした。

2007年4月から2011年6月までに自然史博物館に搬入された401体のイノシシメスの内、胚胎が確認された78体について、胚胎の子宮内分布と退化状況を観察した。1腹あたりの平均黄体数は5.7個、平均胚胎数は4.2個であり、出生前死亡率は27.2%と推定された。子宮内退化胚胎児の死亡率は、推定胎齢日60日と100日で22.6%、27.3%と高い値が示された。胎児の高い生存率は、群馬県においてイノシシは良好に繁殖していることを示し、今後、さらなる生息数の増加が予測される。

キーワード: *Sus scrofa*, 出生前死亡率, 黄体, 胚, 胎児, 退化胚胎児