



# Comparison of Serum Testosterone Levels in Male Wild Boars and Domestic Pigs in Japan

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**Simple Summary:** It is important to develop methods to effectively utilize harmful wild animals such as wild boars. To investigate the characteristics of wild animals as food, we examined serum testosterone levels in male boars and pigs. Testosterone has an analeptic effect even in small amounts. Testosterone was detected in wild boars, as in other large mammals, but not in pigs, which are castrated shortly after birth. Male wild boars are thus a good food source from which to obtain testosterone.

**Abstract:** (1) Background: The numbers of wild animals in Japan are increasing due to changes in the industrial structure and a decline in the population. Various extermination approaches have been used against animals that are classified as harmful, such as boars. Making effective use of exterminated wild animals will revitalize extermination activities by developing markets as the number of hunters declines. We measured serum testosterone levels to examine the potential value of male wild boars as a meat source and compared them with the testosterone levels in domestic male pigs. Testosterone has an analeptic effect even in small amounts. (2) Methods: Blood testosterone levels were measured by electrochemiluminescence in wild boars and domestic pigs, collected using box traps in Sasebo City. (3) Results: Almost no testosterone was detected in the sera of castrated domestic male pigs, and more testosterone was detected in wild male boars than in pigs. (4) Conclusions: The analysis demonstrated that male wild boars have unique nutritional value compared with domestic pigs.

**Keywords:** androgen; nutrition; food; population



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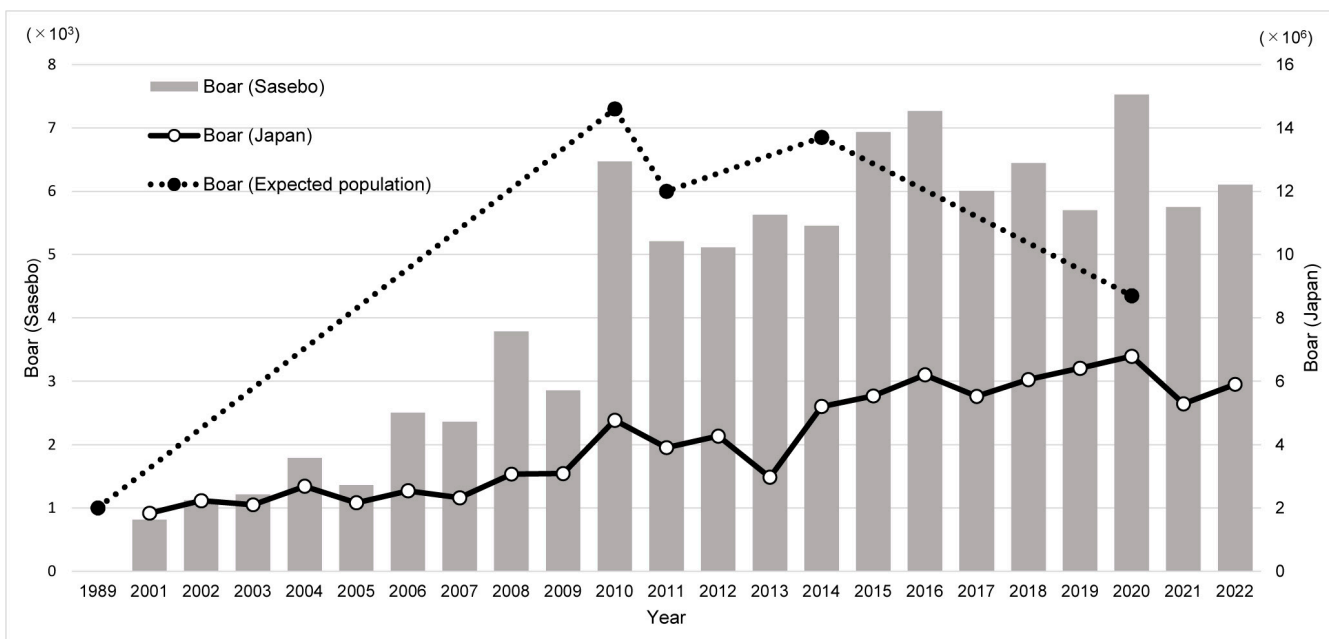
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## 1. Introduction

Globally, the population of wildlife has declined by more than two-thirds in less than 50 years [1], and the protection of wildlife is becoming increasingly important. The numbers of harmful invasive animals, including deer, boars, bears, and raccoons, are increasing in Japan, accompanied by damage to agriculture and residential areas. At present, municipal authorities are capturing many animals and disposing of them as general waste. As the number of captured animals increases, safe and efficient disposal methods are needed. This process of adjusting to the increasing numbers of wild animals, and establishing effective ways to utilize them, will become important issues for Japan in the future (Figure 1). The population of wild boars in Japan increased from 200,000 in 1989 to 1.45 million in 2010, and was reportedly 720,000 in 2021 [2], causing in increased damage to crops (Figure 1). Sasebo City in Nagasaki Prefecture prospered as a coal mining area and developed into a typical Japanese city after the energy revolution. In Sasebo, 7.5 times more wild boars were caught in 2022 than in 2001 (Figure 1, Table 1).



**Figure 1.** Estimated population and number of captured wild boars in Japan. Boar (Japan), (expected population) refer to number of captured boars and the estimated boar population from captured boars [2].

Feeding methods have been devised for livestock to raise them efficiently while considering animal welfare. Infections in pigs caused by fighting are prevented by tail cropping, incising teeth, and castration. In addition, appropriate antibiotics are administered. It is thought that the nutritional content of domestic pigs and wild boars is different considering their living environment. Hormones are nutrients that are thought to have health benefits when consumed by humans in small amounts. We investigated the difference in the serum testosterone levels between domestic pigs and wild boars. We measured the blood testosterone levels in wild boars to examine whether these animals are suitable as food. Testosterone is a low-molecular-weight androgen and is expected to have beneficial effects on depression and climacteric symptoms, even when ingested in small amounts [3]. As testosterone may have nutritional value, we compared its levels in the sera of domestic pigs and wild boars.

**Table 1.** Number of captured harmful animals in Sasebo.

Species \ Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Boar	812	1120	1212	1789	1359	2507	2361	3785	2854	6470	5210	5113	5628	5455	6934	7268	6006	6445	5704	7525	5751	6105
Boar (Japan) × 10 <sup>3</sup>	183	223	210	268	216	254	232	307	309	478	391	427	297	521	554	620	553	605	641	670	529	590
Raccoon Dog			2	1	30	27	24	46	36	72	116	180	246	223	233	268	191	105	177	187	178	188
Badger					75	60	72	90	152	142	162	222	213	273	209	257	240	239	177	250	341	301
Raccoon					18	57	67	109	152	466	385	654	690	634	659	848	634	745	924	1316	938	1025
Deer						4	11	10	14	17	32	30	67	65	51	83	62	112	189	195	314	331
Crow	520	1103	871	336	371	938	886	768	768	885	547	531	726	735	1854	703	428	573	462	795	432	822
Duck Pheasant		41	51	14	29	26		4	23	1	3	7	10	2								
Pigeon Heron			4	3	13				8						62							

## 2. Materials and Methods

These experiments were approved by the Institutional Committee of Laboratory Animal Experimentation and Ethics of Nagasaki International University (ID No. 179). Immediately after sacrifice, 1 mL blood samples were collected from 7 male adult (>40 kg) and 3 prepubertal ( $\geq 35$  kg) boars captured in box traps in Sasebo City. Blood was also collected from 6 male domestic pigs at Kuroshio Pork, Co., Ltd. (Miyazaki, Japan). The domestic boars were castrated within 5 days of birth and were approximately 160 days old. The collected blood was stored at 4 °C for 1 day, and serum was then separated by centrifugation and stored at −70 °C. Testosterone in the collected serum was measured by electrochemiluminescence immunoassay (ECLIA; Oriental Yeast Co., Ltd., Shiga, Japan). The limit of detection of the ECLIA was 0.03 ng/mL.

Data are expressed as the mean  $\pm$  standard deviation. The normality of the data distribution was determined by the Shapiro–Wilk normality test. Statistical analysis was performed using Student’s *t*-test and one-way analysis of variance followed by Dunnett’s or Tukey’s test. A *p*-value < 0.01 was considered significant.

## 3. Results

The number of wild boars is reported to be increasing nationwide, including in Sasebo City, and numbers caught have plateaued in recent years due to the limited number of people who can capture them. To investigate the nutritional value of male boars captured in Sasebo City, we examined their serum testosterone levels. These levels ranged from 0.26 to 8.53 ng/mL (Table 2). Testosterone was also detected in prepubertal boars (boars 1, 2, and 8 in Table 2), although at lower levels than in adults. In contrast, almost no testosterone was detected in the blood of castrated male pigs raised under conventional conditions (Table 2).

**Table 2.** Testosterone in serum of male boars and pigs.

Title 1	Body Weight (kg)	Day of Sampling	Testosterone (ng/mL)
Domestic pigs *	90.0 $\pm$ 7.1	7 November	0.03 > ***
Wild boars **	38.5 $\pm$ 12.2	7 October to 23 January	3.6 $\pm$ 3.6 ***
boar 1	10	10 October	0.26
boar 2	35	13 October	0.65
boar 3	40	46 October	2.08
boar 4	40	7 October	2.48
boar 5	40	19 October	6.27
boar 6	50	11 October	10.1
boar 7	46	16 January	8.53
boar 8	30	19 January	0.40
boar 9	54	19 January	3.84
boar 10	40	23 January	1.10

The limit of detection of the assay was 0.03 ng/mL. \* Average value for 6 pigs. \*\* Average value for boars 1 to 10 in the electrochemiluminescence immunoassay. \*\*\* *p* < 0.001. Mean  $\pm$  S.D.

## 4. Discussion

While populations of wild animals are decreasing due to environmental changes, the numbers of some wild animals are increasing, resulting in damage to agriculture and residential areas. There are several possible reasons for these increases in numbers, but the extermination of bears is thought to be one reason for the increase in the population of wild boars in Kyushu, Japan, as it has left humans as their only predators. Moreover, humans are now concentrated in specific areas, leading to significant environmental changes in mountainous regions, including increased numbers of wild boars in these areas. Humans rarely hunt wild boars because the breeding of pigs, which are domesticated boars, is now well established. It is important to control the number of wild boars to maintain a natural environment. Domestic pigs are treated with hormones in other countries, and in Japan, they are treated with antibiotics to suppress the risk of zoonotic diseases. Although wild

boars carry the risk of zoonotic diseases [4], those that are handled with care, including the use of appropriate cooking methods, are considered to be useful as a drug-free food source.

In this study, we examined the edible value of wild boars, which are usually captured and discarded; we compared the blood levels of testosterone, a nutritional hormone that is expected to have an effect when ingested in small amounts, between wild boars and pigs. The findings shed light on the value of boars as a natural food source and can be expected to lead to more effective control of wild boar populations by provision of a market for wild boar meat. Testosterone, a low-molecular-weight hormone, is expected to be effective in small amounts when ingested and to have beneficial effects on depression, erectile dysfunction, late-onset hypogonadism, and other nutritional and tonic purposes [3]. We found that testosterone was almost undetectable in castrated domestic pigs, but we detected it at various levels in wild boars, regardless of body weight.

Differences among individuals in the level of testosterone are thought to be due to individual health status or the male sexual cycle [5]. Although we did not measure serum concentrations of dihydrotestosterone, a male hormone that is expected to have a stronger effect, wild boars are thought to have higher ratios of dihydrotestosterone to testosterone in their serum than domestic pigs. Testosterone is transported in the blood to the muscles and affects muscle mass [6]. The blood is drained after slaughter, but not completely. Here, we measured serum testosterone, and the higher testosterone levels in boars than in pigs are thought to be reflected in their processed meat.

In a study from Europe, the average annual testosterone level in wild boars was  $7.6 \pm 6.3$  ng/mL, with the highest average level of 14.0 ng/mL measured in October, during the mating season [7]. We found that the average testosterone level in adult male wild boars in Japan (excluding boars 1, 2, and 8 in Table 2) was  $4.9 \pm 3.45$  ng/mL in October and January. Thus, testosterone levels in Japanese and European male wild boars do not differ significantly, considering subtle seasonal differences.

The reference range for total testosterone in Japanese adult men is reportedly 2.0–7.5 ng/mL [3]. Average testosterone levels of bears in the reproductive season [8], deer in the pre-rutting season [9], donkeys [10], and hemi-castrated cattle [11] are reportedly 17, 2.26, 5.85, and 10 ng/mL, respectively, and the testosterone level of adult mice bred in the laboratory is reportedly 0.2 ng/mL [12]. Our results confirmed that wild boars have average testosterone levels, similar to most large mammals. Wild boar meat is a better food than pork for patients with late-onset hypogonadism, who may benefit from testosterone supplementation. On the other hand, eating too much wild boar meat may not be good for healthy people and children because it may act like an environmental hormone.

Although some captured wild boars are used as food, many are discarded. Based on our findings, wild boars may be used as food, with characteristics different from those of the meat of domestic pigs. Focusing on the nutritional value of wild animals and reassessing their value as food will increase demand for wild boars, create commercial value, and encourage research. This approach is expected to increase the number of professional hunters and eliminate wild boars from the environment. Advances in research will lead to the development of more effective attractants and improved capture methods to facilitate slaughter.

## 5. Conclusions

The analysis demonstrated that male wild boars have unique nutritional value compared with domestic pigs. Wild boar meat is considered to be a beneficial food for human health that may be effective against erectile dysfunction and late-onset hypogonadism.

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