FULL PAPER *Surgery*

Canine tumor development and crude incidence of tumors by breed based on domestic dogs in Gifu prefecture

Satoshi KOMAZAWA[1)], Hiroki SAKAI[1,2)], Yusuke ITOH[2)], Mifumi KAWABE[2)], Mami MURAKAMI[1,2)], Takashi MORI[1,2)] and Kohji MARUO[1,2)]*

[1)]*The United Graduate School of Veterinary Sciences, Gifu University, Yanaghido 1–1, Gifu, Gifu 501–1193, Japan*
[2)]*Comparative Cancer Center, Gifu University, Yanaghido 1–1, Gifu, Gifu 501–1193, Japan*

(Received 8 October 2015/Accepted 18 April 2016/Published online in J-STAGE 6 May 2016)

ABSTRACT. We analyzed the status of tumor development in dogs by breed based on tumor cases that presented to the Department of Veterinary Pathology of the Gifu University for diagnostic examinations over eight years (2005–2012). We also calculated the crude incidence of tumors in dogs by breed based on the results of a survey conducted in 2011 in Gifu Prefecture. The most common sites of tumor development included the skin, digestive organs and mammary glands. Smaller dogs showed a tendency to have a higher incidence of breast tumors. We thus identified dog breeds with a higher crude incidence of tumors (Bernese mountain dog, golden retriever, corgi, etc.) and those with a lower crude incidence of tumors (Pomeranian, poodle, Chihuahua, etc.). Unlike the current trends for domestic dogs in the US and Europe, Japan has a higher number of small dogs as pets; it is therefore necessary to develop a policy for canine cancer specific to Japan.
KEY WORDS: benign-malignant tumor ratio, breed difference, canine tumor, crude incidence of tumors, number of domestic dogs

doi: 10.1292/jvms.15-0584; *J. Vet. Med. Sci.* 78(8): 1269–1275, 2016

In recent years, the incidence of various diseases in companion animals has increased along with their extended life expectancy has been extended. Among such diseases, the incidence of cancer in dogs—an intractable disease—seems to be increasing in particular. However, there are no detailed reports regarding the current status of cancer in dogs in Japan, and the incidence of tumors in dogs is not clear. This is primarily because the accurate number of domestic dogs in Japan is unknown. Although the results of research conducted by the Japan Pet Food Association and/or pet insurance companies [21], and data published by governmental agencies and/or domestic dog registration organizations are available, they are not adequate. Under these circumstances, considering that no epidemiological studies have been conducted, effective management of cancer in domestic dogs is not possible.

There are reports concerning the incidences of tumors in dogs in Denmark and some other regions of the world [2–5, 16, 18, 19, 22], including a report based on a survey conducted by a Swedish insurance company [8] as well as a survey conducted in Italy, which revealed the results by age distribution [15]. With respect to human data, cancer registration started in the mid-twentieth century, serving as a basis for effective cancer management in subsequent years.

Therefore, we conducted the following analysis to understand the current status of tumor development in dogs by breed: (1) Analysis of the status of tumor development in dogs by breed based on the tumor cases in Gifu Prefecture for which the Department of Veterinary Pathology of the Gifu University received a request for diagnostic examinations from veterinary hospitals and clinics in Gifu Prefecture over eight years, and (2) Calculation of the crude incidence of tumors in dogs by breed based on the number of dogs obtained from the survey conducted in all municipalities in Gifu Prefecture in 2011.

*CORRESPONDENCE TO: MARUO, K., The United Graduate School of Veterinary Sciences, Gifu University, Japan.
e-mail: kmaruo@gifu-u.ac.jp

MATERIALS AND METHODS

1. Analysis of tumor cases over eight years

Among the samples for which the Department of Veterinary Pathology, Gifu University, received requests for histological examination from other institutions during the eight-year period from 2005 to 2012, we used data only from the institutions located in Gifu Prefecture to understand the status of tumor development in dogs by breed in the prefecture.

1–1. Distribution of age at the time of diagnosis of tumor cases classified by sex

Of the requested samples, only tumor cases were extracted for the analysis of age distribution of tumor cases classified by sex. Statistical analysis was conducted using JMP11 analysis software (SAS Institute Inc., Tokyo, Japan), and the mean age by sex and standard deviation were calculated; the Wilcoxon rank sum test was conducted at a significance level of less than 5%.

1–2. Ratios between benign and malignant tumors by dog breed

We calculated the ratios between benign and malignant tumors in dogs by breed for the tumor cases included in this study.

Table 1. Tumor classification by breed and incidence

	Tumor sites	No. of cases	Incidence of tumor sites (%)	BG	BMD	CG	CK	CW	DAX	FB	GR	LR	MAR	MIX	other	PAP	PD	PG	POM	SCH	SIB	SSD	SZ	YT
1	Skin and adnexa	1,233	30.9	29.5	33.3	28.1	**17.6**	30.0	**18.4**	30.4	**41.2**	**35.5**	**31.5**	**34.4**	33.5	**22.8**	30.2	**58.3**	**12.1**	35.4	28.9	**27.5**	**26.0**	**15.2**
2	Gastrointestinal system, including oral cavity	733	18.4	20.1	10.0	**11.4**	8.8	18.6	**17.4**	34.8	**15.5**	19.7	**14.1**	**21.5**	16.7	**6.3**	20.6	**17.9**	24.2	**30.8**	20.1	**18.1**	**23.1**	**15.2**
3	Mammary glands	716	18.0	13.7	**0.0**	17.8	**41.2**	24.3	**41.5**	4.3	**6.4**	**12.8**	**33.7**	**14.4**	**15.2**	**38.0**	**28.6**	**7.1**	**36.4**	12.3	**10.8**	**7.0**	14.9	**33.9**
4	Not available and other tissue	1,303	32.7	36.7	56.7	42.7	32.4	27.1	22.6	30.4	36.9	31.9	20.7	29.7	34.6	32.9	20.6	16.7	27.3	21.5	40.2	47.4	35.9	35.7
	Total	3,985	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Tumor incidence by dog breed and tumor site was statistically calculated by the chi-square test. The result was "chi-squared=447.05, p-value <2.2e-16". These results indicate that between each dog species and whole dog species has a significant difference in Table 1 (P<0.05). Additionally, we performed residual analysis to clarify and confirm this further. A significantly high incidence (P<0.05) is indicated by values in bold, and a significantly low incidence (P<0.05) is indicated by values in bold and underlined font. Tumors in the skin and adnexa accounted for 30.9% of all tumors, those in the gastrointestinal system adnexa accounted for 18.4%, and mammary gland tumors accounted for 18.0%; the tumors in these four sites accounted for approximately 70% of all tumors. The incidence of mammary gland tumors was found to be higher in small dogs, such as CK, DAX, MAR, PAP, PD, POM and YT, and lower in large dogs.

The comparison of the ratios of benign and malignant tumors by breed was statistically calculated using the chi-square test with a significance level of less than 5% using R (version 3.2.2). Additionally, we performed residual analysis to clarify and confirm this further.

1–3. Classification of tumors in dogs by breed

Tumors were classified as shown in Table 1 in reference to the report by Brønden *et al.* [5]. To analyze the common sites for the development of tumors in dogs by breed, we determined the total number of tumor cases by calculating multiple tumors individually, i.e., when multiple, different types of tumors developed in the same dog, each tumor was separately included in the calculation. However, with regard to breast tumors, since the formation of numerous tumors is common and each tumor is given a different definitive diagnosis, it was difficult to classify each of the tumors separately. Therefore, in such cases, only the most malignant tumor among the tissues submitted for pathological examination was selected for calculation.

The incidence of tumor sites by dog breed was statistically calculated using the chi-square test with a significance level of less than 5% using R (version 3.2.2.). Additionally, we performed residual analysis to clarify and confirm this further.

2. Analysis of the number of domestic dogs by breed and crude incidence of tumors in dogs in Gifu Prefecture

2–1. The number of domestic dogs based on the dogs receiving antirabic vaccination in 2011 in Gifu Prefecture

A request for a questionnaire survey regarding the number of domestic dogs by breed was sent to 42 municipalities through postal mail or email. For the types of dog breed, 20 breeds, including crossbreeds, were selected (Table 2) in reference to Shimamura's report [21]. For the number of domestic dogs by breed, the number of dogs that received antirabic vaccination (RV) was selected, since these data were considered to reflect the current status most appropriately, and the number of domestic dogs for the 20 breeds was investigated for the period from April 2011 to March 2012. Although the official data for the number of dogs receiving RV are published by each of the prefectural and municipal veterinarian associations as well as the Ministry of Health, Labour and Welfare (MHLW), the figure represents the total number of dogs receiving RV, and the breakdown by dog breed is unknown. Therefore, we collected the information through questionnaire surveys (Fig. 1).

2–2. The crude yearly incidence of tumors in dogs and the crude yearly incidence of malignant tumors in dogs based on the number of dogs receiving antirabic vaccination in 2011 in Gifu Prefecture

To identify the number of tumor cases in dogs, the tumor cases from veterinary hospitals and clinics located only in Gifu Prefecture were extracted to calculate the samples for which the Department of Veterinary Pathology of the Gifu University received a request for histological examination in 2011, as stated in the previous section. With regard to the dog breeds, 20 breeds were selected, including crossbreeds.

The crude incidences of tumors and malignant tumors were calculated in the following manner, using the number of dogs receiving RV in 2011 in Gifu Prefecture and the data mentioned above.

Crude incidence of tumors (%)=the number of tumor cases (the above-mentioned data) ÷ the number of domestic dogs (number of dogs receiving RV in 2011) × 100

Crude incidence of malignant tumors (%)=the number of cases of malignant tumor (the above-mentioned data) ÷ the number of domestic dogs (number of dogs receiving RV in 2011) × 100

The crude incidence of tumors and malignant tumors by dog breed was statistically calculated by the chi-square test with a significance level of less than 5% using R (version 3.2.2.). Additionally, we performed residual analysis to clarify and confirm this further.

RESULTS

1. Analysis of tumor cases over eight years

As of April 2012 (mid-term), there were 131 veterinary hospitals and clinics in practice in Gifu Prefecture. Among them, approximately 23% or 31 hospitals and clinics requested the Department of Veterinary Pathology of the Gifu University to conduct tests for tumors in 3,597 cases (1,598 male dogs; 2,160 female dogs; and 161 dogs of unknown

Research of domestic dogs receiving RV in 2011 in Gifu prefecture (*1)

Registration dog species	Number of dogs	Notes
Dachshund		including miniature, standard, kaninchen, etc.
Chihuahua		including long and smooth
Poodle		including standard, toy and teacup
Shiba		only pure breed dogs
Yorkshire terrier		only pure breed dogs
Papillon		only pure breed dogs
Shih Tzu		only pure breed dogs
Welsh corgi		including cardigan and pembroke
Pomeranian		only pure breed dogs
Schnauzer		including miniature and standard
Labrador retriever		only pure breed dogs
French bull dog		only French bull dog
Cavalier King Charles Spaniel		only pure breed dogs
Golden retriever		only pure breed dogs
Maltese dog		only pure breed dogs
Pug		only pure breed dogs
Mixed breed		all mixed breed
Bernese mountain dog		only pure breed dogs
Beagle		only pure breed dogs
Shetland sheepdog		only pure breed dogs

(*1) : Not registration number of dogs. Check of RV receiving dogs.
(*2) : Not registration birthday of dogs. Check of RV receiving dogs.
(*3) : Not registration number of dogs. Check of RV receiving dogs in 2011.

City/Town _____

Birthday of domestic dogs (*2)

Birth of	Male	Female
1989		
1990		
1991		
1992		
1993		
1994		
1995		
1996		
1997		
1998		
1999		
2000		
2001		
2002		
2003		
2004		
2005		
2006		
2007		
2008		
2009		
2010		
2011		
2012		

Number of dogs receiving RV (*3)

	Male	Female
2011		

Fig. 1. Questionnaire regarding domestic dogs receiving RV in 2011 in Gifu Prefecture.

Table 2. Abbreviated terms for the dog breeds included in this study and the number of tumor cases

Dog breed	Abbreviated word	No. of tumor cases
Dachshund[a)]	DAX	407
Golden retriever	GR	388
Labrador retriever	LR	304
Shih Tzu	SZ	281
Siba	SIB	204
Welsh Corgi	CG	185
Shetland sheepdog	SSD	171
Beagle	BG	139
Yorkshire terrier	YT	112
Maltese dog	MAR	92
Pug	PG	84
Papillon	PAP	79
Chihuahua	CW	70
Schnauzer[a)]	SCH	65
Poodle[a)]	PD	63
Cavalier King Charles Spaniel	CK	34
Pomeranian	POM	33
Bernese mountain dog	BMD	30
French bulldog	FB	23
Mixed breed	MIX	713
Other breed	Other	508
Total		3,985

a) Dachshund, Schnauzer and Poodle: In the original data, these dogs were not classified into miniature or standard. Therefore, all of these dogs were calculated as the same type.

sex) over the eight-year period from 2005 to 2012. Among the total of 3,597 tumor cases that presented for pathological examination requests, 388 cases were found to have more than one tumor, excluding breast tumors, including 277 cases (6.95%) with 2 different types of tumors and 41 cases (1.03%) with 3–5 different types of tumors. Including these multiple tumors, a total of 3,985 tumors were diagnosed (Table 2).

1–1. Distribution of the age at the time of diagnosis of tumor cases classified by sex

In the analysis of age in all the samples, the mean age at which a tumor developed was 10.4 ± 3.0 years (mean ± S.D.) in male dogs and 10.4 ± 2.8 years (mean ± S.D.) in female dogs, showing no significant difference between males and females (Fig. 2).

1–2. Ratios between benign and malignant tumors by dog breed

The proportion of malignant tumors in all dogs was revealed to be 57.5%. The ratio of malignant tumors was significantly lower ($P<0.05$) in the following five dog breeds: Yorkshire terrier (YT) (32.1%), Maltese dog (MAR) (42.4%), Poodle (PD) (44.4%), Shih Tzu (SZ) (48.0%) and Dachshund (DAX) (48.2%), while the proportion of malignant tumors was significantly higher in the following seven dog breeds: Labrador retriever (LR) (63.2%), Welsh corgi (CG) (65.9%), Shiba (SIB) (68.1%), Shetland sheepdog (SSD) (69.0%), Chihuahua (CW) (70.0%), Beagle (BG) (73.4%) and Bernese mountain dog (BMD) (80.0%) ($P<0.05$) (Fig. 3).

Analysis of the ratios between the benign and malignant tumors by dog breed showed that smaller dogs tended to have a higher proportion of benign tumors.

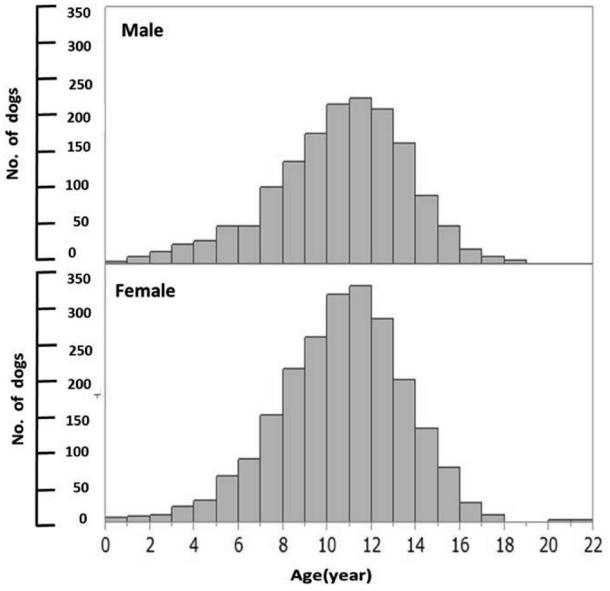

Fig. 2. Distribution of the age at the time of diagnosis of tumor cases classified by sex. The age of the dogs diagnosed as tumor cases at the time of the examination request is shown in the graph classified by sex. Analysis of age of the samples by pathological classification revealed that the mean age of developing tumors in male dogs was 10.4 ± 3.0 years (mean ± S.D.) and that in female dogs was 10.4 ± 2.8 (mean ± S.D.), showing no significant difference in the age between males and females.

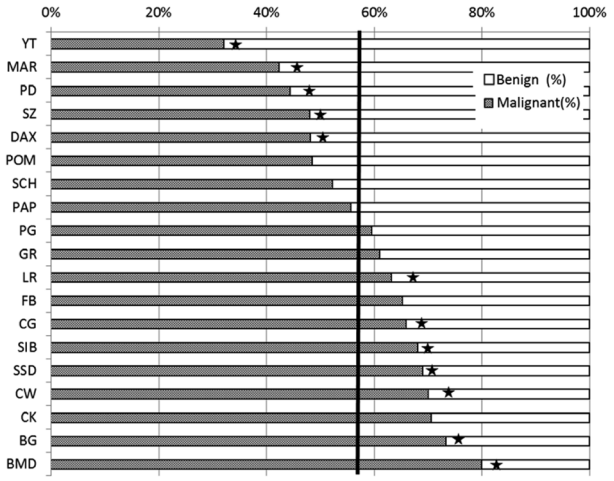

Fig. 3. Ratio of benign and malignant tumors by dog breed. The ratio of tumor and malignant tumors by dog breed was statistically calculated by the chi-square test. The result was "chi-squared=130.65, *P*-value <2.2e-16". These results indicate that between each dog species and whole dog species has a significant difference in Fig. 3 ($P<0.05$). Additionally, we performed residual analysis to clarify and confirm this further. The bold black line shows the mean of the ratio of malignant tumors in all dogs. ★: The ratio of malignant tumors was significantly lower in the following five dog breeds: YT (32.1%), MAR (42.4%), PD (44.4%), SZ (48.0%) and DAX (48.2%) ($P<0.05$), while the ratio of malignant tumors was significantly higher in the following seven dog breeds: LR (63.2%), CG (65.9%), SIB (68.1%), SSD (69.0%), CW (70.0%), BG (73.4%) and BMD (80.0%) ($P<0.05$).

1–3. Classification of tumors by dog breed

In the analysis of the 3,985 tumors in terms of the location of tumor development, tumors were found most often in the skin and surrounding tissues, with 1,233 cases accounting for 30.9%. In particular, the pug (PG) and Golden retriever (GR) breeds had the highest incidence of tumors in the skin and surrounding tissues with an incidence of 58.3% and 41.2%, respectively, while YT and Pomeranian (POM) had a lower incidence of 15.2% and 12.1%, respectively. Gastrointestinal tumors were the second most common tumors and were found in 733 cases accounting for 18.4%. Gastrointestinal tumors included the areas from the oral cavity to the anus, and intraoral melanoma was particularly common, accounting for 55% of all gastrointestinal tumors as an intraoral tumor, followed by perianal tumors that accounted for 21%. Breast tumors were the third most common tumors and were found in 716 cases that accounted for 18.0%. Smaller dog breeds had greater proportion of breast tumors, which accounted for 41.5% in DAX, 41.2% in Cavalier King Charles Spaniel (CK), 38.0% in papillon (PAP), 36.4% in POM, 33.9% in YT and 33.7% in MAR, while medium to large dog breeds had fewer breast tumors, which accounted for 0% in BMD, 7.1% in pug (PG), 6.4% in GR, 7.0% in SSD, 10.8% in SIB and 12.8% in LR. With regard to mast cell tumors, they were found more often in the two breeds, PG and BMD, accounting for 46.4% and 23.3%, respectively.

2. Analysis of the number of domestic dogs by breed and crude incidence of tumors in dogs in Gifu Prefecture

2–1. The number of domestic dogs in Gifu Prefecture by breed based on the number of dogs receiving RV in 2011

We conducted a questionnaire survey in 42 municipalities in Gifu Prefecture, and 29 of the 42 (approximately 69%) responded. With regard to the number of domestic dogs, the number of dogs receiving RV during the period from April 2011 to March 2012 was 93,234 according to the Gifu Veterinary Medical Association, and information about 76,316 dogs or approximately 82% of the total number of RV dogs was collected through the questionnaire survey. The numbers of domestic dogs in Gifu Prefecture revealed by this questionnaire survey included 18,357 mixed breeds (MIX) (24.1%), 9,609 DAX (12.6%), 8,609 SIB (11.3%), 5,017 PD (6.6%) and 4,873 CW (6.4%); this demonstrated the high popularity of small dog breeds except for MIX and SIB, while large dog breeds were fewer, namely, 2,312 LR (3.0%) and 1,213 GR (1.6%). The top 5 dog breeds including MIX accounted for 60% of all the dogs (Table 3).

2–2. The crude incidence of tumors in dogs and the crude incidence of malignant tumors in dogs in 2011 in Gifu Prefecture

With regard to the number of samples for which examination was requested from the University during the one-year period (2011), most requests were for MIX, with 116 samples, followed by DAX with 71, LR with 61, CG with 57, GR with 52 and SIB with 41 samples (Table 3).

Table 3. Crude tumor incidence and crude malignant tumor incidence by dog breed

Dog breed	Registration volume	Breeding ratio	Sample volume	Crude incidence rate		Malignant sample volume	Malignant crude incidence rate (%)	
DAX	9,609	12.6	71	0.7	↓*	43	0.4	
SIB	8,609	11.3	41	0.5	↓*	28	0.3	↓*
PD	5,017	6.6	8	0.2	↓*	1	0.0	↓*
CW	4,873	6.4	13	0.3	↓*	9	0.2	↓*
LR	2,312	3.0	61	2.6	↑*	43	1.9	↑*
SZ	2,021	2.6	30	1.5	↑*	15	0.7	
CG	1,927	2.5	57	3.0	↑*	40	2.1	↑*
PAP	1,809	2.4	24	1.3	↑*	13	0.7	
BG	1,636	2.1	38	2.3	↑*	30	1.8	↑*
YT	1,554	2.0	23	1.5	↑*	6	0.4	
POM	1,432	1.9	1	0.1	↓*	1	0.1	↓*
GR	1,213	1.6	52	4.3	↑*	34	2.8	↑*
SCH	1,061	1.4	16	1.5	↑*	8	0.8	
SSD	877	1.1	22	2.5	↑*	15	1.7	↑*
MAR	831	1.1	17	2.0	↑*	5	0.6	
CK	754	1.0	9	1.2		6	0.8	
PG	652	0.9	14	2.1	↑*	6	0.9	
FB	534	0.7	4	0.7		4	0.7	
BMD	140	0.2	11	7.9	↑*	9	6.4	↑*
MIX	18,357	24.1	116	0.6	↓*	66	0.4	↓*
Other	11,098	14.5	86	0.8	↓*	47	0.4	↓*
Total	76,316	100.0	714	0.9		429	0.6	

By calculating the number of domestic dogs and the ratio of each dog breed, crude tumor incidence and crude malignant tumor incidence were analyzed based on the number of samples for each dog breed obtained over a one-year period of time. Tumor crude incidence by dog breed was statistically calculated by the chi-square test. The result was "chi-squared=476.01, *P*-value <2.2e-16". These results indicate that between each dog species and whole dog species has a significant difference in Table 3 ($P<0.05$). Additionally, we performed residual analysis to clarify and confirm this further. Significantly high incidences are indicated by $P<0.05$ ↑*, and significantly low incidences are indicated by $P<0.05$ ↓*. The crude tumor incidence was found to be low in DAX, SIB, PD, CW, POM, MIX and other breeds ($P<0.05$), while it was high in LR, SZ, CG, PAP, BG, YT, GR, SCH, SSD, MAR, PG and BMD ($P<0.05$). The crude incidence of malignant tumors was also calculated in the same manner; it was found to be low in SIB, PD, CW, POM, MIX and other breeds ($P<0.05$), but high in LR, CG, BG, GR, SSD and BMD ($P<0.05$).

Using the samples collected for pathological examination, the crude incidences of tumors by dog breed were calculated for reference. Our results showed that the crude incidence of tumors was significantly low in POM at 0.1%, PD at 0.2%, CW at 0.3%, SIB at 0.5%, DAX at 0.7%, and MIX at 0.6% ($P<0.05$), while it was significantly high in PAP at 1.3%, SZ at 1.5%, YT at 1.5%, SCH at 1.5%, MAR at 2.0%, PG at 2.1%, BG at 2.3%, SSD at 2.5%, L R at 2.6%, CG at 3.0%, GR at 4.3%, and BMD at 7.9% ($P<0.05$). In addition, the crude incidence of malignant tumors was calculated in the same manner, and it was significantly low in SIB at 0.3%, PD at 0.0%, CW at 0.2%, POM at 0.1%, and MIX at 0.4% ($P<0.05$), and it was significantly high in LR at 1.9%, CG at 2.1%, BG at 1.8%, GR at 2.8%, SSD at 1.7%, and BMD at 6.4% ($P<0.05$).

DISCUSSION

The analysis of tumor development in dogs by breed in Gifu Prefecture revealed the following characteristics: Common breeds of dogs, such as MIX and DAX, showed a high number of tumor cases, and uncommon breeds of dogs, such as GR and LR, also showed a high number of tumor cases; in contrast, common breeds of dogs, such as SIB, showed a low number of tumor cases, suggesting the possibility that the crude tumor incidence in dogs varied depending on the dog breed. The analysis of the ratio between benign and malignant tumors by dog breed showed that small dog breeds tended to have a greater proportion of benign tumors. Although the ratio of malignant tumors in this study was 57.5%, there was a Swiss report in which malignant tumors accounted for 47.07% of all investigated tumors in the survey [10]. This difference was considered to be caused by the differences in the types of dog breeds and breeding environment; however, further investigation is necessary to clarify this point. With regard to the samples submitted for pathological examination, there is a possibility of potential bias with regard to the collection of the samples, since the primary veterinary hospital or clinic may have sent fewer samples of benign tumors or more samples, of malignant tumors, keeping in mind that the “University” would be performing the pathological examination.

With regard to analysis of the most commonly developed organ systems, tumors were found most frequently in the skin and surrounding tissues, similar to reports from other countries [7, 10, 14], but the organ systems showing a high

frequency of tumors after the skin and surrounding tissues, differed slightly from reports from other countries. This is considered to be due to the differences in the types and incidence of dog breeds, e.g., reports from other countries included higher number of large dog breeds.

With regard to breast tumors, dogs were divided into the high incidence group, including CK, DAX, MAR, PAP, PD, POM and YT, and the low incidence group, including BMD, GR, LR, MIX, PG and SSD. Itoh *et al.* have also reported that small dog breeds have a lower risk of malignant breast tumors compared to another types of dogs [12]. In some of the reports from other countries concerning breast tumors in dogs, dogs, such as boxer, cocker spaniel, English springer spaniel, DAX, pointer, PD and Boston terrier, had a higher incidence of breast tumors [14, 16]; further, contrary to the results of our study, there was a report that breast tumors developed more frequently in large dog breeds, such as Leonberger, Irish wolfhound and BMD [13]. It has been known for some time now that mast cell tumors develop more frequently in the mastiff-type boxer dog breeds [1]. Mast cell tumors have been found with a high frequency in PG, BMD and FB, which are related to mastiff-type breeds in the same manner as boxer breeds [21, 23], and breeds with a lower frequency for such tumors were also revealed to be CK, POM, SSD and YT.

Frequently, data registered at municipalities do not reflect the deaths of domestic dogs accurately. Therefore, there is a possibility that many dogs as old as 25 years and even older exist in the database, and the research of Hayashidani, *et al.* [11] also showed that there is a possibility that the data of elderly dogs that are not alive have not been removed from the records. In this study, there were not many domestic dogs older than 20 years; therefore, the reliability of the municipal data collected in this study was considered to be high. With regard to the fewer domestic dogs younger than 3 years noted in the age distribution, it was probably caused by unregistered younger dogs (RV not received) and decreasing number of breeding dogs. The performance rate of RV in Gifu Prefecture has been 79.5–80.9% every year (2008 to 2011), which was higher than the national mean of 72.8% (2011). This shows the regional characteristics of Gifu Prefecture, and it was considered that the basic data were thus reliable. The decreasing number of domestic dogs leads to a bias in the age distribution. When more elderly dogs are present than younger dogs, the tumor incidence should be calculated after adjustment for age to be accurate, because higher figures would be noted otherwise. However, at present, it is difficult to obtain information regarding age for each breed from the municipal data, and we therefore decided to investigate the crude tumor incidence.

The crude incidence of 0.9% seems to be slightly lower than the tumor incidence reported overseas, ranging from 0.96% to 4.82% [14, 17, 20], which may be the influence of basic data. It was considered that the tumor incidence calculated in this study may be lower than the actual incidence, because the performance rate of RV was not 100% of the population, and there is a possibility that the primary institutions may only have sent approximately 24% of the tumor samples for examination. In addition, since the number of dogs with tumors that visit a veterinary hospital (some dogs may not visit a hospital), the percentage of dogs diagnosed with a tumor at veterinary hospitals or clinics (some dog owners do not want to have examinations) and the percentage of cases for which a sample is sent to the University for pathological examination (some samples may be sent to another pathology laboratory) influenced the tumor incidence, it was considered that there is a possibility that the calculation of the crude tumor incidence and crude malignant tumor incidence in this study may have underestimated the reality. To control such bias, measures should be adopted to select target animals randomly in future studies.

Although the crude tumor incidence calculated by breed may be lower than it should be due to the problems with the size of the population and the number of samples collected, it is considered that the incidence by breed and by organ would not be easily affected by the changes in the number of samples or age distribution.

Most domestic dogs in Japan are of small breeds, such as those kept mainly inside the house; in our study, only three large dog breeds (LR, GR and BMD) were present among all the 20 selected breeds, which differed largely from the reports from other countries [6, 9, 20]. Since the crude tumor incidence was affected by the type of breed and the body size, it is considered that the data obtained in this study are unique to Japan, where most domestic dogs are small- and medium-sized, differing from data from other countries. It is necessary to investigate the relationship between the breeding environment and the crude tumor incidence in future studies.

We consider that, in addition to improving the accuracy of the survey data, it is necessary to promote antirabic vaccination, to utilize the municipal database, and to obtain an accurate number of bred animals by adding an item in the surveys, such as a census, to investigate the status of bred animals. In addition, it is important to use domestic Japanese data to manage cancers in dogs in Japan, instead of using data obtained from other countries, where the size of the dogs is mostly large, considering the differences in dog size in Japan and other countries.

ACKNOWLEDGMENTS. The authors gratefully acknowledge Dr. Takehisa Yamamoto for his instructions for statistical analysis and Dr. Hideki Hayashidani for his advice regarding the study design.

REFERENCES

1. Abadie, J., Hédan, B., Cadieu, E., De Brito, C., Devauchelle, P., Bourgain, C., Parker, H. G., Vaysse, A., Margaritte-Jeannin, P., Galibert, F., Ostrander, E. A. and André, C. 2009. Epidemiology, pathology, and genetics of histiocytic sarcoma in the Bernese mountain dog breed. *J. Hered.* **100** Suppl 1: S19–S27. [Medline] [CrossRef]
2. Bonnett, B. N., Egenvall, A., Hedhammar, A. and Olson, P. 2005. Mortality in over 350,000 insured Swedish dogs from 1995–2000: I. Breed-, gender-, age- and cause-specific rates. *Acta Vet. Scand.* **46**: 105–120. [Medline] [CrossRef]

3. Brønden, L. B., Eriksen, T. and Kristensen, A. T. 2009. Oral malignant melanomas and other head and neck neoplasms in Danish dogs—data from the Danish Veterinary Cancer Registry. *Acta Vet. Scand.* **51**: 54. [Medline] [CrossRef]
4. Brønden, L. B., Eriksen, T. and Kristensen, A. T. 2010. Mast cell tumours and other skin neoplasia in Danish dogs—data from the Danish Veterinary Cancer Registry. *Acta Vet. Scand.* **52**: 6. [Medline] [CrossRef]
5. Brønden, L. B., Nielsen, S. S., Toft, N. and Kristensen, A. T. 2010. Data from the Danish veterinary cancer registry on the occurrence and distribution of neoplasms in dogs in Denmark. *Vet. Rec.* **166**: 586–590. [Medline] [CrossRef]
6. Dobson, J. M. 2013. Breed-predispositions to cancer in pedigree dogs. *ISRN Vet. Sci.* **2013**: 941275. [Medline] [CrossRef]
7. Dobson, J. M., Samuel, S., Milstein, H., Rogers, K. and Wood, J. L. N. 2002. Canine neoplasia in the UK: estimates of incidence rates from a population of insured dogs. *J. Small Anim. Pract.* **43**: 240–246. [Medline] [CrossRef]
8. Egenvall, A., Nødtvedt, A. and von Euler, H. 2007. Bone tumors in a population of 400,000 insured Swedish dogs up to 10 y of age: incidence and survival. *Can. J. Vet. Res.* **71**: 292–299. [Medline]
9. Dorn, C. R. and Priester, W. A. 1987. Epidemiology. Veterinary Cancer Medicine, 2nd ed., Lea & Febiger, Philadelphia.
10. Grüntzig, K., Graf, R., Hässig, M., Welle, M., Meier, D., Lott, G., Erni, D., Schenker, N. S., Guscetti, F., Boo, G., Axhausen, K., Fabrikant, S., Folkers, G. and Pospischil, A. 2015. The Swiss Canine Cancer Registry: a retrospective study on the occurrence of tumours in dogs in Switzerland from 1955 to 2008. *J. Comp. Pathol.* **152**: 161–171. [Medline] [CrossRef]
11. Hayashidani, H., Omi, Y., Ogawa, M. and Fukutomi, K. 1988. Epidemiological studies on the expectation of life for dogs computed from animal cemetery records. *Jpn. J. Vet. Sci.* **50**: 1003–1008. [Medline] [CrossRef]
12. Itoh, T., Uchida, K., Ishikawa, K., Kushima, K., Kushima, E., Tamada, H., Moritake, T., Nakao, H. and Shii, H. 2005. Clinicopathological survey of 101 canine mammary gland tumors: differences between small-breed dogs and others. *J. Vet. Med. Sci.* **67**: 345–347. [Medline] [CrossRef]
13. Jitpean, S., Hagman, R., Ström Holst, B., Höglund, O. V., Pettersson, A. and Egenvall, A. 2012. Breed variations in the incidence of pyometra and mammary tumours in Swedish dogs. *Reprod. Domest. Anim.* **47** Suppl 6: 347–350. [Medline] [CrossRef]
14. MacVean, D. W., Monlux, A. W., Anderson, P. S. Jr., Silberg, S. L. and Roszel, J. F. 1978. Frequency of canine and feline tumors in a defined population. *Vet. Pathol.* **15**: 700–715. [Medline] [CrossRef]
15. Merlo, D. F., Rossi, L., Pellegrino, C., Ceppi, M., Cardellino, U., Capurro, C., Ratto, A., Sambucco, P. L., Sestito, V., Tanara, G. and Bocchini, V. 2008. Cancer incidence in pet dogs: findings of the Animal Tumor Registry of Genoa, Italy. *J. Vet. Intern. Med.* **22**: 976–984. [Medline] [CrossRef]
16. Moe, L. 2001. Population-based incidence of mammary tumours in some dog breeds. *J. Reprod. Fertil. Suppl.* **57**: 439–443. [Medline]
17. Morris, J. and Dobson, J. 2001. Small Animal Oncology, Blackwell Science, Oxford.
18. Nødtvedt, A., Berke, O., Bonnett, B. N. and Brønden, L. 2012. Current status of canine cancer registration - report from an international workshop. *Vet. Comp. Oncol.* **10**: 95–101. [Medline] [CrossRef]
19. Nødtvedt, A., Gamlem, H., Gunnes, G., Grotmol, T., Indrebø, A. and Moe, L. 2011. Breed differences in the proportional morbidity of testicular tumours and distribution of histopathologic types in a population-based canine cancer registry. *Vet. Comp. Oncol.* **9**: 45–54. [Medline] [CrossRef]
20. Ostrander, E. A. 2012. Franklin H. Epstein Lecture. Both ends of the leash—the human links to good dogs with bad genes. *N. Engl. J. Med.* **367**: 636–646. [Medline] [CrossRef]
21. Shimamura, A. 2012. Insurance data in household animals. *J. Vet. Epidemiol.* **16**: 67–73. [CrossRef]
22. Vascellari, M., Baioni, E., Ru, G., Carminato, A. and Mutinelli, F. 2009. Animal tumour registry of two provinces in northern Italy: incidence of spontaneous tumours in dogs and cats. *BMC Vet. Res.* **5**: 39. [Medline] [CrossRef]
23. White, C. R., Hohenhaus, A. E., Kelsey, J. and Procter-Gray, E. 2011. Cutaneous MCTs: associations with spay/neuter status, breed, body size, and phylogenetic cluster. *J. Am. Anim. Hosp. Assoc.* **47**: 210–216. [Medline] [CrossRef]