

# EFFECT OF INDOOR-KEEPING OF HOUSE- DOGS ON THE TRANSMISSION OF *DIROFILARIA IMMITIS* IN NAGASAKI CITY, JAPAN

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**Abstract:** The positive rate of house-dogs for *Dirofilaria immitis* microfilariae decreased in 27 years from 1968 to 1994 in northern and southern parts of Nagasaki City. It was examined whether or not the increase of indoor-kept dogs contributed greatly to the reduction in positive rate of house-dogs in the city. Positive rate of dogs was generally lower in indoor-kept dogs than in outdoor-kept dogs. From the lower positive rate of indoor-kept dogs, *D. immitis* infection is considered to have occurred mainly in outdoor-kept dogs. Positive rate was high from 1968 to 1983 when rate of indoor-kept dogs was low and thereafter positive rate gradually decreased though the rate of indoor-kept dogs was not greatly changed. From this, increase of indoor-kept dogs may be a factor causing the decrease of positive rate in all examined dogs from 1968 to 1983, but the reduction of positive rate thereafter is considered to be due to decrease of positive rate in outdoor-kept dogs.

**Keywords:** *Dirofilaria immitis*, house-dogs, transmission, indoor-keeping, positive rate of microfilariae

## INTRODUCTION

The prevalence of dirofilariasis in house-dogs decreased in 27 years from 1968 to 1994 in Nagasaki City, and the population of the main vector mosquito, *Culex pipiens pallens*, also decreased in parallel with the expansion of the sewage system (Oda *et al.*, 1994a: 1995). In addition, the results of a questionnaire survey on living environments of dogs (Oda *et al.*, 1994b) indicated the increase of households that kept dogs indoors. However, it was not clear whether or not the increase of indoor-kept dogs contributed greatly to the reduction in positive rate of dogs in the city. On the other hand, the infection with *Dirofilaria immitis* was

reported in dogs kept indoors (Yasuda *et al.*, 1985). In this study we analyzed the role of indoor-kept dogs in the transmission of *D. immitis*.

## STUDY AREA AND METHODS

To examine the microfilariae of *D. immitis*, we sampled blood from an earlobe of about 400 registered dogs in April or May once in each year from 1983 to 1994 in a southern district (Tomachi) and three northern districts (Sakamoto, Takao and Yamazato) in Nagasaki City. Blood samples were subjected to Giemsa staining. The data on breed, sex and age of examined dogs were taken from the record of Nagasaki City Health Center (Oda *et al.*, 1993; 1995). In addition, a questionnaire survey was conducted to owners of registered dogs

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in the northern and southern parts in 1989 and 1993 to know the living environment of domestic dogs, including a question whether they are kept indoors or outdoors. The details of the questionnaire survey method were reported in the previous paper (Oda *et al.*, 1994b). The breed names of dogs followed the book "Inu" (Ohno, 1973).

## RESULTS

### 1. Breed of dogs kept indoors and outdoors

We carried out a questionnaire survey on living environments of house-dogs in 1989 and 1993, and based on the replies from dog owners, all dogs examined for *D. immitis* infection in each year were classified into dogs kept indoors (indoor group) and outdoors (outdoor

group) (Table 1).

Among 370 dogs examined in Nagasaki City, 111 dogs were kept indoors, and the remaining 259 were kept outdoors. There were 15 breeds in the indoor group and 19 breeds in the outdoor group. Five breeds of Mixed breed (No. 1), Shiba Inu (No. 2), Shetland Sheepdog (No. 4), Beagle (No. 5) and Dalmatian (No. 14) were kept both indoors and outdoors.

### 2. Positive rate of *D. immitis* by dog breed

Table 2 shows the prevalence of *D. immitis* in dogs kept indoors and outdoors by dog breed based on the record of blood examination in the years from 1968 to 1994. Here, the dogs of 5 breeds, Nos. 1, 2, 4, 5 and 14 in the indoor group in Table 1, were regarded as those kept outdoors, because much more dogs were found in

Table 1 Breed of dogs kept indoors and outdoors in Nagasaki City, according to questionnaire

Dog breed		Indoor-kept dogs	Outdoor-kept dogs	Total
No.	Name	No. examined	No. examined	No. examined
1 *	Mixed Breed	34	170	204
2 *	Shiba Inu	5	42	47
3	Maltese	23		23
4 *	Shetland Sheepdog	8	8	16
5 *	Beagle	2	13	15
6	Yorkshire Terrier	9		9
7	Pomeranian	7		7
8	Chihuahua	5		5
9	Toy Poodle	5		5
10	Shih Tzu	4		4
11	Terrier		4	4
12	Dachshund	3		3
13	Pug	3		3
14*	Dalmatian	1	1	2
15	Setter		2	2
16	Afghan Hound		2	2
17	Bulldog		2	2
18	Japanese Spaniel		2	2
19	Pointer		2	2
20	Siberian Husky		2	2
21	Shikoku Inu		2	2
22	Wirehaired Fox Terrier		2	2
23	Papillon	1		1
24	Pekingese	1		1
25	Japanese Spitz		1	1
26	Akita Inu		1	1
27	American Cocker Spaniel		1	1
28	Doberman Pinscher		1	1
29	Labrador Retriever		1	1
Total		111	259	370

\*Kept both indoors and outdoors.

Table 2 Microfilarial prevalence of *Dirofilaria immitis* by dog breed

Dog breed		Indoor-kept dogs			Outdoor-kept dogs			Total		
No	Name	No. ex- amined	No. pos- itive	(%)	No. ex- amined	No. pos- itive	(%)	No. ex- amined	No. pos- itive	(%)
1	Mixed Breed				2979	806	27.1	2979	806	27.1
2	Shiba Inu				561	104	18.5	561	104	18.5
3	Shetland Sheepdog				254	27	10.6	254	27	10.6
4	Maltese	243	5	2.1				243	5	2.1
5	Beagle				158	34	21.5	158	34	21.5
6	Toy Poodle	110	1	0.9				110	0.6	0.9
7	Pomeranian	105	3	2.9				105	3	2.9
8	Yorkshire Terrier	104	0	0.0				104	0	0.0
9	Japanese Spitz				77	23	29.9	77	23	29.9
10	Terrier				47	10	21.3	47	10	21.3
11	Akita Inu				42	14	33.3	42	14	33.3
12	Shih Tzu	41	0	0.0				41	0	0.0
13	Dachshund	40	4	10.0				40	4	10.0
14	Chihuahua	38	0	0.0				38	0	0.0
15	Pug	32	1	3.1				32	1	3.1
16	Pointer				26	12	46.2	26	12	46.2
17	Chow Chow				20	3	15.0	20	3	15.0
18	Japanese Spaniel				20	1	5.0	20	1	5.0
19	German Shepherd Dog				19	7	36.8	19	7	36.8
20	Collie				17	5	29.4	17	5	29.4
21	Pekingese	16	3	18.8				16	3	18.8
22	Afghan Hound				16	0	0.0	16	0	0.0
23	Dalmatian				13	2	15.4	13	2	15.4
24	American Cocker Spaniel				13	4	30.8	13	4	30.8
25	Wirehaired Fox Terrier				13	1	7.7	13	1	7.7
26	Doberman Pinscher				13	4	30.8	13	4	30.8
27	Siberian Husky				11	0	0.0	11	0	0.0
28	Shikoku Inu				10	1	10.0	10	1	10.0
29	Labrador Retriever				9	0	0.0	9	0	0.0
30	Bulldog				9	2	22.2	9	2	22.2
31	Papillon	8	0	0.0				8	0	0.0
32	Setter				8	1	12.5	8	1	12.5
33	Scottish Terrier				6	1	16.7	6	1	16.7
34	Boxer				6	4	66.7	6	4	66.7
35	White Terrier				5	0	0.0	5	0	0.0
36	Kai Inu				4	1	25.0	4	1	25.0
37	Miniature Pinscher	3	0	0.0				3	0	0.0
38	Cavalier King Charles Spaniel				3	0	0.0	3	0	0.0
39	Golden Retriever				3	0	0.0	3	0	0.0
40	Kishu Inu				3	0	0.0	3	0	0.0
41	Tosa Inu				2	0	0.0	2	0	0.0
42	Boston Terrier				2	0	0.0	2	0	0.0
43	Mikawa Inu				1	0	0.0	1	0	0.0
44	Fox Terrier Smooth				1	0	0.0	1	0	0.0
45	St. Bernard				1	0	0.0	1	0	0.0
Total		740	17	2.3*	4372	1067	24.4*	5112**	1084	21.2

\*Significant ( $P < 0.01$ )

\*\*This figure shows total number of house-dogs with blood examination and the clear record on breed name in period from 1968 to 1994 in Nagasaki City.

the outdoor group than in the indoor group. Thus, the indoor group consists of the following 11 breeds: Maltese, Yorkshire Terrier, Pomeranian, Toy Poodle, Dachshund, Shih Tzu, Pug, Chihuahua, Papillon, Miniature Pinscher and Pekingese. Miniature Pinscher was also added in the indoor-kept dog, because this was usually kept inside the house as toy dog, although not shown in a questionnaire survey.

The positive rate was 2.3% in the outdoor group but much higher (24.4%) in the outdoor group. Positive rate

varied with dog breed in the indoor group as well as in the outdoor group.

### 3. Positive rates of dogs kept indoors and outdoors

Table 3 shows annual changes in the positive rates for microfilariae in indoor-kept and outdoor-kept dogs in each year from 1968 to 1994. The positive rate of indoor-kept dogs was much lower in any study year than that of outdoor-kept dogs. The positive rate of indoor-kept dogs was generally low from 1968 to 1986

Table 3 Annual changes in microfilarial prevalence of *Dirofilaria immitis* in the dogs kept indoors or outdoors in Nagasaki City

Year	Indoor-kept dogs			Outdoor-kept dogs			Total			Percentage of Indoor-kept dogs {A/(A+B) × 100}
	No. examined (A)	No. positive	(%)	No. examined (B)	No. positive	(%)	No. examined (A+B)	No. positive	(%)	
1968	1	0	0.0	301	131	43.5	302	131	43.4	0.3
1977	23	5	21.7	214	79	36.9	237	84	35.4	9.7
1983	52	3	5.8	287	95	33.1	339	98	28.9	15.3
1984	66	4	6.1	338	100	29.6	404	104	25.7	16.3
1985	43	1	2.3	250	82	32.8	293	83	28.3	14.7
1986	24	1	4.2	277	78	28.2	301	79	26.2	8.0
1987	44	0	0.0	317	82	25.9	361	82	22.7	12.2
1988	64	0	0.0	387	98	25.3	451	98	21.7	14.2
1989	73	1	1.4	334	87	26.0	407	88	21.6	17.9
1990	80	0	0.0	342	61	17.8	422	61	14.5	19.0
1991	70	0	0.0	294	40	13.6	364	40	11.0	19.2
1992	63	1	1.6	349	55	15.8	412	56	13.6	15.3
1993	71	1	1.4	325	40	12.3	396	41	10.4	17.9
1994	66	0	0.0	357	39	10.9	423	39	9.2	15.6
Total	740	17	2.3	4372	1067	24.4	5112	1084	21.2	14.5

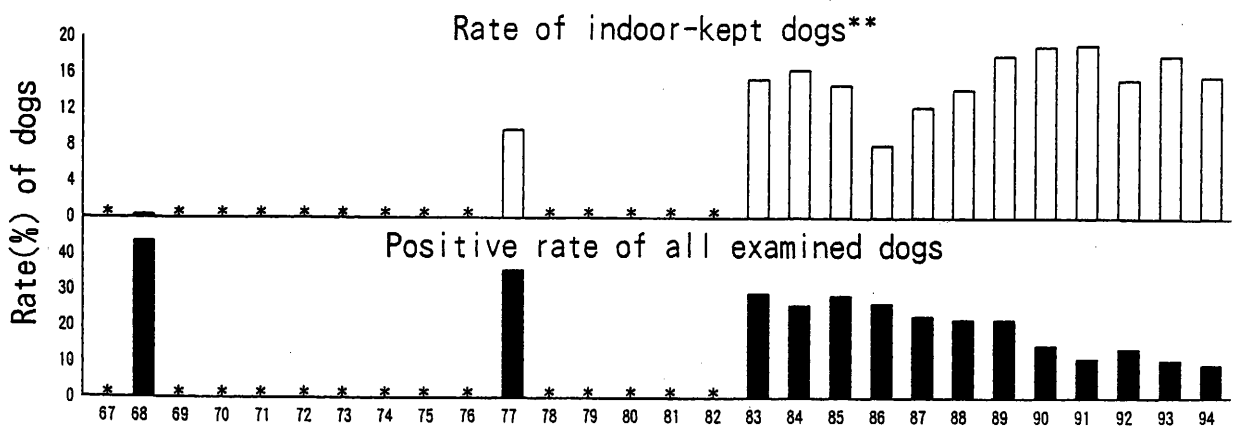


Figure 1 Annual changes in microfilarial prevalence of *Dirofilaria immitis* in the all examined dogs and rate of indoor-kept dogs in Nagasaki City.

\*Data not available

\*\*Rate of indoor-kept dogs shows percentage of, indoor-kept dogs for all examined dogs,  $A/(A+B) \times 100$ , in Table 3.

and thereafter it became lower. The annual changes in positive rate were analyzed for all examined and outdoor-kept dogs by the trend test (Armitage, 1955). A decrease was observed in both rates from 1968 to 1994 ( $p < 0.01$ ).

#### 4. Relationship between positive rate of all examined dogs and the rate of indoor-kept dogs

We calculated the rate of indoor-kept dogs for total number of examined dogs from Table 3 and showed annual changes in the positive rate of all examined dogs and the rate of indoor-kept dogs in Fig. 1, to make clear the relation between both rates. This figure indicated that the positive rate in all examined dogs was high when rate of indoor-kept dogs was low from 1968 to 1983 and thereafter the positive rate gradually decreased though rates of indoor-kept dogs were not greatly changed. Therefore, the reduction of positive rate after 1983 is considered to be due to decrease of positive rate in outdoor-kept dogs.

#### DISCUSSION

The present study clearly showed that the positive rate for *D. immitis* microfilariae was lower in indoor-kept dogs than in outdoor-kept dogs. This finding was consistent with the results reported by Appleton and Arlian (1979) and Thrasher *et al.* (1963: 1968). Wada *et al.* (1989) reported that the protection of humans from mosquito bites increased in Nagasaki City. This really means that it became difficult for mosquitoes to enter a house with closed windows due to recent widespread use of air conditioners. This may be the primary cause for the lower positive rate in the indoor-kept dogs.

As described above, the population of the indoor-kept dogs accounted for about 15% of all examined dogs and the positive rate was markedly lower in indoor-kept dogs than in outdoor-kept dogs. In other words, these results suggest that *D. immitis* infection occurs mainly in house-dogs kept outdoors. From present and previous results, the decrease in *Cx. p. pallens* seems to play an important role in the decrease of the positive rate in house-dogs in Nagasaki City. The increase of indoor-kept dogs may be a factor for the decrease of the positive rate in 1968 to 1983, and thereafter, the reduction of positive rate is considered to be due to the decrease of positive rate in outdoor-kept dogs. Other possible causes are the use of repellent coils and preventive drugs such as Ivermectin, but their effects are estimated to be not high, as suggested by Oda *et al.* (1995). In addition, change in the composition of dog

breed may have a role for reduction in positive rate, but in our data, positive rate did not vary by the breed. The dogs with long hair is supposed to be low in positive rate, but Ohishi (1986) reported that positive rates were not different between dogs with long hair and those with short hair.

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