The inheritance and breeding results of hairless descendants of Mexican hairless dogs

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Summary

The inheritance and breeding results of hairless descendants of Mexican hairless dogs (MHDs) were investigated. When the male hairless dogs were bred to female beagles, the birth ratio of hairless and haired dogs was 1:1. Mating between MHDs gave both hairless and haired pups. The results indicated that an autosomal dominant monogenic gene was responsible for their hairless characteristics. We propose the symbol *Hm* for this gene (hairless, Mexican type). The survival rate of hairless pups was markedly lower than that of haired ones. It was elevated to 50–90% by warming their cages to a minimum of 25°C.

Keywords: Hairless dogs; Hairlessness; Autosomal dominant monogenic gene; Beagles; Backcross

Hairless mutants are documented as occurring in several breeds of dogs such as Mexican hairless dog, Chinese crested dog, Inca hairless dog (Peruvian hairless dog), Peruvian Inca Orchid and American hairless terrier (Wilcox & Walkoicz, 1989). To date, only 2 types of hairless gene have been reported: one is the dominant lethal gene for the Chinese crested dog (*Hr*) (Robinson, 1985) and the other is the recessive gene for the American hairless terrier (*ha*) (Sponenberg *et al.*, 1988).

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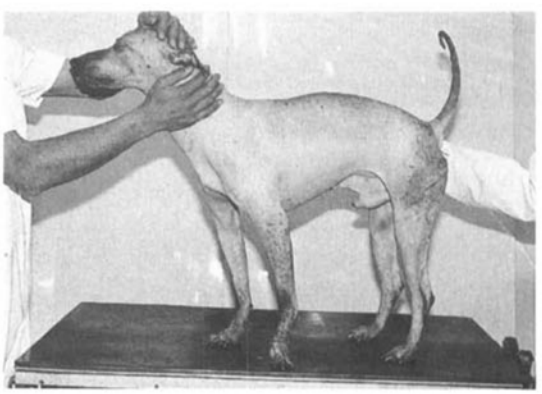

Fig. 1. Appearance of a Mexican hairless dog.

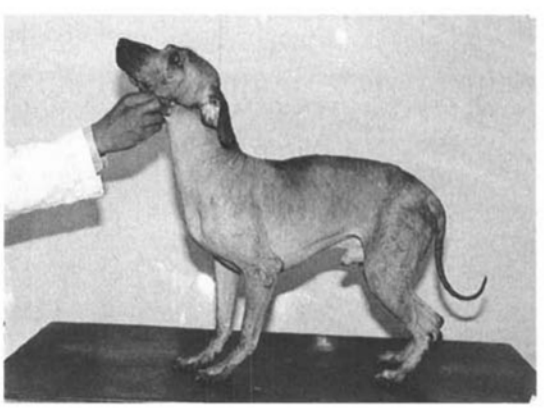

Fig. 2. Appearance of a hairless descendant of Mexican hairless dogs.

Mexican hairless dogs (MHDs) generally referred to as Xoloitzcuintli in Mexico are said to have been raised by native Indian people in Mexico since the Aztec era, and a small number of MHD still exist in Mexico. A pair of MHD

Fig. 3. Appearance of a haired descendant of Mexican hairless dogs.

of unknown age was introduced to Japan in 1983. One of these descendants which was born on 10 May 1986 (Fig. 1) was crossed to female beagles to obtain hybrid hairless dogs. Then, the resulting male hairless F1 hybrids were backcrossed to female beagles to produce BCF1 hybrids (Figs 2 & 3). We are repeatedly backcrossing between male hairless offspring and female beagles in order to establish a colony of experimental hairless dogs. Hairless dogs are expected as a useful tool for the investigations of sunburn and contact dermatitis and the efficacy assessment of cosmetics. In addition, they seem to be also useful as a model of immunodeficiency (Hirota *et al.*, 1990). The purpose of this paper is to describe the hairless inheritance for the MHD and breeding results.

Materials and methods

Animals

The number of pups and the birth rate for hairless and haired dogs were recorded. The survival rate to 7 days of age was also investigated. In addition, mating of the original pair of MHD gave 3 litters.

Animals were individually housed in stainless steel cages (85×95×75 cm) in a controlled animal room environment (temperature, 20–25 °C; humidity, 50–70%). Lightning was controlled to give 12 h light (0600–1800) and 12 h dark (1800–0600) per day. The animal room ventilated 10–15 times per hour with fresh air.

Table 1. Breeding results in hairless and haired dogs

		Hairless dogs (male, female)				*Haired dogs (male, female)*			
Generation	*Mating system (male×female)*	*Born*		*Survival*		*Born*		*Survival*	
P	MHD×MHD	7	(1, 6)	0	(0, 0)	1	(1, 0)	0	(0, 0)
		3	(1, 2)	1	(0, 1)	2	(1, 1)	2	(1, 1)
		6	(6, 0)	4	(4, 0)	2	(1, 1)	2	(1, 1)
		16	(8, 8)	5	(4, 1)	5	(3, 2)	4	(2, 2)
F1	MHD×beagle	3	(2, 1)	1	(1, 0)	3	(2, 1)	3	(2, 1)
		4	(3, 1)	2	(2, 0)	2	(2, 0)	2	(2, 0)
		3	(1, 2)	2	(1, 1)	3	(2, 1)	2	(1, 1)
		5	(4, 1)	0	(0, 0)	2	(0, 2)	2	(0, 2)
		2	(2, 0)	0	(0, 0)	4	(1, 3)	4	(1, 3)
		5	(3, 2)	0	(0, 0)	1	(0, 1)	1	(0, 1)
		22	(15, 7)	5	(4, 1)	15	(7, 8)	14	(6, 8)
BCF1	F1 hairless hybrid×beagle	2	(0, 2)	1	(0, 1)	5	(4, 1)	5	(4, 1)
		4	(2, 2)	4	(2, 2)	4	(2, 2)	3	(2, 1)
		4	(1, 3)	4	(1, 3)	2	(0, 2)	1	(0, 1)
		10	(3, 7)	9	(3, 6)	11	(6, 5)	9	(6, 3)
BCF2	BCF1 hairless hybrid×beagle	4	(3, 1)	2	(2, 0)	1	(1, 0)	1	(1, 0)
		2	(1, 1)	2	(1, 1)	3	(1, 2)	3	(1, 2)
		2	(1, 1)	0	(0, 0)	5	(2, 3)	5	(2, 3)
		8	(5, 3)	4	(3, 1)	9	(4, 5)	9	(4, 5)
Total number of F1, BCF1 and BCF2		40	(23, 17)	18	(10, 8)	35	(17, 18)	32	(16, 16)

Table 2. The birth and survival rate in hairless and haired dogs

	Hairless dogs		Haired dogs	
	Birth rate	Survival rate	Birth rate	Survival rate
MHD	76·2	31·3	23·8	80·0
F1	59·5	22·7	40·5	93·3
BCF1*	47·6	90·0	52·4	81·8
BCF2*	47·1	50·0	52·9	100·0

*Heating up cages using nursery infrared heaters for piglets and heating mats for pets.

They were fed a commercial dry dog food (Labo D Standard, Nihon Nosan Kogyo Co. Ltd, Yokohama, Japan) and tap water *ad libitum*. The body weight of each dog was recorded once a week throughout the experimental period.

On the basis of F1 breeding data, we tried to enhance survival rate of BCF1 and BCF2. Namely, nursery infrared heaters for piglets were hung on the roofs of cages, and heating mats for pets were laid on the floor. As a result, the temperature in the cages was kept at >25 °C.

Statistical analysis

Statistical analysis on the birth rate data was performed using the χ-square test.

Results

Birth rate

Tables 1 and 2 show the birth rate. F1 generation consisted of 22 hairless and 15 haired dogs. The results did not deviate from a 1:1 ratio ($\chi^2 = 1 \cdot 324$ for 1 df, $P > 0 \cdot 05$). The mean number of pups per litter was 6·2. The sex ratio (male:female) was as follows: hairless dogs (15:7) and haired dogs (7:8).

BCF1 generation consisted of 10 hairless and 11 haired dogs and BCF2 generation was composed of 8 hairless and 9 haired dogs. In both BCF1 and BCF2, the ratio of hairless and haired dogs was 1:1 ($\chi^2 = 0 \cdot 048$, and $0 \cdot 059$, respectively, for 1 df, $P > 0 \cdot 05$). The mean number of pups in BCF1 and BCF2 was 7·0 and 5·7, respectively. The sex ratio (male:female) of BCF1 was 3:7 (hairless dogs) and 6:5 (haired dogs). That of BCF2 was 5:3 (hairless dogs) and 4:5 (haired dogs). The total number of pups in F1, BCF1 and BCF2 was 40 hairless dogs (23 males, 17 females) and 35 haired dogs (17 males, 18 females), and the ratio of hairless and haired dogs was 1:1 ($\chi^2 = 0 \cdot 333$, for 1 df, $P > 0 \cdot 05$).

Mating of a male MHD with a female MHD gave 3 litters. The result was 16 hairless and 5 haired dogs. The deviation from a monogenic 3:1 ratio was nonsignificant ($\chi^2 = 0 \cdot 016$ for 1 df, $P > 0 \cdot 05$). Their mean litter size was 7·0, and the sex ratio in hairless and haired pups was 8:8 and 3:2, respectively (Table 1).

Survival rate

Tables 1 and 2 show the survival rate. In the pups between a pair of MHD, the survival rate of haired dogs was 80%, while that of the hairless dogs was very low (31·3%). In the F1, BCF1 and BCF2, more than 80% haired dogs survived. On the other hand, the survival rate of F1 hairless hybrids was very low (22·7%), but that of BCF1 and BCF2 hairless hybrids rose to 90% and 50%, respectively, when extra heat was given. In the case of hairless dogs, deaths occurred within 24 h.

Discussion

In this breeding trial, we conducted 3 types of mating, that is, F1 (male MHD × female beagles), BCF1 (male F1 hairless hybrids × female beagles) and BCF2 (male BCF1 hairless hybrids × female beagles). Each birth ratio of hairless and haired dogs did not deviate from an expected 1:1 ratio on the assumption of a Mendelian dominant mode of inheritance. Mating between a pair of MHD gave a monogenic 3:1 ratio of hairless and haired pups. These data were consistent with the results reported by Hintze (1975) and Goto *et al.* (1987). There were no significant sex difference in hybrid dogs.

These findings reveal that the characteristics of MHD is governed by the Mendelian law with hairlessness dominant to normal coat. We propose the symbol *Hm* for this gene (hairless, Mexican type). When the hairlessness is expressed by this symbol, the genotype of the

MHD is *Hm/Hm* and/or *Hm/hm*, and that of the beagle *hm/hm*. When the male MHD or hairless hybrids are crossed to female beagles, the segregation ratio of *Hm/hm* and *hm/hm* is a 1:1 ratio. Namely, that of hairless and haired dogs is 1:1. From mating between MHD, 3 genotypes of *Hm/Hm*, *Hm/hm* and *hm/hm* are observed at a ratio of 1:2:1. That is, 2 phenotypes of hairless and haired dogs are found at a ratio of 3:1. The assortment data are consistent with autosomal dominant monogenic inheritance of hairless characteristics, with both homozygotes viable, though no proven homozygous *Hm/Hm* dogs have been identified.

Robinson (1985) reported the following results: although the observed ratio of hairless to normal pups from matings between Chinese crested dogs does not differ significantly from a 3:1 ratio, the agreement is poor and just fails to be significant; the ratio is much closer to the 2:1 ratio to be expected upon the assumption that the homozygous hairless is lethal. Therefore, the hairlessness of this breed is assumed to be due to a dominant lethal gene. Our observation suggested that the hairless gene of MHDs might be different from *Hr* gene described by Robinson, and we could not clarify the cause of death in the homozygous hairless dogs.

The survival rate of pups for mating between MHD were consistent with the data reported by Yankell *et al.* (1970). In haired F1 hybrids between MHD and beagles, the survival rate was also similar to that reported by Yankell *et al.* (1970) and Goto *et al.* (1988). However, the survival rate of hairless dogs in the present study was markedly lower than that in their study (50–100%). As a result of heating the cages, the survival rate was elevated to much the same as haired F1 hybrids. Yankell *et al.* (1970) suggested that MHD appeared to be more sensitive to the environment than haired dogs, and that MHD shivered and appeared uncomfortable at normal room temperature. The present results support their observation. It will be important to heat up the room temperature, when experimental hairless dogs are raised.

There was no significant difference in the number of pups per litter among 4 modes of mating, and the litter size was almost equal to that of beagles. The number of pups per litter will not be affected, when we continue to backcross male hairless dogs to female beagles in order to establish experimental hairless dogs.

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