

## Effective Treatment for Improving the Survival Rate of Raccoon Dogs Infected with *Sarcoptes scabiei*

Nobuhide KIDO<sup>1,2)\*</sup>, Tomoko OMIYA<sup>1,2)</sup>, Chihiro KAMEGAYA<sup>1,3)</sup>, Yuko WADA<sup>1)</sup>, Maya TAKAHASHI<sup>1)</sup> and Yasuhiko YAMAMOTO<sup>1)</sup>

<sup>1)</sup>Kanazawa Zoological Gardens, 5-15-1 Kamariya higashi, Kanazawa-ku, Yokohama 236-0042, Japan

<sup>2)</sup>Nogeyama Zoological Gardens, 63-10 Oimatsu cho, Nishi-ku, Yokohama 220-0032, Japan

<sup>3)</sup>Enoshima Aqualium, 2-19-1 Katase Kaigan, Fujisawa 251-0035, Japan

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**ABSTRACT.** *Sarcoptes scabiei* is one of the important external parasites. Although ivermectin is the recommended treatment, many raccoon dogs (*Nyctereutes procyonoides*) that were rescued and brought to the Kanazawa Zoological Gardens (Yokohama, Japan) have died because of *S. scabiei*, even after receiving single ivermectin treatment. Therefore, supportive treatment should be required. The present study revealed the number of animals that survived was greater after the administration of ivermectin along with an antibiotic for all raccoon dogs, as well as following the administration of fluid therapy to the debilitated raccoon dogs infected with *S. scabiei*, immediately after the rescue. During the initial period, treatment to improve the general clinical condition was required prior to deworming treatment for *S. scabiei*.

**KEY WORDS:** antibiotic, fluid therapy, raccoon dog, *Sarcoptes scabiei*, wildlife rescue

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*Sarcoptes scabiei* is an ectoparasite that infests humans, as well as domestic and wild mammals [3]. Wild animals cannot be treated, if they are infested with *S. scabiei*. Therefore, an *S. scabiei* infection is considered a major cause of mortality in wildlife [2, 3, 9, 13]. Raccoon dogs (*Nyctereutes procyonoides*) are a native species of Japan [14]. In Japan, many reports of *S. scabiei* infestation in raccoon dogs have been documented, and infestation was the cause of mortality for these animals [7, 12, 17]. The effectiveness of ivermectin for the treatment of *S. scabiei* has been studied in many different species, and ivermectin is recommended for animals infested with *S. scabiei* [8, 10, 15, 18]. However, many raccoon dogs that were rescued and brought to the Kanazawa Zoological Gardens (Yokohama, Japan) because of an *S. scabiei* infestation died despite single ivermectin treatment. Therefore, supportive treatment, in addition to an ivermectin administration, should be provided to help increase the survival rate.

Previously, we analyzed the serum biochemical values of raccoon dogs infested with *S. scabiei* and showed that these raccoon dogs clinically developed sepsis, dehydration and malnutrition [6]. In the present study, we evaluated the effectiveness of a treatment including an antibiotic and a fluid in addition to ivermectin that might help improve a raccoon dog's condition, such as sepsis and dehydration.

In the present study, 239 free-range raccoon dogs that

were rescued between April 2003 and March 2010 at the Kanazawa Zoological Gardens because of an *S. scabiei* infestation were examined. Each raccoon dog's whole body surface was affected by *S. scabiei*, and its hair was partially or completely lost, depending on its skin lesions. The skin was hyperkeratotic, thickened, wrinkled and a slate-gray color, as well as partially covered with numerous suppurative scabs. Moreover, pyoderma was observed on many raccoon dogs. Keratinized epidermal specimens treated with 10% potassium hydroxide (KOH) revealed the presence of sarcoptic mites by microscopic observation.

Raccoon dogs were divided into the following two groups: Group 1 included raccoon dogs that were rescued between April 2003 and March 2007, while raccoon dogs in Group 2 were rescued between April 2007 and March 2010. In addition, the raccoon dogs in each group were divided into two subgroups, debilitated and nondebilitated raccoon dogs, according to the following features on the day of their rescue: debilitated raccoon dogs appeared emaciated; had anorexia; had pale oral and conjunctival mucosae, hypothermia, enophthalmos and anastasia; and did not resist human handling. Nondebilitated raccoon dogs did not display these clinical signs. The difference in the degree of skin disease was not large between the debilitated and nondebilitated raccoon dogs. The raccoon dogs that were infested with *S. scabiei*, but did not appear hyperkeratotic or have thickened skin and had only lost minimal hair within a small area were excluded.

Treatment which was certainly conducted for all raccoon dogs in each group immediately after the rescue differed as follows. In Group 1, the raccoon dogs were subcutaneously administered ivermectin (Ivomec injection, Merial Japan, Tokyo, Japan) twice at 400 µg/kg every 2 weeks during the first month. Group 2 was subcutaneously administered

\*CORRESPONDENCE TO: KIDO, N., Nogeyama Zoological Gardens, 63-10 Oimatsu cho, Nishi-ku, Yokohama 220-0032, Japan. e-mail: kido@hama-midorinokyokai.or.jp

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Fig. 1. A debilitated raccoon dog infested with *Sarcoptic scabiei* is shown in the top image. As shown in the bottom image, after treatment, its skin lesion had healed, and it had normal hair growth.

Table 1. The number of raccoon dogs that recovered from and survived an *S. scabiei* infestation, as well as their survival rate. Group 1 included the raccoon dogs that were administered ivermectin. Group 2 was administered ivermectin and cephalixin, and the debilitated raccoon dogs also received fluid therapy

	Total number	Number of survived raccoon dogs	Number of died raccoon dogs	Survival rate (%)
Group 1	68	29	39	42.6
Debilitated	24	3	21	12.5
Nondebilitated	44	26	18	59.1
Group 2	157	96*	61	61.1
Debilitated	53	21*	32	39.6
Nondebilitated	104	75	29	72.1

Significant differences between Groups 1 and 2 are indicated: \* $P < 0.05$ .

ivermectin three times at 400  $\mu\text{g}/\text{kg}$  every 2 weeks and oral or intravenous cephalixin (Larixin, Taisho Toyama Pharmaceutical Co., Ltd., Tokyo, Japan) at 20 mg/kg twice a day for 1 week during the first month. In addition, a lactated Ringer's solution (Solulact, Terumo Co., Tokyo, Japan) was intravenously administered to all debilitated raccoon dogs in Group 2. Ivermectin remains in the natural environment because of animal excretions [1], and the half-life of ivermectin in a domestic dog is known to be 1.8 days [5]. When the raccoon dog was released to the wild, the effect to the natural environment by ivermectin was considered.

The raccoon dogs that survived were characterized as follows: had healed skin lesions, had normal hair growth and could be reintroduced to the wild. Figure 1 shows a raccoon dog that recovered from an *S. scabiei* infestation and had normal hair growth. Until the raccoon dogs were reintroduced to the wild, they had been kept in the Kanazawa Zoological Gardens for an average of 128.1 days. However, the raccoon dogs that were not categorized in this group died before their

skin lesions healed and could not be reintroduced to the wild. The number of animals that survived and the survival rate were determined in Groups 1 and 2, as well as in the debilitated and nondebilitated subgroups.

The significant differences in the number of animals that survived between Groups 1 and 2 were compared with the  $\chi^2$  test. A statistical analysis was conducted using Microsoft Excel 2010.

Two hundred thirty-nine raccoon dogs were rescued between April 2003 and March 2010 because of *S. scabiei* infestation, but 14 of the 239 raccoon dogs did not appear to have many symptoms and were excluded from the present study. Groups 1 and 2 included 68 (42 males, 24 females and 2 unknown [because the clinical record did not describe this attribute]) and 157 (81 males, 70 females and 6 unknown) raccoon dogs, respectively.

Table 1 shows the survival rate, as well as the number of raccoon dogs that recovered from and survived the *S. scabiei* infestation, in each group. The total number of raccoon

dogs and the debilitated subgroup of Group 2 that survived were significantly greater than those of Group 1 ( $P < 0.05$ ). In Group 2, one raccoon dog that was in the nondebilitated subgroup had dry and scaly skin over its whole body, and its hair did not grow, although a skin lesion, along with its hyperkeratotic, thickened, wrinkled and scabbed skin, associated with *S. scabiei* healed. Finally, the animal died 483 days after rescue, because of emaciation.

The present study showed the number of animals that survived was significantly greater after three ivermectin administrations during the first month and an antibiotic for all raccoon dogs, as well as the administration of fluid therapy to the debilitated raccoon dogs infested with *S. scabiei* immediately after the rescue. Generally, domestic and captured wild animals can be treated with a single ivermectin administration 2 or 3 times, because the treatment can be started before their symptoms and lesions become severe. However, free-range wild animals could not be immediately treated, and their symptoms and lesions became severe. Actually, 57.4% of the raccoon dogs in Group 1 died despite a single ivermectin administration; the survival rate of the debilitated raccoon dogs that had more severe symptoms was much lower than that of the nondebilitated animals. Therefore, supportive treatment was required to save their lives.

A previous study elucidated the hematological and serum biochemical values from raccoon dogs infested with *S. scabiei* and indicated that raccoon dogs debilitated by an *S. scabiei* infestation appeared septic, dehydrated and malnourished [6, 11]. Therefore, the administration of an antibiotic at the beginning of rescue was important to control sepsis. In addition, fluid therapy might be effective for debilitated raccoon dogs. During the initial treatment period, for debilitated raccoon dogs, treatment to improve their general clinical condition was required soon along with a deworming treatment for *S. scabiei*. Therefore, an antibiotic and fluid therapy might be important and related to the significant improvement in the number of debilitated raccoon dogs that survived in Group 2. In addition, three ivermectin administrations were effective to deworm the raccoon dogs of *S. scabiei* that appeared to have more severe symptoms than the domestic animals. A previous study indicated that three administrations were required for a severe *S. scabiei* case in an African buffalo (*Syncerus caffer*) [10]. In the present study, these aggressive treatments including an antibiotic, fluid therapy and three ivermectin administrations were effective for improving the survival rate. As far as we know, the present study might be the first report to describe the effectiveness of ivermectin use, along with other medications, in a relatively large number of individual wildlife cases.

*S. scabiei* is a fatal disease for most wildlife species, because they are not able to receive sufficient treatment. In the wild, an *S. scabiei* outbreak might dramatically decrease the wildlife population [4, 7, 16]. In addition, a rapid change in one wildlife population might affect the population of other species [7]. Therefore, in case of an *S. scabiei* outbreak in the wild, treatment of *S. scabiei*-infected raccoon dogs and their reintroduction to the wild may help prevent a dramatic change in the wildlife population.

However, some issues associated with reintroduction should be considered. First, there is a possibility that reintroduction could contribute to the spread of an *S. scabiei* infestation if a raccoon dog is released prior to complete recovery. Actually, the number of rescued raccoon dogs was increased in Group 2, and *S. scabiei* infestation was considered to be expanded. However, the raccoon dogs were confirmed to be completely cured as their skin lesions had healed and they had normal hair growth for an average of 128.1 days before their reintroduction. In addition, since 2006, the local government has begun to aggressively rescue raccoon dogs. Therefore, there is little risk that the *S. scabiei* infestation was expanded during the present study. Second, animal excretion including ivermectin affects the natural environment [1]. In the present study, the raccoon dogs were not released into the wild until approximately 3 months after the final ivermectin administration. Therefore, excretions from released raccoon dogs might rarely contain ivermectin. Although wildlife rescues have some issues, the reintroduction of raccoon dogs did not induce adverse effects to the natural environment in the present study.

In the present study, the treatment was effective for the raccoon dogs in Groups 1 and 2, similar to that of domestic dogs, and treatment resistance was not observed. The difference in survival numbers between debilitated and nondebilitated animals was based on their clinical condition. 60.4% of the debilitated raccoon dogs in Group 2 still died, although the rate was improved with treatment. Malnutrition was one of the significant symptoms in debilitated raccoon dogs [6]. If the debilitated raccoon dogs appeared anorexic, they did not eat any food and died. During the present study, we could not identify effective treatment that could improve nutritional status. In addition, one raccoon dog died 483 days after rescue despite treatment. The animal had a skin lesion, and its hair did not grow normally. Although we could not determine the cause, nutritious or other infectious factors might have affected the lesion. A further study is necessary to reveal these points.

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