Infestation of introduced raccoons (Procyon lotor) with indigenous ixodid ticks on the Miura Peninsula, Kanagawa Prefecture, Japan

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1. Introduction

The first report of feral raccoons (Procyon lotor) in Japan was reported in 1962 in Aichi Prefecture and the raccoon was imported to Japan as a pet and increased number in the late 1970s (Ikeda, 2006). A survey performed by the Japanese government in 2006 confirmed that raccoons have established populations throughout Japan (Ikeda, 2006). They compete for resources with native mammals, such as the raccoon dog (Nyctereutes procyonoides) and the red fox (Vulpes vulpes japonica; Ikeda, 2006; Ikeda et al., 2004), prey on endangered reptiles (Kaneda and Kato, 2011), damage crops (Ikeda, 2006), break into houses (Ikeda, 1999, 2006) and are recognized as an invasive species (Ikeda, 1999). Furthermore, they are hosts to ticks and associated pathogens that impact the health of human, livestock, and other indigenous wildlife. Multiple reports indicate that raccoons have a role as a reservoir of tick-borne diseases (TBD), (e.g., Japanese spotted fever; JSF) (Inoue et al., 2011), tularemia (Berrada et al., 2006; Fujita, 2009a; Inoue et al., 2011), babesiosis (Kawabuchi et al., 2005), and severe fever and thrombocytopenia syndrome (SFTS) (Takahashi et al., 2014). Since both human infestation and TBD case reports, such as JSF, concentrate in seasons, ticks are mostly active in the environment (Mahara, 1997). Also, TBD pathogens circulate between wildlife and ticks and the distribution of host wildlife is overlapped with vector ticks (Tsukada et al., 2014). Thus, the seasonal patterns of ticks and distributional patterns of ticks and host wildlife are strongly interacting each other. Moreover, on-host ticks observation indicates how vector ticks widen their distribution. However, the seasonal patterns of on-host ticks are not fully understood especially among introduced wildlife. and Haemaphysalis flava, H. megaspinosa, H. longicornis, H. japonica, Ixodes ovatus, and I. tanuki, from 100 out of 115 raccoons. The dominant tick species was H. flava (96.8%) and individuals were mainly adults. Seasonal patterns of infestation intensity of adults and nymphs peaked in the autumn and winter and decreasing in the late spring and summer, May to August, while larvae peaked in August. Our results indicated that host–parasite relationships between invasive raccoons and Japanese tick species, especially H. flava, were established in Kanagawa Prefecture. The ticks infest invasive raccoons for their blood-meal and also for overwintering. The results of this study extend our understanding of the ecology of tick-borne diseases.

ABSTRACT

Since the raccoon (Procyon lotor) was introduced to Japan, studies have established that they are infested with native Japanese tick species. However, the quantity of ticks infesting raccoons is unknown. We conducted a survey of ticks on invasive raccoons captured on the Miura Peninsula, Kanagawa Prefecture, Japan, from April 2015 through June 2016 to determine the species of ticks and to quantify the intensity of tick infestation in order to obtain basal information related to the ecology of host–parasite relationships among indigenous tick species and an alien mammalian species. We collected and identified 15,931 ticks of two genera and six species, namely, Haemaphysalis flava, H. megaspinosa, H. longicornis, H. japonica, Ixodes ovatus, and I. tanuki, from 100 out of 115 raccoons. The dominant tick species was H. flava (96.8%) and individuals were mainly adults. Seasonal patterns of infestation intensity of adults and nymphs peaked in the autumn and winter and decreasing in the late spring and summer, May to August, while larvae peaked in August. Our results indicated that host–parasite relationships between invasive raccoons and Japanese tick species, especially H. flava, were established in Kanagawa Prefecture. The ticks infest invasive raccoons for their blood-meal and also for overwintering. The results of this study extend our understanding of the ecology of tick-borne diseases.

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wildlife hosts and vector ticks are important to define the ecoepidemiology of TBD (Alexander et al., 2012).

The purpose of our research was to identify and quantify the species of ticks infesting raccoons. This survey is a first step to obtaining a full understanding the host–parasite relationship between invasive raccoons and Japanese ticks.

2. Material and methods

2.1. Study area

The study was conducted in Yokosuka City (35°16′53.5″N 139°40′19.4″E) and the town of Hayama (35°16′19.6″N 139°35′10.3″E), Miura Peninsula, Kanagawa Prefecture (Fig. 1). The area is located in the central eastern region of Honshu Island, Japan. The peninsula is characterized by a humid subtropical climate, classified as “humid subtropical climate” under the Köppen climate classification with four seasons: spring (March–May), summer (June–August), autumn (September–November), and winter (December–February) (Japan Meteorological Agency, 2016; Kottek et al., 2006).

Fauna in the study area included raccoon dog, Japanese badger (Meles anakuma), and invasive raccoons. The Japanese Sika deer (Cervus nippon), Japanese macaque (Macaca fuscata), and Japanese wild boar (Sus scrofa leucomystax) were not present based on an animal survey conducted by the Biodiversity Center of Ministry of the Environment of Japan (2004).

2.2. Raccoon samples

Since the Invasive Alien Species Act in 2005 listed the raccoon as an invasive alien species, local governments of Japan have implemented countermeasures against the biological and economical damage caused by raccoons (Ama, 2007). Kanagawa Prefecture initiated the Kanagawa Prefecture Raccoon Control Implementation Plan (2016) in 2006, where licensed hunters captured invasive raccoons using box traps (Havahart Model 1089; Woodstream, Pennsylvania, USA). Raccoons were euthanized with carbon dioxide gas following the Guidelines for Management of Invasive Alien Species of the Japan Veterinary Medical Association (Japan Veterinary Medical Association, 2007). During this study, raccoons were captured and euthanized from April 2015 through June 2016.

2.3. Tick collection and identification

Ticks were collected from 115 raccoon carcasses using forceps and combing all skin surfaces using a cat flea comb. Ticks were preserved in 70% ethanol and then identified to species, stages of development, and sex of adults based on morphological examination under a stereo-microscope and a biological microscope using standard keys (Yamaguti et al., 1971).

2.4. Data analysis

The mean burden and proportion of each tick species were
Table 1

Life stage* and sex of ticks infesting the raccoons captured in Kanagawa Prefecture, Japan from April 2015 through June 2016. H. flav a was the most abundant species found on the raccoons. * M: male adult, F: female adult, N: nymph, L: larva.

| Month (Number of raccoons infested) | H. flav a | H. megaspinosa | H. longicornis | H. japonica | I. tanuki | L. o vatus | Unknown |
|-----------------------------------|----------|---------------|---------------|-------------|-----------|-----------|---------|
|                                   | M        | F             | N             | L           | M         | F         | N       |
| 2015 Apr (0/1)                    | Not Detected |               |               |             |           |           |         |
| 2015 May (0/1)                    | Not Detected |               |               |             |           |           |         |
| 2015 Jun (0/3)                    | Not Detected |               |               |             |           |           |         |
| 2015 Jul (2/2)                    | 2        | 0             | 0             | 0           | 0         | 0         | 0       |
| 2015 Aug (2/2)                    | 0        | 0             | 331           | 0           | 0         | 0         | 0       |
| 2015 Sep (0/1)                    | Not Detected |               |               |             |           |           |         |
| 2015 Oct (12/12)                  | 267      | 83            | 43            | 3           | 14        | 3         | 1       |
| 2015 Nov (6/7)                    | 496      | 259           | 168           | 2           | 5         | 3         | 0       |
| 2015 Dec (4/4)                    | 256      | 198           | 191           | 4           | 10        | 14        | 3       |
| 2016 Jan (23/23)                  | 1931     | 1169          | 1306          | 4           | 42        | 43        | 17      |
| 2016 Feb (17/18)                  | 2554     | 1485          | 1584          | 5           | 5         | 7         | 6       |
| 2016 Mar (12/13)                  | 1119     | 749           | 441           | 1           | 8         | 33        | 5       |
| 2016 Apr (4/4)                    | 191      | 75            | 59            | 0           | 2         | 0         | 0       |
| 2016 May (4/4)                    | 53       | 48            | 9             | 0           | 0         | 0         | 0       |
| 2016 Jun (14/17)                  | 69       | 73            | 75            | 1           | 1         | 1         | 5       |
| **Total**                         | **6938** | **4139**      | **3946**      | **91**      | **73**    | **179**   | **39**  |

15,414 232 92 2 38 98 55

estimated. The dominant species and seasonal abundance of ticks were determined.

3. Results

3.1. General findings

A total of 100/115 (87.0%) of the raccoons examined were infested with a total of 15,931 ticks belonging to six species and two genera (Table 1). The mean number of ticks collected per raccoon was 138.5 (range: 0–1346). A total of 55 ticks were not identified to species due to damages. Haemaphysalis flav a accounted for the highest number of ticks (15414; 96.8%), followed by H. megaspinosa (232; 1.5%), L. o vatus (98; 0.6%), H. longicornis (92; 0.6%), I. tanuki (38; 0.2%), and H. japonica (2; < 0.1%). All stages of H. flav a, H. megaspinosa, and H. longicornis were collected on raccoons. Ticks were infested by adult males and females of I. tanuki, females only of L. o vatus, and only single individuals of a nymph and adult H. japonica were collected (Table 1).

3.2. Seasonal patterns

Temporal analyses of H. flav a on the invasive raccoons demonstrated a relatively intense infestation in the autumn and winter which decreased in the late spring and summer, May to August (Fig. 2; Table 1). Adult ticks peaked in the winter, while larvae peaked in August. In addition, despite seasonal changes, H. flav a used raccoons as a host throughout the year for every developmental stage (Table 1).

4. Discussion

Our results and previous studies which reported tick infestation on raccoons in Japan (Fujita, 2009b; Kobayashi et al., 2012) indicated that invasive raccoons and the Japanese native tick, H. flav a, have a well established host-parasite relationship.

The previous study in Chiba Prefecture, Japan, about 80 km east of our study area, also reported that larval H. flav a were the most abundant in the summer and adult H. flav a were the most abundant in the autumn and winter (Asanuma, 1956; Saito, 1959). In addition, two previous tick surveys in the western region of the Republic of Korea during April and October by Cobrun et al. (2016), and in the southeastern region of the Republic of Korea during March and October by Johnson et al. (2017), reported that adult and nymphal H. flav a were frequently collected in April, May and October, and decreased during August, while larvae were collected starting July and peaked in August. Moreover, Johnson et al. (2017) reported that the habitat preference of H. flav a was the forest environment.

Our results indicated a relatively high intensity of adult and nymphal H. flav a infestation that started to increase in November and peaked in February while larval H. flav a peaked in August (Fig. 2). Asanuma and Sakurai (1958), Yoshida (1980), Fujimoto et al. (1987), and Kakuda et al. (1990) reported larval H. flav a and H. longicornis overwintered on the host. Thus, our results of intense infestation on raccoons during winter indicated on-host overwinter habitat of adult and nymphal H. flav a. H. flav a is known that they frequently infest domestic dogs (Canis lupus familiaris) going into forest environment (Choe et al., 2011). Also, surveys in previous studies were conducted before invasive raccoons spread across Japan, infestations of H. flav a (Saito, 1959; Saito et al., 1965), H. longicornis (Saito et al., 1965), I. tanuki (Saito, 1964), and L. o vatus (Saito, 1959) were found from medium-sized carnivores, including raccoon dogs, red foxes, Japanese weasels (Mustela sibirica tiansi), and Japanese badgers. These ticks established host–parasite relationships with indigenous medium-sized carnivores in the Miura Peninsula before or at the time of the introduction of raccoons. In addition, our study area, Miura Peninsula was the area that Japanese Sika deer and Japanese wild boar have not been observed in recent decades, which were known to be hosts of various tick species, such as H. longicornis, H. megaspinosa, A. testudinatum, and L. o vatus, (Biodiversity Center of Ministry of the Environment of Japan, 2005; Yamaguti et al., 1971; Tsukada et al., 2014). This implies that H. flav a, H. longicornis, L. o vatus, and I. tanuki may have selected raccoons or at least used raccoons as hosts in addition to indigenous medium-sized carnivores because of its availability as the host. Although, Yamaguti et al. (1971) reported that larval H. flav a prefer small mammals and small birds, we observed larvae H. flav a infestation in August (Fig. 2). This indicated larval H. flav a may be able to infest larger mammals (e.g., raccoon) if they were more abundant in the area or used the environment of the area frequently.

5. Conclusion

The relationships between native ticks and invasive raccoons in...
Kanagawa Prefecture, Japan was observed. Various tick species in Japan exhibited a high adaptability of infesting the invasive raccoons in our study area that were recently introduced in the past few decades. Every developmental stage of *Haemaphysalis flava* using raccoons as host for their blood-meal and especially adults and nymphal *H. flava* may have used raccoons for overwintering.

*H. flava*, *H. longicornis*, *H. megaspinosa*, *H. kitaokai*, *Amblyomma testudinarium* were known as vector ticks of SFTS. Also, *H. flava*, *H. longicornis*, *H. megaspinosa*, *H. japonica* and *I. ovatus* were the ticks that detections of the spotted fever group rickettsiae (Ishikura et al., 2000; Katayama et al., 1996, 2001) and cases of human infestation (Seishima et al., 2000; Yamauchi et al., 2010) were reported in the past. Raccoon, which was infested by ticks in our study area, is known as an urban wildlife breaking into houses and using various environment (e.g. forest, grassland, urban) (Ikeda, 2009). Thus, it is highly possible that ticks spread its distribution toward urban living environment by infesting a raccoon and those ticks possibly harbor TBDs. It is necessary to perform tick surveys of medium-sized carnivores living in our study area to have a better understanding of the host preferences of various tick species and their associated pathogens they harbor in Japan.

**Conflicts of interest**

None.

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**References**

Alexander, K.A., Lewis, B.I., Marathe, M., Eubank, S., Blackburn, J.K., 2012. Modelling of wildlife-associated zoonoses: applications and caveats. Vector Borne Zoonotic Dis. 12, 1005–1018.

Ama, N., 2007. Outline of the invasive alien species Act. J. Weed Sci. Technol. 52, 137–140 (in Japanese).

Asanuma, K., 1956. Tularemia, ticks, and mesostigmatid mites of Far East. In: Ann. Prof. Rep. 406th Medical General Laboratory, pp. 91–96.

Asanuma, K., Sakurai, N., 1958. Comparison between the infestation of *Ixodes nipponensis* and *Haemaphysalis flava* on wild rabbits. Annu. Rep. Ohara. Hosp. 4, 26 (in Japanese).

Berrada, Z.L., Goethert, H.K., Telford, S.R., 2006. Raccoons and skunks as sentinels for enzootic tularemia. Emerg. Infect. Dis. 12, 1019–1021.

Biodiversity Center of Ministry of the Environment of Japan, 2004. The National Survey on the Natural Environmental Report of the Distributional Survey of Japanese Animals (Mammals). (in Japanese).

Choe, H.C., Fudge, M., Sames, W., Robbins, R.G., Lee, I.Y., Chevalier, N.A., Chilcoat, C.D., Lee, S.H., 2011. Tick surveillance of dogs in the Republic of Korea. Syst. Appl. Acarol-UK 21, 215–222.

Cobrun, J.M., Chong, S., Kim, H., Chang, N.W., Calix, I.C., Resto, K., Lee, D., Johnson, J.L., Robbins, R.G., Klein, T.A., 2016. Tick surveillance in four southwestern pro-vinces of the Republic of Korea during 2013. Appl. Acarol-UK 21, 147–165.

Fujimoto, K., Yamaguti, N., Takahashi, M., 1987. Ecological studies on ixodid ticks. 2. Comparison of the seasonal occurrence of three ixodid ticks, *Haemaphysalis flava*, *Ixodes ovatus* and *I. nipponensis* in the south-western part of Saitama Prefecture. Jpn. J. Sanit. Zool. 38, 7–12 (in Japanese with English summary).

Fujita, H., 2009a. Ixodid ticks collected from *Procyon lotor* and its antibody survey. Annu. Rep. Ohara. Hosp. 49, 31 (in Japanese).

Fujita, H., 2009b. Survey on Tick and Tick-borne Disease Survey on Raccoon (*Procyon lotor*) in Tanabe City, Wakayama Prefecture. Annual Report Wildlife Control Council (in Japanese).

Furuno, K., Lee, K., Itoh, Y., Suzuki, K., Yonemitsu, K., Kowata, R., Shimoda, H., Watarai, M., Maeda, K., Takano, A., 2017. Epidemiological study of relapsing fever borreliosis detected in *Haemaphysalis* ticks and wild animals in the western part of Japan. PLoS One 12, e0174727.

Ikeda, T., 1999. The Annual Report on Cultural Sciences. Progress of Naturalization of Raccoons and Related Problems in Hokkaido, vol. 47. Faculty of Letters, Hokkaido University, pp. 149–175 (in Japanese).

Ikeda, T., 2006. Problem controlling the invasive raccoon in Japan. Mammalian Sci. 46, 95–97 (in Japanese).

Ikeda, T., Asano, M., Matoba, Y., Abe, G., 2004. Present status of invasive alien raccoon and its impact in Japan. Global Environ. Res. 8, 125–131.

Inoue, K., Kabeya, H., Fujita, H., Makino, T., Asano, M., Inoue, S., Inoue, H., Nogami, S., Matsumoto, Y., 2010. Serological survey of *Procyon lotor* and its antibody survey. Annu. Rep. Toyma Inst. Health. 23, 118–128 (in Japanese).

Ishikura, M., Ando, S., Watanabe, M., Shinagawa, Y., Fujita, H., Matsuura, K., Hasegawa, S., Maruyama, T., 2000. Phylogenetic analysis of gltA and rompA genes of spotted fever group rickettsia amplified by PCR from ticks in Japan. Annu. Rep. Toyama Inst. Health. 23, 118–128 (in Japanese).

Japan Meteorological Agency, 2016. Climate of Japan in 2015. pp. 8–10 (in Japanese).

Japan Veterinary Medical Association, 2007. Guidelines for the Management of Invasive Alien Species. The Wildlife Committee Report (Division of Small Animal Medicine in Japan Veterinary Medical Association). (in Japanese). http://nishiusu.linc.jp.gr.jp/kouyu/pdf/h19_07_yasei.pdf, Accessed date: December 2017.

Johnson, J.L., Kim, H., Cobrun, J.M., Chong, S., Chang, N.W., Robbins, R.G., Klein, T.A., 2017. Tick surveillance in four southeastern provinces, including three metropolitan areas, of the Republic of Korea during 2014. Appl. Acarol-UK 22, 271–288.

Kakuda, H., Shiraishi, H., Uchida, T.A., 1990. Seasonal changes in the abundance of *Haemaphysalis flava* in the forest, grassland, urban (Ikeda, 1999). Fig. 2. Temporal change of raccoon infesting *Haemaphysalis flava* in the Miura Peninsula, Japan from April 2015 to June 2016.

Katayama, T., Furuya, Y., Yoshida, Y., Kaiho, I., 1996. Spotted fever group rickettsiosis in Tanabe City, Wakayama Prefecture. Annual Report Wildlife Control Council (in Japanese).

Kato, T., Akiyama, K., Inoue, K., Kabeya, H., Fujita, H., Makino, T., Asano, M., Inoue, S., Inoue, H., Nogami, S., Maruyama, T., 2011. Serological survey of five zoonoses, scrub typhus, Japanese spotted fever, tularemia, Lyme disease, and Q fever, in feral raccoons (*Procyon lotor*) in Japan. Vector Borne Zoonotic Dis. 11, 15–19.

Kanagawa Prefecture, 2006. 3rd Kanagawa Prefecture Raccoon Control Implementation Plan. (in Japanese). www.pref.kanagawa.jp/uploaded/attachment/819555.pdf, Accessed date: July 2017.

Kaneda, M., Kato, T., 2011. A threat to amphibians and reptiles by invasive alien raccoons. Bull. Herpetol. Soc. Jpn. 2, 148–154 (in Japanese).

Katayama, T., Furuya, Y., Yoshida, Y., Kaiho, I., 1996. Spotted fever group rickettsiosis and vectors in Kanagawa Prefecture. Jpn. J. Infect. Dis. 70, 561–568 (in Japanese).
Katayama, T., Furuya, Y., Inada, T., Hara, M., Yoshida, Y., Imai, M., Itagaki, A., 2001. Detection of spotted fever group rickettsiae DNA from ticks in Kanagawa, Shimane and Kochi Prefectures. Jpn. J. Infect. Dis. 75, 53–54 (in Japanese).

Kawabuchi, T., Tsuji, M., Sada, A., Matoba, Y., Aokiwa, M., Ishikara, C., 2005. Babesia microti-like parasites detected in feral raccoon (Procyon lotor) captured in Hokkaido, Japan. J. Vet. Med. Sci. 67, 825–827.

Kobayashi, S., Nakamoto, A., Shimizu, K., Takada, A., Moriwaki, M., 2012. The first capture with ectoparasitic ticks and the first photograph in life of wild raccoon, Procyon lotor (Linnaeus 1758), in Okayama Prefecture. Naturalist (Rotherham) 16, 83–90 (in Japanese with English abstract).

Kottek, M., Grieser, J., Beck, C., Rudolf, B., Rubel, F., 2006. World Map of the Köppen-Geiger climate classification updated. Meteorol. Z. 15, 259–263.

Makara, F., 1997. Japanese spotted fever: report of 31 cases and review of the literature. Emerg. Infect. Dis. 3, 105–111.

Saito, Y., 1959. Studies on ixodid ticks, I. On ecology, with reference to distribution and seasonal occurrence of ixodid ticks in Niigata Prefecture, Japan. Acta Med. Biol. 7, 193–209.

Saito, Y., 1964. Studies on ixodid ticks, VII. Notes on the ticks infesting badgers in Japan with description of Ixodes tanuki n. sp. Acta Med. Biol. 12, 59–66.

Saito, Y., Kubota, M., Yajima, A., Watanabe, T., Kamino, K., 1965. Studies on ixodid ticks, VIII. On Haemaphysalis bispinosa Neumann, 1897 in Niigata Prefecture, Japan, with some supplementary observation on bovine piroplasmosis. Acta Med. Biol. 13, 143–159.

Seishima, M., Izumi, T., Oyama, Z., Kadosaka, T., 2000. Tick bite by Haemaphysalis megapisiosa - first case. Eur. J. Dermatol. 10, 389–391.

Takahashi, T., Maeda, K., Suzuki, T., Ishido, A., Shigeoka, T., Tominaga, T., Kamei, T., Honda, M., Ninomiya, D., Sakai, T., Senba, T., Kaneyuki, S., Sakaguchi, S., Satoh, A., Hoesekawa, T., Kawabe, Y., Kuribara, S., Izumikawa, K., Kihno, S., Azuma, T., Suemori, K., Yasukawa, M., Mizutani, T., Oomatsu, T., Katayama, Y., Miyahara, M., Ijuin, M., Doi, K., Okuda, M., Umeki, K., Saito, T., Fukushima, K., Nakajima, K., Yoshikawa, T., Tani, H., Fukushi, S., Fukuma, A., Ogata, M., Shimosima, M., Nakajima, N., Nagata, N., Katano, H., Fukushima, H., Sato, Y., Hasegawa, H., Yamagishi, T., Oishi, K., Kurane, I., Morikawa, S., Saijo, M., 2014. The first identification and retrospective study of Severe Fever with Thrombocytopenia Syndrome in Japan. J. Infect. Dis. 209, 816–827.

Tsukada, H., Nakamura, Y., Ramio, T., Inokuma, H., Hanafusa, Y., Matsuda, N., Maruyama, T., Ohba, T., Nagata, K., 2014. Higher sika deer density is associated with higher local abundance of Haemaphysalis longicornis nymphs and adults but not larvae in central Japan. Bull. Entomol. Res. 104, 19–28.

Yamaguti, N., Tipton, V.J., Keegan, H.L., Toshioka, S., 1971. Ticks of Japan, Korea and the Ryukyu Islands. Brigham Young Univ. Sci. Bull. Biol. Ser. 15, 1–226.

Yamauchi, T., Fukui, Y., Watanabe, M., Nakagawa, H., Kamimura, K., 2010. Forty cases of human infestations with hard ticks (Acarii: Ixodidae) in Toyama Prefecture, Japan. Med. Entomol. Zool. 61, 133–143 (in Japanese with English abstract).

Yoshida, T., 1980. Ecology of the tick, Haemaphysalis longicornis, in the pasture of Japan. Biol. Sci. 32, 1–10 (in Japanese).