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Pseudogagrella amamiana (Opiliones: Sclerosomatidae) from Kanto District, Japan, as the first probable cases of domestically introduced species in Japanese harvestmen

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Abstract — A population of *Pseudogagrella amamiana* (Nakatsudi 1942) (Arachnida: Opiliones: Sclerosomatidae) was found from a town park in the suburbs of Yokohama City, Kanagawa Prefecture, Honshu, Japan, in 2017. Furthermore, another population of the species was found from Unomisaki Point, Ishihama Beach, Hitachi City, Ibaraki Prefecture, in 2019. This species has been known from the Ryukyu Islands (in and north of Kumejima Island), and sporadically from Kyushu and westernmost part of Honshu (Yamaguchi Prefecture). It is highly probable that these populations in Yokohama and Unomisaki Point have originated from a few males and females or a gravid female or soil litter containing eggs somehow introduced from the native ranges of the species, because the present localities are more than 700 km apart from the nearest known locality of the species in Yamaguchi Prefecture. The chromosome number of these populations showed 2n = 18, hence it seems that the population came from the native ranges of the species other than Okinawa and Kumejima Islands where it is 2n = 20.

Key words — *chromosomes, distribution, Ibaraki Prefecture, introduced species, Kanagawa prefecture, Pseudogagrella amamiana*

Introduction

Pseudogagrella amamiana (Nakatsudi 1942) (Sclerosomatidae: Gagrellinae), with large black body (ca. 5 mm long in males and ca. 6–7 mm long in females) and long legs (ca. 130 mm long in the second legs (Nakatsudi 1942a; Suzuki 1944, 1971, 1973), is the most common species of harvestmen in the middle (Okinawa Islands) and northern (from Amami Islands to Yakushima Island and Tanegashima Island) parts of the Ryukyu Islands (Suzuki 1973). The species occurs abundantly on trunks of trees, on underside of leaves of tree ferns such as *Cyathea spinulosa*, or on herbs and ferns in woodlands, making loose clutches, in the islands. This species can easily be distinguished from other species of harvestmen by its black body having a long spine on the second tergite of the scutum and having a pair of white markings made of wax, which are distinct especially in males, on the both lateral sides of the dorsal spine. The markings made of wax, of which fluid secreted from ozopores was solidified, can be robbed off when scraped.

Other than the Ryukyu Islands, the species had been known only from the Koshiki Islands of Kagoshima Prefecture (Suzuki 1971, 1973). However, recently, additional populations of the species have been found sparsely from several sites in Kyushu and western part of Yamaguchi Prefecture of Honshu (Tsurusaki et al. 2011, Yamada & Iwakiri 2011).

In September 2017, the first author of this paper, unexpectedly collected this species in a grove in Kosuzume Park, Totsuka-ku, Yokohama City, Kanagawa Prefecture (Figs. 1, 2A).

Furthermore, the second author found photos of a harvestman that are allegedly taken in Hitachi City, Ibaraki Prefecture on the Instagram posted by a nature lover, Ms. Suga Kikuchi, in 2019 and he thought the species may be *P. amamiana*. Getting the information on the locality, the third author tried to collect specimens from the population by dropping by the site during his survey on the opilionid fauna in northern Kanto District in September 2019 and successfully found the species at the site and confirmed that it was certainly *P. amamiana*.

These populations of the species in Kanto District are extremely separated from the known distributional range of the species in westernmost part of Japan (Fig. 1). The area intervening these two remotely separated areas, namely, Shikoku, Kii Peninsula, Tokai district, Izu Peninsula, and Izu Islands

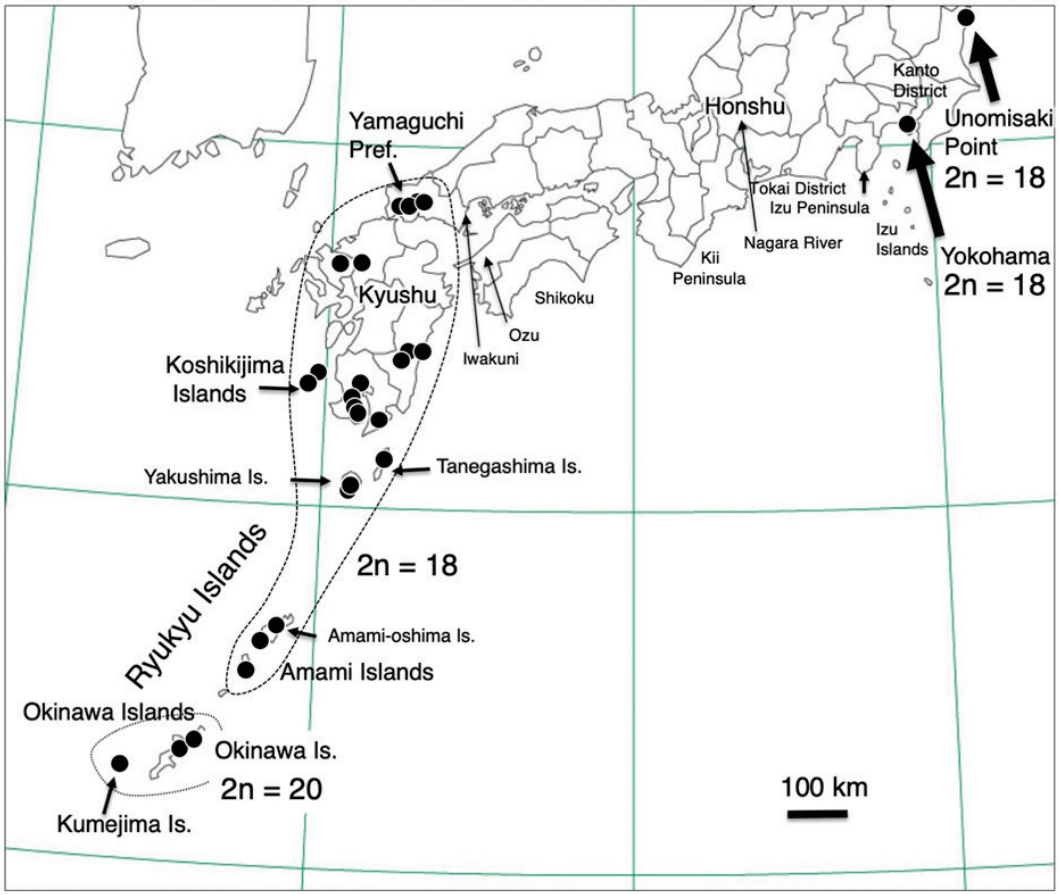

Fig. 1. Known distribution of *Pseudogagrella amamiana* with location of two sites (arrows) in the Kanto District where the species was newly found with diploid number of chromosomes (Numbers from southwestern populations are based on unpublished data by Tsurusaki et al.). Note that each of the solid circles on islands does not represent a single population but two or more populations to prevent disappearance of outlines of islands.

(Fig. 1), have been more extensively studied for opilionid fauna than any other areas in Japan (e.g. Nakatsudi 1942b; Suzuki & Kunita 1972; Suzuki & Ohrui 1973; Tsurusaki & Minato 2000; Tsurusaki & Ikeda 1987; Tsurusaki 2000, 2009a, b). However, no specimens of *P. amamiana* have been found from the area. Harvestmen have neither wings nor effective dispersal means like ballooning in spiders. Furthermore, they cannot resist desiccation, due to insufficient development of wax layer on the integument of the body and large surface/volume ratio that comes from having long appendages. Low resistance to desiccation also leads to harvestmen's persistence to woodlands with sufficient moisture and in turn causes their low vagility. They cannot get across wide open bare ground beyond the border of woodland. Thus, it is highly probable that these populations in Kanto District are not of native but of recently introduced populations.

On the other hand, extensive geographic variability in the chromosome number is the norm in various Japanese species of screrosomatid harvestmen (Tsurusaki 2007a). Diploid number of chromosomes of the species also varies geographically from 18 to 20 (Tsurusaki et al. unpublihed data)(Fig. 1). Thus, if we got info for the chromosome number for these two populations, it may serve to estimate the origin of these populations. For example, if these population showed a number different from the known numbers in this species (18 or 20), the different number would attest a long history of the populations in situ. Thus, to know the chromosome number shown by those localities, we checked chromosomes for the both populations. We will present here those records from Kanto District and the number of chromosomes surveyed.

Materials and Methods

Using location data of the first findings in the Kanto District, we tried to collect additional specimens of

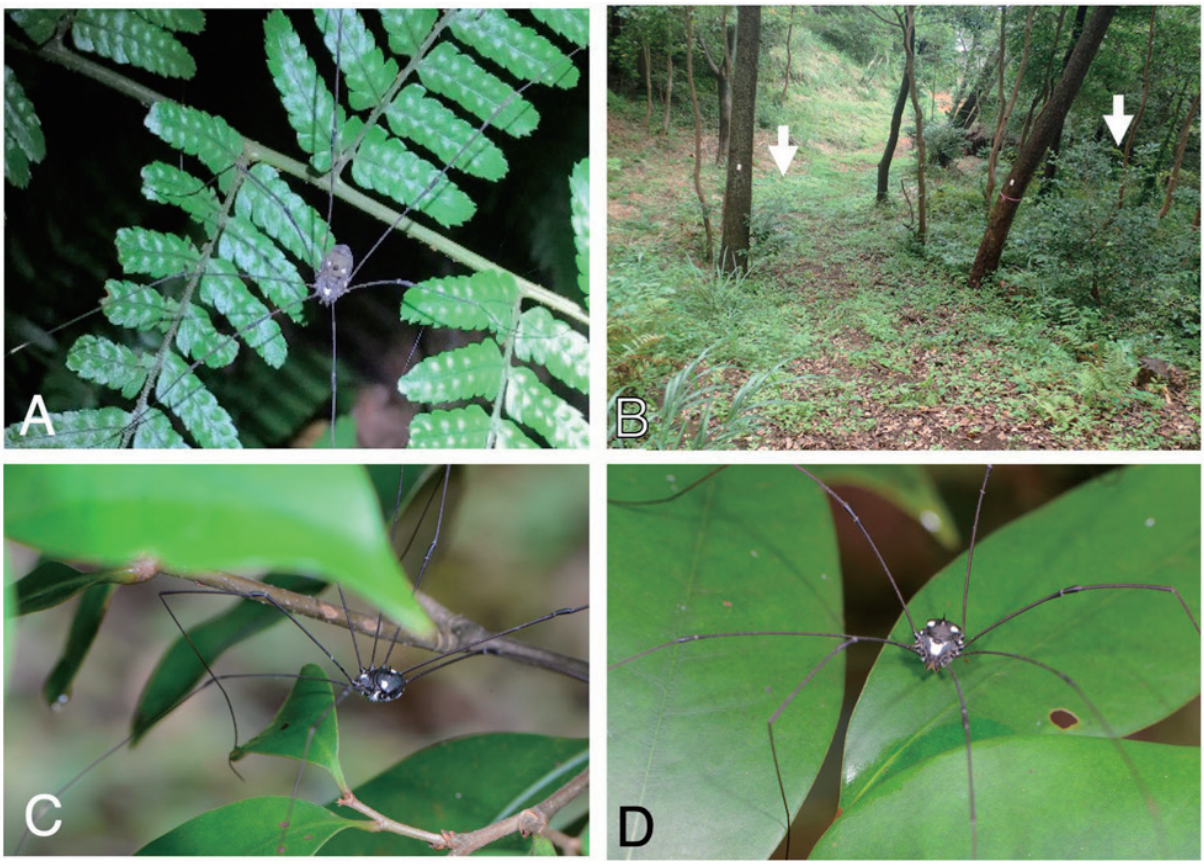

Fig. 2. *Pseudogagrella amamiana.* A, An adult female perched on fern in Kosuzume-Park, Yokohama-City, Kanagawa-Pref., 17 September 2017; B–D, Unomisaki Point, Ishihama Beach, Ibaraki Pref., 3 September 2019; B, A site where *P. amamiana* was found. The species perched on leaves and twigs on shrubs, *Ilex integra,* arrowed. C–D, An adult male.

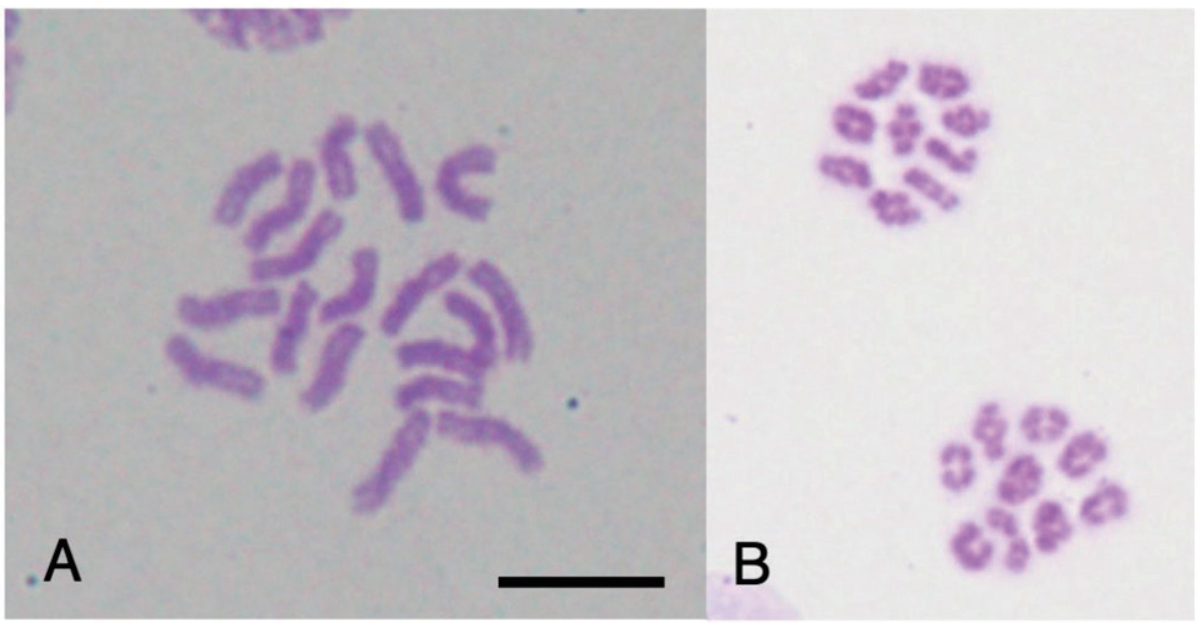

Fig. 3. Chromosomes of a male *Pseudogagrella amamiana* from Kosuzume Park, Yokohama. A, Spermatogonial metaphase (2n = 18); B, Two metaphase spreads at the first meiotic division showing 9 bivalents. Scale = 10 μm.

the species for chromosome study. Adult males collected were transported alive to the laboratory (Yokohama specimens) or a hotel room (Unomisaki Cape specimens) for subsequent chromosome preparation.

Karyological data were obtained by using testes of adult males by air-drying method with dissociation of cells by lactic acid and acetic acid (Tsurusaki 2007). Chromosomes were observed using an Olympus BX60 microscope and photographed with an Olympus DP21 camera.

Results

Specimens safely identified as *P. amamiana* by Suzuki 1971, 1973) in this study were as follows.

Specimens examined — Kanagawa Prefecture: Kosuzume Park (35.368844,139.511958), 60 m alt., Totsuka-ku, Yokohama City,: 10♂6♀, 15 September 2017; 7♂(of these, 3♂Chrom, 99%EtOH), 1 October 2017, All A. Takehara leg. — **Ibaraki Prefecture:** Unomisaki Point, Ishihama Beach, Jûô-cho, Hitachi City (1 probably male photographed without collecting by Suga Kikuchi, 19 June 2019; 1♀, 8 July 2019, S. Kikuchi leg.); Unomisaki Point (36.662115,140.714859), 30 m alt., on *Ilex integra*, Ishihama Beach, Jûô-cho, Hitachi City [3♂(of these, 2♂Chrom, 99%EtOH) 2♀, 3 September 2019, N. Tsurusaki leg.]. Of these, males marked "Chrom" in parentheses were dissected and testes of them were used for chromosome preparation.

Chromosomes. Three males from Kosuzume Park, Yokohama City and two males from Unomisaki Point, Hitachi City, showed invariably 2n = 18, n = 9 (MI)(Fig. 3). The karyotype consisted of several pairs of metacentrics and submetacentrics. Details of the karyotype will be reported elsewhere together with those from other localities.

Discussion

As already stated and as shown in Fig. 1, the present two localities from Kanto District are extremely apart from the known ranges of the species. Of the two localities, Kosuzume Park is a park in the midst of suburban residential area in Yokohama City, where no harvestmen had been recorded. The site where the present specimens were found was on ferns or herbs under shrubs in a grove without moderate moisture (Fig. 2A). Thus, it is very likely that the site is an introduced population that started from a gravid female or a few males and females artificially released by someone, or eggs contained in soil of garden trees transplanted from elsewhere.

On the other hand, the population in the Unomisaki Point is located in suburban area by the Pacific Coast. The point is famous as the provenance that provides all the cormorants, *Phalacrocorax capillatus,* used for traditional cormorant fishings performed in various sightseeing spots (e.g. Nagara River in Gifu Pref., Nishiki River in Iwakuni, Yamaguchi Pref., Hijikawa River, in Ozu, Ehime Pref.) in Japan. This suggests occurrence of rather active shuttle of goods between this site and those cormorant fishing spots, although all of those spots listed above are out of the known range of *P. amamiana* (Fig. 1). Furthermore, Unomisaki Point has a hot spring and a resort hotel with a lot of garden trees in the premises. Thus, this population at Unomisaki Point may also be an introduced one by transplantations of trees or by some other human activities, though trees on which *P. amamiana* perched were of native species of evergreen broad-leaved tree (*Ilex integra*) that is common along the coast of Japanese main islands (Fig. 2B–D). In a whip scorpion species, *Typopeltis stimpsonii*, it is estimated that such domestic introduction had actually occurred through transplantation of garden plants by a phylogenetical survey using mitochondrial COI region (Karasawa et al. 2015). However, this site is close to shores facing the Pacific, where the Kuroshio Current (Black Current) reaches. Accordingly, the idea that the population might have originated from rare natural migration by rafting cannot be excluded completely. Trans-oceanic dispersal is attested in a trap-door spider genus *Moggridgea* occurring in both southern Australia and Africa (Harrison et al. 2017). Unlike trap-door spiders that can build silk-lined burrows that may provide safe microhabitat to the spiders during long period of rafting, it is hard to envisage dispersal by rafting frequently happen in harvestmen. However, occurrence of three opilionid species of Palpatores in the Bonin (Ogasawara) Islands (Suzuki 1974, 1978), which are oceanic islands that have never been connected to other land masses, seems to demonstrate such dispersal by rafting actually happen occasionally also in harvestmen during a long history.

Past chromosome survey for populations from the Ryukyu Islands and western main islands (Kyushu, westernmost part of Honshu) of *P. amamiana* showed two different karyotypes: 2n=20 (Okinawa Is. and Kumejima Is.) and 2n=18 (other islands) (Tsurusaki et al., unpublished). The number shown by present populations (2n = 18) from Kanto District was the same as that shown by islands other than Okinawa Is. and Kumejima Is. Thus, if the population would have originated from the western range of the species, it is likely that their origin would be somewhere in the northern Ryukyu Islands including Yakushima Island or Kyushu. Further study using molecular data is in progress to know detailed origin of these two populations in Kanto District.

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