

Cytogeography of Duchesnea (Rosaceae) in central Japan

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Naohiro Naruhashi¹, Hirotaka Seki^{1,2}, Yasuo Yakura^{1,3}, Yukiyasu Nagata^{1,4} and Yoshikane Iwatsubo¹: **Cytogeography of *Duchesnea* (Rosaceae) in central Japan**

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Abstract

Chromosome numbers of *Duchesnea* (Rosaceae) of 2,133 sites in the area comprising eight prefectures in central Honshu were investigated. Diploid, triploid, heptaploid, octoploid and dodecaploid plants were observed. The triploid plant was found in only one site in Gifu Prefecture. Diploid and dodecaploid plants were very common. Heptaploid and octoploid plants which are believed to be natural hybrids between diploid and dodecaploid plants were variable in distribution depending on the areas, i.e., higher rate distribution of them in the Japan Sea side than those of the Pacific side. The reason of the high frequency of both heptaploid and octoploid plants in the Japan Sea side may be the high rate emergence of hybrid achenes, however, the exact matter is obscure.

Key words : chromosome, cytogeography, *Duchesnea*, Japan, polyploidy.

The genus *Duchesnea* (Rosaceae) is indigenous in the Old World from Afghanistan, through India, Malaysia, China, to Korea, Japan, Taiwan, and the Philippines (Kalkman 1968 ; Naruhashi 2001).

Hara and Kurosawa (1959) reported *D. chrysantha* (Zoll. et Moritzi) Miq. to be diploid ($2n=14$) and *D. indica* (Andrews) Focke to be dodecaploid ($2n=84$), and the natural hybrid plant between them to be heptaploid, having $2n=49$. Moreover, a triploid *D. chrysantha* with $2n=21$ chromosomes was also reported from a locality in Gifu Prefecture (Naruhashi and Takano 1987). Octoploid plants ($2n=56$) were found in many localities in both Toyama Pref. and Gifu Pref. (Naruhashi et al. 1986 ; Naruhashi and Takano 1987). Karyotypes of these plants were already reported by Iwatsubo and Naruhashi (1991) and Naruhashi and Iwatsubo (1991a, 1991b).

The authors of this paper started to examine the geographical distribution of these polyploids from Toyama Pref. in 1984. The results were previously reported, namely on plants from Toyama Pref. (Naruhashi et al. 1986), Gifu Pref. (Naruhashi and Takano 1987) and Kagawa Pref.

(Kume et al. 1987). After that the cytological observations of *Duchesnea* were extended to neighboring prefectures ; Aichi Pref. by Naruhashi, Iwatsubo and Seki, Fukui Pref. and Mie Pref. by Naruhashi, Iwatsubo and Yakura, and Niigata Pref., Ishikawa Pref. and Shiga Pref. by Naruhashi, Iwatsubo and Nagata were examined, respectively. These results and previous ones concerning eight prefectures in central Japan throughout, from the Pacific side to the Japan Sea side, are combined and discussed in the present paper.

Materials and methods

Duchesnea plants are clonal plants, i.e., clusters of individuals are generally consisting of clonal reproduction by runner. The plants examined for the present study were obtained from natural populations in eight prefectures. Over 200 sites per prefecture were chosen as a target, and moreover, the sites were chosen by different place-name for a collection from wide range. However, sites which were adjacent to each other were recorded as different sites, if they were inhabited by two different clones and fur-

thermore, if they showed apparently different on the morphological characters. At flowering or fruiting time of plants we collected about 8 individuals of living plants from a clone as much as possible and made 3 specimens simultaneously. Except for the above mentioned both times, specimens were made after cultivation at University of Toyama. The voucher specimens were deposited in the Herbarium of Department of Biology, Faculty of Science, University of Toyama.

For the somatic chromosome studies, young and healthy root tips were pretreated in 0.002M 8-hydroxyquinoline for an hour at room temperature, and then kept at 4°C for 15 hs. The root tips were fixed in acetic acid and ethyl alcohol (1:3) for 40 min, macerated with 1N-HCl at 60°C for 11.5 min, and immersed in distilled water for a few minutes. They were then stained and squashed in 1.5% lacto-propionic orcein.

Results

The plants from a total of 2,133 sites were examined, and as a result no other polyploids except for the five polyploids of 2x, 3x, 7x, 8x and 12x plants that had already been known in Japan were observed (Fig. 1). Of 2,133 sites, diploid plants were 1,459 (68.40%), triploid plant was 1 (0.05%), heptaploid plants were 41 (1.95%), octaploid plants 153 (7.17%) and dodecaploid plants 479 (22.46%), respectively (Table 1).

Diploid plants are prevalent in all areas in all prefectures and the distribution frequency is high with 57.8-78.3%. Triploid plant was found only in Gifu Pref. Heptaploid plants are ob-

served in seven prefectures except for Mie Pref., and the frequency is low, being 0.4-3.8%. Octoploid plants occurred in all prefectures, and are variable in the frequency with 2.0-15.8%. Dodecaploid plants are also variable, showing a high ratio in the frequency of 16.0-33.6%.

Frequency of each polyploid plant and geographical variation is shown in Fig. 2. The ratio of heptaploid and octoploid plants in the prefectures in the Japan Sea side is higher than those in the Pacific side. Combining both ratio of heptaploid and octoploid plants it reaches about 20% in Fukui Pref.

The relation between polyploidy and their vertical distribution is shown in Fig. 3. They showed similar vertical distribution. Roughly speaking four polyploid plants are abundant in frequency below and higher than 100 m above sea level, gradually decreasing in higher altitudes and nearly stopping at 800 m above sea level.

Discussion

The distribution frequency of the diploid against that of the dodecaploid plant is higher. This is thought to be due to the distribution of paddy fields against mountainous region and frequent visiting to paddy field by unconscious preference, because diploid plants are very common in paddy fields.

Diploid and dodecaploid plants have different ecological preference, i.e., the former prefers sunny places such as open sites, while the latter is found in places with low light intensity such

Table 1. Distribution frequency of polyploids of *Duchesnea* in central Japan

| | 2 x | 3 x | 7 x | 8 x | 12 x | Total |
|----------------|----------------|-----------|------------|-------------|--------------|-------|
| Mie Pref. | 162 (73.3%) | | | 7 (3.2%) | 52 (23.5%) | 221 |
| Aichi Pref. | 199 (78.3%) | | 1 (0.4%) | 5 (2.0%) | 49 (19.3%) | 254 |
| Shiga Pref. | 141 (66.2%) | | 8 (3.8%) | 14 (6.6%) | 50 (23.5%) | 213 |
| Gifu Pref. | 189 (57.8%) | 1 (0.3%) | 2 (0.6%) | 25 (7.6%) | 110 (33.6%) | 327 |
| Fukui Pref. | 146 (60.8%) | | 9 (3.8%) | 38 (15.8%) | 47 (19.6%) | 240 |
| Ishikawa Pref. | 129 (64.5%) | | 7 (3.5%) | 13 (6.5%) | 51 (25.5%) | 200 |
| Toyama Pref. | 220 (68.5%) | | 9 (2.8%) | 29 (9.0%) | 63 (19.6%) | 321 |
| Niigata Pref. | 273 (76.5%) | | 5 (1.4%) | 22 (6.2%) | 57 (16.0%) | 357 |
| Total | 1,459 (68.40%) | 1 (0.05%) | 41 (1.92%) | 153 (7.17%) | 479 (22.46%) | 2,133 |

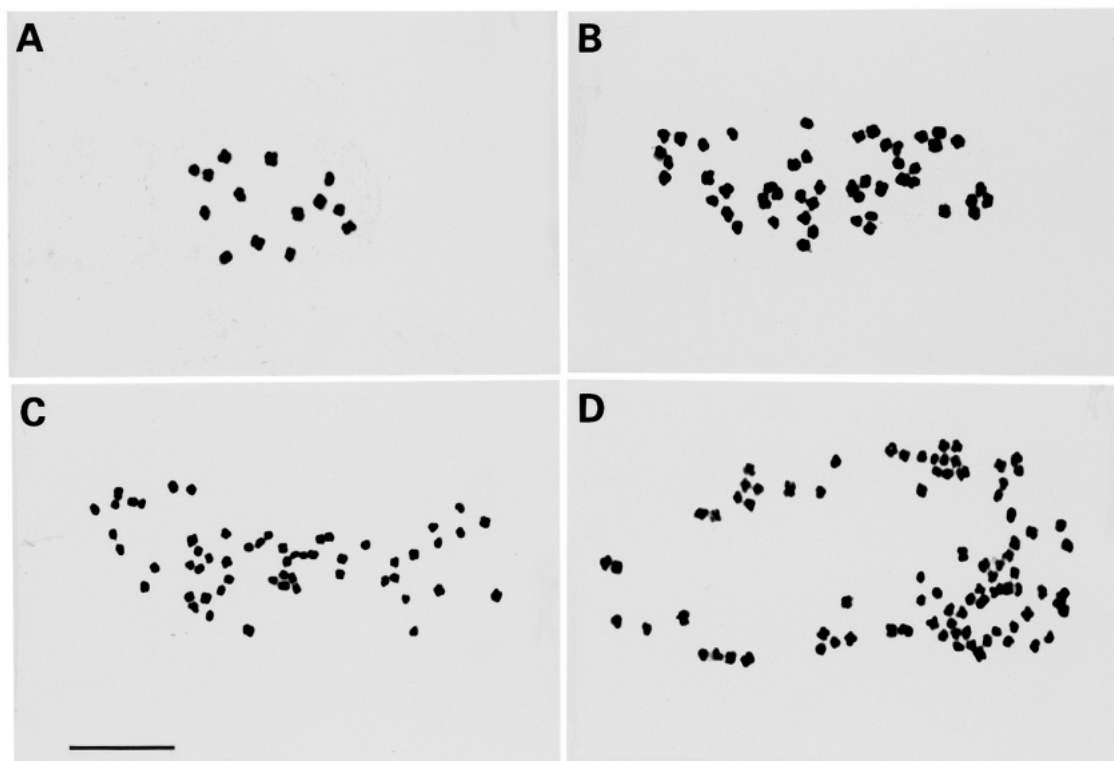


Fig. 1. Somatic metaphase chromosomes of diploid, heptaploid, octoploid and dodecaploid plants in *Duchesnea*. A: *D. chrysantha*, diploid ($2n=14$). B: hybrid, heptaploid ($2n=49$). C: hybrid, octoploid ($2n=56$). D: *D. indica*, dodecaploid ($2n=84$). Bar represents 10 μ m.

as forest margins, woodlands, etc. (Kume et al. 1987). However there were no difference between them concerning the vertical distribution.

The frequency of triploid plant with 0.05% is very low. The reason may be that the triploid plant is hardly ever produced from diploid plants or is weak as it has homologous chromosome sets (Iwatsubo and Naruhashi 1991).

Heptaploid and octoploid plants are the hybrids between diploid and dodecaploid plants (Hara and Kurosawa 1959; Naruhashi and Sugimoto 1996; Naruhashi and Iwatsubo 1991 b). Furthermore the former is believed to be the combination of the half chromosome set from diploid plant and the half one from dodecaploid plant, the latter is explained as the combination of the two chromosome sets of diploid plant and the half set of dodecaploid plant. The fact that octoploid plants are nearer to diploid plants than heptaploid plants is morphologically supported (Sugimoto et al. 1991).

At every prefecture investigated in the present

study diploid and dodecaploid plants are very common and they are nearly located to each other in many localities. Both flowers are morphologically very similar and begin to bloom from April to May with the difference of earlier both in first bloom and peak bloom of diploid plant (Naruhashi and Sugimoto 1996). Therefore, natural hybrids possibly occur in all areas investigated here. Moreover, there is a difference in the frequency of these hybrids, heptaploid and octoploid plants. The octoploid plant is 2-10 times more frequent than the heptaploid plant. This is probably because the two hybrids are produced by different ways or that there is a difference in the struggle for existence. No heptaploid and octoploid plants observed at 207 sites in Kagawa Pref. (Kume et al. 1987), a low ratio of 3.2% of both polyploids in Mie Pref. and 2.4% in Aichi Pref., while a higher ratio of 10.0% in Ishikawa Pref. and 11.8% in Toyama Pref. as well as a higher ratio of 19.6% in Fukui Pref. were recorded. On the basis of these results,

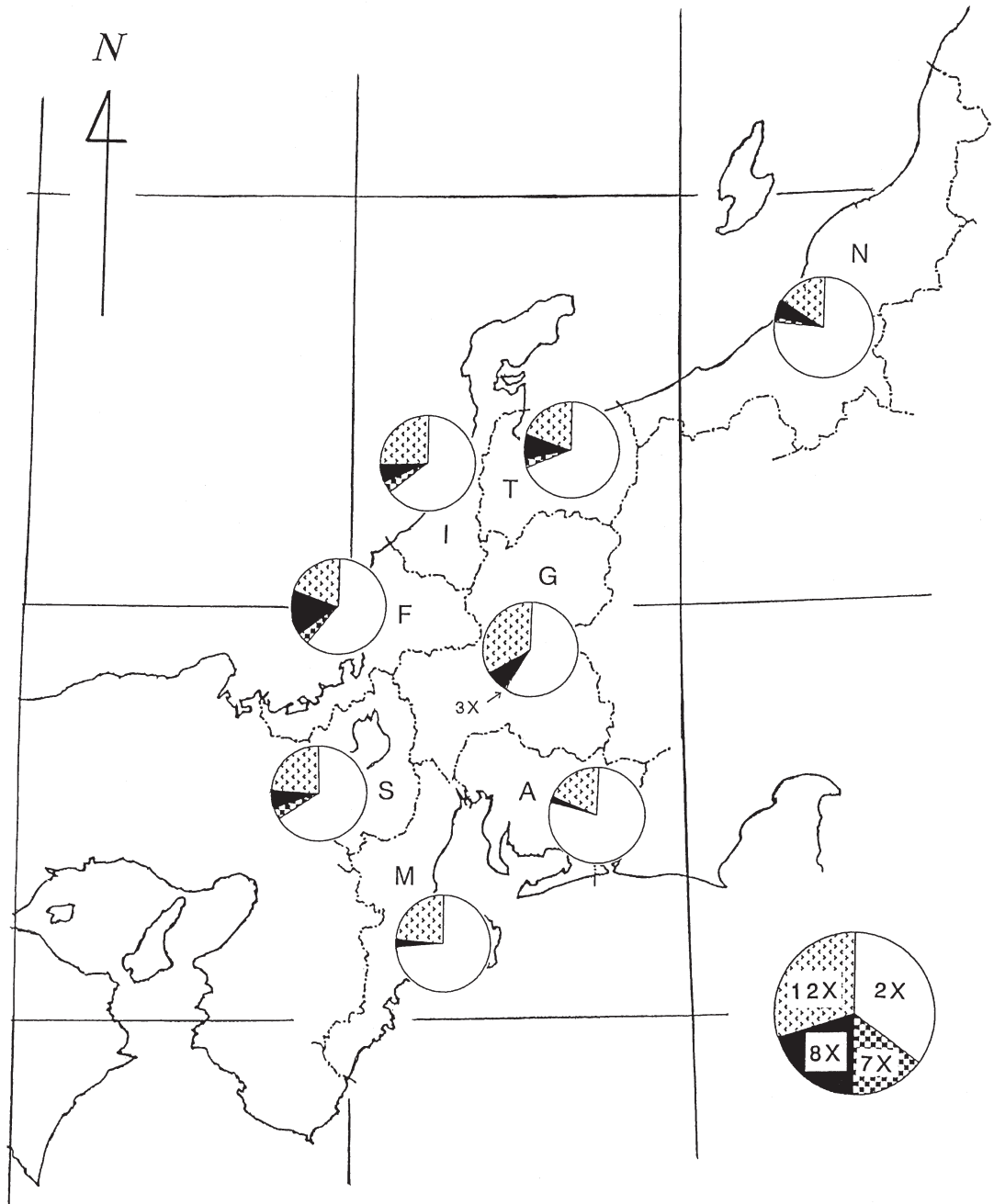


Fig. 2. Polyploid component of *Duchesnea* in each prefecture in central Japan.

A, Aichi Pref.; F, Fukui Pref.; G, Gifu Pref.; I, Ishikawa Pref.; M, Mie Pref.; N, Niigata Pref.; S, Shiga Pref.; T, Toyama Pref.

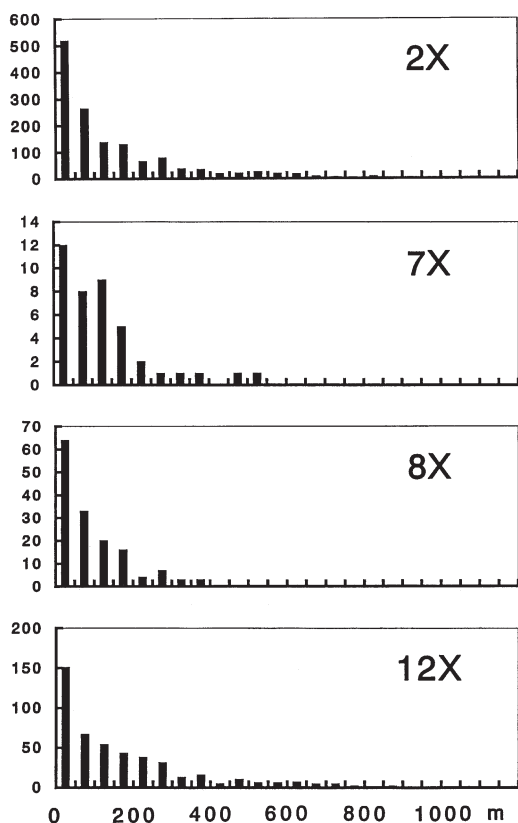


Fig. 3. Vertical distributions of each of the polyploid plant communities.
Horizontal axis : elevation of sampling sites. Vertical axis : number of sites.

both forms of hybrids show a low ratio in distribution in the Pacific side and a high ratio in the Japan Sea side. These distributional variations, i.e., frequency of natural hybrids, may be due to the ratio of hybrid seeds produced by parental plants or to the surviving ratio of hybrids. Because the living power or propagation capacity of the hybrids compared with that of the parents is not weak, the distributional variation can be regarded to be due to the emergence rate of the hybrid seeds.

The origin of these two types of hybrids is obscure. In spite of our three year's experiments to make artificial hybrids between diploid and dodecaploid plants, we could not succeed besides obtaining one individual of octoploid plant, notwithstanding obtaining many juvenile plants which have the same polyploidy as the mother plant, from the germination of achenes from en-

larging receptacle. This means that to make artificial hybrids is very difficult. Further experiments to make artificial hybrids are needed to resolve the distributional variation.

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鳴橋直弘¹・関 弘毅^{1,2}・矢倉保男^{1,3}・永田幸泰^{1,4}・岩坪美兼¹: 中央日本におけるバラ科ヘビイチゴ属 (*Duchesnea*) の細胞地理学

本州中央部の新潟県, 富山県, 石川県, 福井県, 岐阜県, 滋賀県, 愛知県, および三重県の8県の

バラ科ヘビイチゴ属の染色体数を調査した。本属植物は一般的にランナーによる栄養繁殖集団からなる。採集地2,133カ所の内, 2倍体は1,459カ所(68.40%), 3倍体は1カ所(0.05%), 7倍体は41カ所(1.92%), 8倍体は153カ所(7.17%), および12倍体は479カ所(22.46%)であった。2倍体はどの県でも半分以上(57.8-78.3%)であり, 12倍体は2~3割(16.0-33.6%)であった。0.05%と予想以上に3倍体の出現頻度が低かった。垂直分布では, 各倍数体間で差が見られなかった。

各倍数体の割合を県別に調べると, 7倍体と8倍体の出現頻度が日本海側で高いことが分かった。両倍数体を合わせると, 三重県3.2%、愛知県2.4%に対し, 富山県11.8%、福井県19.6%であった。この7倍体と8倍体はアイノコヘビイチゴであり, 通常2倍体であるヘビイチゴと12倍体であるヤブヘビイチゴの自然雑種と考えられ, 日本海側で多産することになる。このような地理的分布の理由については不明である。

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Appendix

Since diploids (= *Duchesnea chrysantha* (Zoll. et Moritzi) Miq.) and dodecaploids (= *D. indica* (Andrews) Focke) examined in the present investigation are huge number, they are omitted here. Similarly, data from Toyama Pref. and Gifu Pref. are omitted as they were reported previously (Naruhashi et al. 1986; Naruhashi and Takano 1987).

2n=49 (= *D. ×harakurosawae* Naruh. et M. Sugim., heptaploids)

Niigata Pref.

Kitakoura, Sado-shi, 20 m; Tassha, Aikawa-machi, Sado-shi, 4 m; Goishi, Sanpoku-machi, Iwafune-gun, 20 m; Kangawa, Sanpoku-machi, Iwafune-gun, 15 m; Konoura, Noh-machi, Itoigawa-shi, 80 m.

Fukui Pref.

Hanatani, Eiheiji-cho, Yoshida-gun, 50 m; Yakushi, Eiheiji-cho, Yoshida-gun, 60 m; Kantobe, Eiheiji-cho, Yoshida-gun, 220 m; Umeura, Echizen-cho, Nyu-gun, 40 m; Shadani, Minamiechizen-cho, Nanjo-gun, 180 m; Ainami, Minamiechizen-cho, Nanjo-gun, 150 m; Yai, Minamiechizen-cho, Nanjo-gun, 190 m; Utsuo, Minamiechizen-cho, Nanjo-gun, 210 m; Takano, Tsuruga-shi, 50 m.

Shiga Pref.

Hannoura, Kinomoto-cho, Ika-gun, 120 m; Sugino, Kinomoto-cho, Ika-gun, 195 m; Kanaiharu, Kinomoto-cho, Ika-gun, 265 m; Suginojinja, Kinomoto-cho, Ika-gun, 195 m; Karakuni, Torahime-cho, Higashiazai-gun, 97 m; Banba, Maihara-shi, 150 m; Fukashimizu, Imazu-cho, Takashima-shi, 90 m; Hiratsu-cho, Ootsu-shi, 90 m.

Aichi Pref.

Kawate, Inabu-cho, Toyota-shi, 340 m.

2n=56 (= *D. ×harakurosawae* Naruh. et M. Sugim., octoploids)

Niigata Pref.

Oodomari, Hamochi-machi, Sado-shi, 10 m; Seki, Aikawa-machi, Sado-shi, 50 m; Iwayaguchi, Aikawa-machi, Sado-shi, 10 m; Uranokawauchi, Sado-shi, 50 m; Shimokuji, Sado-shi, 5 m; Kawazaki, Sado-shi, 20 m; Komasa, Sado-shi, 5 m; Mitate, Sado-shi, 40 m; Ookawa, Sado-shi, 20 m; Mushizaki, Sado-shi, 60 m; Bogasaki, Sado-shi, 40 m;

Kitakoura, Sado-shi, 20 m ; Shimooshima, Sanpoku-machi, Iwafune-gun, 32 m ; Iwaishi, Sanpoku-machi, Iwafune-gun, 60 m ; Nakahama, Sanpoku-machi, Iwafune-gun, 7 m ; Terao, Asahi-mura, Iwafune-gun, 30 m ; Shimonigorigawa, Myoko-shi, 160 m ; Oota, Bunsui-machi, Tsubame-shi, 5 m ; Ohmi, Ohmi-machi, Itoigawa-shi, 20 m ; Mmogawa, Noh-machi, Itoigawa-shi, 6 m ; Iwayado, Nadachi-machi, Joetsu-shi, 80 m ; Gakko-cho, Murakami-shi, 7 m.

Fukui Pref.

Ootoba, Wakasa-cho, Mikatakaminaka-gun, 60 m ; Asono, Wakasa-cho, Mikatakaminaka-gun, 180 m ; Morimachi, Ooi-cho, Ooi-gun, 120 m ; Nakano, Ooi-cho, Ooi-gun, 180 m ; Teraji, Imadate-cho, Echizen-shi, 80 m ; Ryoke, Imadate-cho, Echizen-shi, 40 m ; Kamikumeda, Maruoka-cho, Sakai-shi, 80 m ; Gonze, Kanazu-cho, Awara-shi, 70 m ; Shimoshinjo, Sabae-shi, 20 m ; Yorito, Mihama-cho, Mikata-gun, 50 m ; Kuchidano, Obama-shi, 20 m ; Kizaki, Obama-shi, 10 m ; Usakaootani, Miyama-cho, Fukui-shi, 200 m ; Shimoyakushi, Miyama-cho, Fukui-shi, 100 m ; Narase, Miyama-cho, Fukui-shi, 60 m ; Minamimiyaji, Miyama-cho, Fukui-shi, 140 m ; Shinagase, Miyama-cho, Fukui-shi, 70 m ; Miyazaki, Takahama-cho, Ooi-gun, 15 m ; Uchiura, Takahama-cho, Ooi-gun, 40 m ; Chichishi, Ooi-cho, Ooi-gun, 20 m ; Hongo, Ooi-cho, 10 m ; Shiroari, Koshino-mura, Fukui-shi, 20 m ; Makuri, Shimizu-cho, Fukui-shi, 10 m ; Shimoitadori, Minamiechizen-cho, Nanjo-gun, 280 m ; Nuka, Minamiechizen-cho, Nanjo-gun, 20 m ; Imaizumi, Minamiechizen-cho, Nanjo-gun, 20 m ; Sugatani, Minamiechizen-cho, Nanjo-gun, 220 m ; Daira, Minamiechizen-cho, Nanjo-gun, 200 m ; Hatta, Minamiechizen-cho, Nanjo-gun, 210 m ; Kamishindo, Minamiechizen-cho, Nanjo-gun, 180 m ; Okamoto-cho, Takefu-shi, 40 m ; Iehisa-cho, Takefu-shi, 20 m ; Oiwake, Takefu-shi, 100 m ; Ayukawa-cho, Fukui-shi, 10 m ; Konyu-cho, Fukui-shi, 20 m ; Kawajiri-cho, Fukui-shi, 5 m ; Ootoshi-cho, Fukui-shi, 15 m ; Amasugo-cho, Fukui-shi, 10 m.

Shiga Pref.

Otowa, Kinomoto-cho, Ika-gun, 180 m ; Kanaiharu, Kinomoto-cho, Ika-gun, 265 m ; Tsubakisaka, Yogo-cho, Ika-gun, 290 m ; Binmanji, Taga-cho, Inukami-gun, 100 m ; Kurokawauenodaira, Tsuchiyama-cho, Kouga-shi, 350 m ; Ohkawara, Tsuchiyama-cho, Kouga-shi, 360 m ; Kamikaide, Makino-cho, Takashima-shi, 100 m ; Noguchi, Makino-cho, Takashima-shi, 180 m ; Amasugawaguchi, Imazu-cho, Takashima-shi, 100 m ; Shimonyu, Maihara-shi, 150 m ; Ikadachiminamisho-machi, Ootsu-shi, 120 m ; Ishiyamadera, Ootsu-shi, 140 m ; Yahazu-ishikura, Ootsu-shi, 200 m ; Kiso-soga, Hikone-shi, 120 m.

Aichi Pref.

Oiwake, Shinshiro-shi, 100 m ; Aigo, Hourai-cho, Shinshiro-shi, 160 m ; Kamigaya, Toyohashi-shi, 40 m ; Ookusu, Toyota-shi, 60 m ; Oshiyama, Inabu-cho, Toyota-shi, 340 m.

Mie Pref.

Shimotage, Misugi-mura, Tsu-shi, 320 m ; Nishitakakura, Ueno-shi, 190 m ; Uchino, Watarai-cho, Watarai-gun, 50 m ; Saita, Minamiise-cho, Watarai-gun, 10 m ; Togu, Minamiise-cho, Watarai-gun, 90 m ; Matsushita, Futami-cho, Ise-shi, 15 m ; Natsuaki, Nabari-shi, 190 m.