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学位論文題目	Study on genetic diversity, population structure, and reproductive system of the genus <i>Monochoria</i> in Asia（アジア産ミズアオイ属植物の遺伝的多様性、集団構造および繁殖システムに関する研究）
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論文内容の要旨

Monochoria korsakowii Regel et Maack, *M. vaginalis* (Burm. f.) Kunth and *M. elata* N. H. Ridley belong to the family Pontederiaceae. *M. korsakowii* and *M. vaginalis* are annual aquatic herbs, generally found in ponds, riversides, marshes, and paddy fields. Due to the overuse of the agricultural herbicides, land abandonment and intensive farming, the *M. korsakowii* populations has significantly decreased, and become an endangered plant in Japan, therefore, it is urgent to protect the genetic resources of this species. Meanwhile, studies on genetic resources distribution, genetic geography and reproductive structure of *M. vaginalis*, a closely correlation species with *M. korsakowii*, are lagging behind, which greatly restricts the development of genetic resources of the genus *Monochoria*. In the study, we collected 200 individuals from 10 populations of *M. korsakowii* and 300 individuals from 15 populations of *M. vaginalis* in Japan, for study genetic diversity and structure of *M. vaginalis* and *M. korsakowii* based on the nuclear genome microsatellite markers (nrSSR), and study adaptive significance of floral structure in genus *Monochoria*. The main results were as follows:

1. Pollination is a key process that allows plants to complete their sexual life-cycle and although many different vectors can transport pollen grains from the male organ

(anther) to the female organ (stigma), there is a high risk of failure. A perennial wetland plant *M. elata* N. H. Ridley (Pontederiaceae) has mirror-image flowers with a large stamen which is of a similar length to the stigma and five small stamens that are half the length. After the flowers close, the perianth twists helically, either clockwise (right-handed flowers as viewed from the plant) or anticlockwise (left-handed flowers). This results in the anthers of the large stamen coming into contact with the stigma to complete pollination without the aid of any pollinating vector. This pollination mechanism represents an autonomous delayed self-pollination that safeguards reproductive success when normal pollinator insects are scarce and demonstrates that enantiostyly can promote self-pollination as well as cross-pollination.

2. The three species of *M. korsakowii*, *M. vaginalis* and *M. elata* have the mechanism of promoting outcrossing, and self-compatibility. The style of *M. elata* N. H. Ridley was taller than the small stamens, that avoid self-pollination, but it has developed vegetative reproductive organs, maintaining its reproduction. Additionally, *M. vaginalis* are predominantly self-pollinated, the anthers of *M. vaginalis* are dehiscence and pollinated before blooming. *M. korsakowii* and *M. vaginalis* have mirror-shaped styles, which is better to maintain the propagation of annual plants.
3. *Monochoria korsakowii* is an endangered annual herbaceous plant that grows in and around Japanese paddy fields. In our study, the genetic diversity and population structure were analyzed in 10 populations of *M. korsakowii* consisting of 200 individuals from Hokkaido, Honshu, and Kyushu, using 15 pairs of nuclear simple sequence repeat (SSR) markers. The result showed that *M. korsakowii* populations have low genetic diversity ($P=32.9$, $N_e=1.0949$, $I=0.0911$, $H=0.0584$, and $PPL=20.56\%$), which could be attributed to the highly disturbed habitat, low gene flow, and repeated genetic bottlenecks. The *M. korsakowii* populations exhibited high genetic differentiation (ranging from 0.5674 to 0.933) owing to the limited gene flow ($N_m = 0.2278$) between them. It was inferred that the gene flow between the *M. korsakowii* populations was hindered by factors such as geographical distance, mountains, straits, and human activities. Cluster analysis showed that geographically close populations tended to cluster together, such as MK-1 and MK-2. MK-4, MK-5, and MK-6 were also highly concentrated, and the PCoA showed that the genetic distance of individuals within the population was lower.
4. For *M. vaginalis*, the genetic diversity and population structure were analyzed in 15 populations (300 individuals) based on nuclear simple sequence repeat (SSR) markers. The result showed that the genetic diversity was also low ($NPL=46.6$, $N_e=1.0969$, $I=0.0943$, $h=0.0603$, $PPL=21.61\%$) and genetic differentiation was

high (ranging from 0.4465 to 0.7082), due to the limited gene flow ($N_m = 0.384$) between population. Cluster analysis indicated that geographically close populations tended to cluster together, such as MV-14 and MV-15, MV-10, MV-11 and MV-12.

5. All *Ottelia alismoides*' populations can use HCO_3^- , and there are obvious differences vary population, but *M. vaginalis* and *M. korsakowii* can't use HCO_3^- as a carbon source. Additionally, titratable acidity also had a significantly distinct diel fluctuation of *O. alismoides*' populations in Japan, except for *O. alismoides* from Nagahama, *M. vaginalis* and *M. korsakowii*. For enzyme experiment, only PEPC activity of *O. alismoides* from Nagahama, *M. vaginalis* and *M. korsakowii* was lower than that of Rubisco activity. Thus, some *O. alismoides*' populations may possess C_4 or CAM-like systems, and *M. vaginalis* and *M. korsakowii* don't have C_4 or CAM-like systems.