Speciation of Polyplloid Lycoris Species Estimated from Cytological Studies in Selfed Progeny

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Summary

Cytological studies in selfed progenies were carried out to clarify the speciation processes of polyplloid Lycoris species. For diploid species, most selfed plants were diploid with the same karyotype as the corresponding parents. However, S1 progenies from L. sprengeri (2n=22A) included two triploids with 2n=33A and one aneuploid with 2n=32(31A+1M); and one S1 from L. aurea (2n=14=8A+6T) was tetraploid with 2n=28(16M+12T). For triploid species, L. radiata (2n=33A), all the S1 plants were aneuploid with chromosome number near to its diploid taxon, L. radiata var. pumila (2n=22A). The results suggest that unreduced gametes occasionally formed through self-pollination in fertile diploid species would be a factor inducing polyplloid species in the genus Lycoris.

Key Words: karyotype evolution, Lycoris, polyplloid, selfed progeny, speciation

Introduction

Genus Lycoris consists of about 20 species including diploid to tetraploid species (Hsu et al., 1994). L. radiata consists of both diploid (L. radiata var. pumila, 2n=22) and triploid taxa (L. radiata var. radiata, 2n=33) (Hsu et al., 1994). Among the L. sanguinea population, triploids (2n=33) and tetraploid (2n=44) plants were found recently in diploid taxon, L. sanguinea var. kiushiana (Kurita, 1988a). L. sprengeri is a diploid taxon (2n=22), but Zhang et al. (1999) reported triploid plants with 2n=33 within the species. Thus, polyplloidization is one of the main factors responsible for karyotype evolution in Lycoris (Inariyama, 1951; Kurita, 1998b).

These polyplloids were thought to have originated from diploid species via meiotic or somatic polyplloidization (Inariyama, 1951; Kurita, 1998b; Zhang et al., 1999). However, clear cytological evidence for the hypotheses and studies on the detailed speciation process are not available, because of the difficulty in obtaining selfed or hybrid progenies in the Lycoris species.

By using ovule culture technique, we obtained a large number of selfed plants from six Lycoris species, which would provide useful materials for evolutionary studies (Ma, 2001). In the present study, we investigated the chromosomal variation in those selfed plants, and discussed the speciation of polyplloid species based on the results.

Materials and Methods

Plants of five diploid taxa (L. sanguinea, L. sprengeri, L. radiata var. pumila (L. pumila, hereafter), L. aurea and L. traubii) and one triploid taxon L. radiata var. radiata (L. radiata, hereafter) were grown in a field of Osaka Prefecture University (Sakai).

Scapes were cut just before anthesis and kept in flasks filled with tap water; and the florets were hand-pollinated at anthesis using pollen grains collected from the same plant. Ovules (immature seeds) were collected 30 to 35 days after pollination and cultured on 1/2 MS medium. The seedlings obtained were transferred onto MS medium containing 6% sucrose for bulb development.

Root tips (1 cm long) that excised from the seedlings and parental plants were pretreated with cold water at 0°C for 24 hr, then fixed in Farmer’s fluid for 2 hr. Subsequently, they were immersed in 1 N HCl for 6 min at 60°C, stained with Feulgen solution for 15 min at room temperature, and squashed in 45% acetic acid. The chromosome number was counted in at least 5 metaphase plates per plant, and the individual chromosome was classified into three types according to Kurita (1986): M (metacentric chromosome), A (acrocentric chromosome) and T (telocentric chromosome).

Results

Each of plants from six species showed standard chromosome number and karyotype of each corresponding species as described by Hsu et al.,(1994) (Table 1).

In diploid species, all the S1 plants of L. sanguinea, L. pumila and L. traubii were diploids with the same chromosome number and karyotype as that of the...
Table 1. Chromosome number and karyotype of selfed plants.

<table>
<thead>
<tr>
<th>Species</th>
<th>Parent plants</th>
<th>$S_1$</th>
<th>No. of plants observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. sanguinea</td>
<td>2n=2x=22A</td>
<td>22A</td>
<td>84</td>
</tr>
<tr>
<td>L. sprengeri</td>
<td>2n=2x=22A</td>
<td>22A</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33A</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32(31A+1M)</td>
<td>1</td>
</tr>
<tr>
<td>L. aurea</td>
<td>2n=2x=14(8M+6T)$^a$</td>
<td>14(8M+6T)</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28(16M+12T)</td>
<td>1</td>
</tr>
<tr>
<td>L. pumila$^a$</td>
<td>2n=2x=22A</td>
<td>22A</td>
<td>21</td>
</tr>
<tr>
<td>L. trauibii</td>
<td>2n=2x=12(10M+2T)</td>
<td>12(10M+2T)</td>
<td>33</td>
</tr>
<tr>
<td>L. radiata$^a$</td>
<td>2n=3x=33A</td>
<td>24A</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25A</td>
<td>2</td>
</tr>
</tbody>
</table>

$^a$ L. radiata var. pumila.
$^b$ L. radiata var. radiata.
$^a$ A: acrocentric chromosome, M: metacentric chromosome, T: telocentric chromosome.

corresponding parents (Table 1). However, in $S_1$ plants, one tetraploid with 2n=16M+12T was detected in L. aurea, and two triploids (2n=33A) and one aneuploid with almost triploid chromosome number (2n=32=31A+1M) were detected in L. sprengeri (Table 1). In $S_1$ plants of the triploid species L. radiata (2n=3x=33A), aneuploids with 2n=24A and 2n=25A were observed (Table 1). Their chromosome numbers were closer to that of its fertile diploid taxon, L. pumila (2n=22A).

Discussion

A tetraploid (2n=44) has been found in L. sanguinea var. kiushiana from a natural population at Tara in Nagasaki (Kurita, 1988a). There is no report of tetraploid in L. aurea but a tetraploid was obtained from self-pollination of L. aurea in this study. The karyotype suggests that this tetraploid might have originated from fertilization of two unreduced gametes with 2n=8M+6T, although further studies are needed to clarify this proposal.

In L. sprengeri, triploid plants (2n=3x=33) were recently discovered in a natural population in south China (Zhang et al., 1999). In this study, two triploids (2n=33A) and one aneuploid (2n=32=31A+1M) were induced by self-pollination of L. sprengeri for the first time, although most $S_1$ plants were diploids. In the genus Lycoris, triploid taxa could be resulted from normal fertilization between gametes with normally reduced chromosome number in crosses of diploid × tetraploid. However, no tetraploid has ever been found in L. sprengeri. Thus, as the origin of triploids, the following mechanisms occurred by the pollination in diploids (especially, self-pollination) should be taken into consideration: 1) a union of an unreduced diploid gamete and a reduced haploid gamete (Grant, 1981); 2) embryogenesis from 3n endosperm cell (Muniyamma, 1977); and 3) the fertilization of an egg by two generative nuclei (Lapidot et al., 1994). The origin of those natural triploids was generally hypothesized as a result of the union between an unreduced diploid gamete and a reduced haploid gamete although it was still under discussion (Inariyama, 1951). That two triploid plants (2n=33A) and one aneuploid (2n=32=31A+1M) were induced though self-pollination in L. sprengeri would provide a practical approach for elucidating the mechanisms for the origin of those natural triploid taxa in the genus Lycoris.

L. radiata is reported as an autotriploid species; its gametic chromosome number is assumed to be in the range from 11 to 22 theoretically (Inariyama, 1951). So the $S_1$ plants are expected to vary in somatic chromosome number from 22 to 44. However, in this study, all $S_1$ plants from L. radiata (triploid) were aneuploids with chromosome number near the diploid. Kihara and Koyama (1954) obtained offsprings with chromosome number varied from 2n=22 to 25 by self-pollination of L. radiata, indicating that gametes of L. radiata having 11, 12, 13 or 14 chromosomes are more vigorous than those with 15 to 22 chromosomes. Hence, this triploid species might have originated from its diploid taxon L. radiata var. pumila (2n=22).

In this study, both tetraploid and triploids including an aneuploid were induced from self-pollination of diploid species, whereas near diploid aneuploids were induced from self-pollination of triploid species. From the chromosome behavior in self-pollination of L. sprengeri, L. aurea and L. radiata, it seems that unreduced gametes occasionally formed through self-pollination in fertile diploid species may be a possible mechanism whereby polyplody species in the genus Lycoris are induced.

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Literature Cited


*Lycoris*属の自殖後代における染色体数変異と倍数性種成立要因の推定

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摘 要

*Lycoris*属における倍数性種の成立要因を解明するために、6種で自殖後代を作出し、その染色体数を調査した。二倍性種の場合、自殖後代の大部分の個体は親個体と同じ染色体数と核型を示したが、*L. sprengeri* (2n=22A) の自殖交代で 2 個体の 3 倍体 (2n=33A) と 1 個体の 3 倍体に近い染色体数を有する異数体 (2n=32=31A+1M) が、また *L. aurea* (2n=14=8M+6T) においては 1 個の四倍体 (2n=28=16M+12T) が観察された。また、三倍性種 *L. radiata* (2n=33A) においては、二倍体に近い染色体数を有する異数体 (2n=24A, 25A) が観察された。これらの結果から、可徳二倍性種の配偶子形成過程における非遺伝子配子の形成とその受精への関与が、*Lycoris*属における倍数性種成立の要因の 1 つであると考えられた。