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On the Way to Domesticate Duckweeds: Hidden Sexuality, Hybridization and Polyploid Evolution

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Duckweeds (Lemnaceae) are emerging as promising crops because of their exceptional biomass productivity and diverse applications. However, progress toward duckweed domestication has been limited by a poor understanding of their sexual reproduction, which is essential to improve genetic information via breeding. Recent genomic studies unexpectedly revealed numerous interspecific hybrids and polyploid lineages in the genera *Lemna* and *Wolffia*, suggesting that sexual reproduction, although rarely observed, has played a much stronger evolutionary role than previously recognized. We systematically investigated the reproductive biology of representative *Lemna* hybrids and their parental species. Furthermore, we performed a comprehensive cytological analysis of meiosis in some selected *Lemna* species to determine the origin and frequency of unreduced gametes associated with polyploids formation. Our analyses revealed remarkable diversity in reproductive traits, including protogyny, homogamy, and variation in self-fertility among species. Except for the naturally fertile allotetraploid *L. ×aoukikusa*, all investigated allodiploid and triploid hybrids were sterile, and artificial whole-genome doubling of natural allodiploid hybrids has failed to restore fertility so far. Cytological analyses combined with fluorescence in situ hybridization showed both dyads and tetrads, representing unreduced and reduced male meiotic cells, respectively. Unreduced gametes occurred at variable, but rather low frequencies (up to 6.85% in *L. turionifera* and 12% in *L. minor*), providing a plausible explanation for the absence of naturally occurring tetraploids in *L. ×japonica* and both parental species, *L. minor* and *L. turionifera*. This study provides keys for elucidating evolutionary pathways of duckweeds and establishes a foundation for future domestication by sexual crossing of this emerging crop.

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References

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