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A complete seed-to-seed cycle beyond vegetative propagation reveals seed development and triacylglycerol mobilization in *Lemna aequinoctialis*

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Duckweeds predominantly propagate vegetatively, and the mechanisms underlying their sexual reproduction and seed biology remain largely unexplored due to the absence of a tractable experimental system. Here, we identified a Korean ecotype of *Lemna aequinoctialis* that completes its entire sexual life cycle under laboratory conditions, and established a developmental framework encompassing photoperiod-dependent flowering, seed maturation, germination, and re-establishment of vegetative growth. Flowering reached 100% under short-day conditions, and seeds remained highly viable after storage at 4°C in darkness for up to two years. Mature seeds accumulated triacylglycerol (TAG) as their major storage reserve, containing approximately 481-fold more TAG than vegetative fronds and no detectable starch. Seed maturation was accompanied by induction of conserved seed developmental regulators (*LEC1*, *ABI3*, *FUS3*, *LEC2*, *WRI1*, and *bZIP67*), together with genes involved in fatty acid synthesis and TAG assembly. During germination, seed-derived TAG was mobilized to sustain early frond establishment prior to the attainment of photosynthetic autonomy, revealing a conserved seed reserve utilization strategy in this aquatic monocot. Together, these findings establish *L. aequinoctialis* as an experimentally tractable model for investigating seed development and storage lipid metabolism in duckweeds, and provide a foundation for future genetic improvement and domestication efforts in this emerging aquatic crop system.

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