

## Sex Conversion in *Ginkgo biloba* (*Ginkgoaceae*)

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A male *Ginkgo* tree at Kami Yagisawa, Minobu-cho, Yamanashi Prefecture, Japan, is shown to possess a small, localized, branch that produces ovules that mature into viable seeds. This tree is recognized as an Ohatsuki Ichō because of the occasional production of pollen sacs on otherwise normal vegetative leaves, but most of the abundant male cones that it produces are of normal morphology. Localized sex conversion, such as that seen in the Kami Yagisawa tree, by which part of otherwise male *Ginkgo* tree switches to producing seeds, may be more common than has previously been noted. Dioecy in extant *Ginkgo biloba* most likely evolved from monoecious ancestors that had ovulate and pollen cones on different parts of the plant. This change from monoecy to dioecy has also been accompanied by the differentiation of a ZW system of sex chromosomes (heterogametic females ZW, homogametic males ZZ) in which the W chromosome is slightly larger. The molecular developmental basis for sex conversion in *Ginkgo* is unknown, but in certain angiosperms a specific transcription factor regulates the expression of the female phenotype. A microRNA, which seems to be male specific, negatively affects this transcriptional regulator, resulting in the suppression of female characters and expression of the male phenotype. Further studies are needed to determine whether a similar or different mechanism operates in *Ginkgo*, and whether localized disruption of the male specific microRNA is responsible for ovule production on a plant that is otherwise morphologically male.

**Key words:** Dioecy, *Ginkgo biloba*, male Ohatsuki Ichō, sex conversion.

*Ginkgo biloba* has been cultivated in China for its edible nuts for about one thousand years and almost from the beginning it was known that two different trees were required for seed production (Crane 2013). *Ginkgo biloba* was first introduced into the West sometime between

about 1720 to 1750 (Loudon 1854), about 30 to 60 years after it was encountered by Engelbert Kaempfer in southern Japan. One of these early introductions, which still survives at the Royal Botanic Gardens, Kew in the U.K., was the first specimen in Europe to be recorded as reaching

kijyu). Bot. Mag. (Tokyo) 5: 341–342 (in Japanese).  
Stadt Wien. 2000. Der Ginkgo-Goethe-Garten im  
Berufschulegarten Kargen.  
Strasburger E. 1892. Histlogische Beiträge. Vol. 4. Gustav  
Fischer Verlag, Stuttgart.

Tanaka N., Takemasa N. and Sinoto Y. 1952. Karyotype  
analysis in gymnospermae. I. Karyotype and  
chromosome bridge in the young leaf meristem of  
*Ginkgo biloba* L. Cytologia 17: 112–123.

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P. R. Crane<sup>d</sup>: イチョウ (イチョウ科) における性転換

山梨県身延町上八木沢の雄のオハツキイチョウの一  
枝にギンナンがなり, そのギンナンから実生が得られ  
た. この木は多くは正常な花粉嚢をつけるが, 葉の上に  
花粉嚢をつけることで, オハツキイチョウとして発見さ  
れている. 上八木沢のオハツキイチョウで見られた局所  
的な性転換は, これまで考えられていたより, もっと多  
く起こっていると思われる. また, 現生イチョウの雌雄  
異株性は, 同一植物の別な位置に花粉と胚珠を付ける雌  
雄同株から進化してきたと思われる. このような雌雄同  
株から雌雄異株への転換は, 性染色体の ZW 型の分化  
を伴って起こった可能性があるが, この場合 Z 型染色  
体の方が若干大きくなっている. なお, ZW の組み合わ  
せで雌性を発現し, ZZ の組み合わせで雄性を発現する.  
イチョウにおける性転換の分子機構は, 未だ分かって

いないが, ある種の被子植物においては雌性の発現は特  
定の転写因子により制御されていることが知られてい  
る. その転写因子が, 雄性由来のマイクロ RNA により  
負に制御されて雌性を抑制し, 雄性の発現をもたらすこ  
とが報告されている. 同様なシステムがイチョウで起こ  
っているのかどうか, あるいはまったく別の機構である  
かどうかは今後の研究に待たねばならないが, 雄性特異  
的マイクロ RNA の局所的破壊によりこの雄のオハツキ  
イチョウにおいて胚珠の形成された可能性は検討に値  
する.

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