Supplementary material

Table 3: Endosperm ploidy levels from *Crataegus*, estimated from flow cytometry

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Summary of data from intra- and inter-ploidy pollinations (Talent and Dickinson 2007a, b), including selfed, intra-specific and inter-specific combinations. The ploidy level of endosperm in apomictic polyploid *Crataegus* was variable, the majority consistent with fertilization by single meiotically reduced sperm as in sexual diploids, a minority consistent with fertilization by either both reduced sperm or a meiotically unreduced sperm.

[a] Evidence for apomeiosis in diploids is rare. Here it is augmented with unpublished data (collaboration with K. I. Christensen): two seeds from European diploid *Crataegus*, both had 2*x* embryos, one had 5*x* and one had 6*x* endosperm.

[b] Endosperm ploidy levels higher than 12*x* are interpreted as derived from gametophytes with three central-cell nuclei, a developmental anomaly that occurs with apomixis (Nogler 1984) and has been observed in *Crataegus* (Muniyamma and Phipps 1984).

[c] Interpreted as involving meiotically derived gametophytes.

[d] The pollen from these 4*x* parents is self pollen; the flowers were not emasculated because doing so appears to disturb development (Celotti 1995; Dickinson and Phipps 1986; Greyson and Tepfer 1967; Greyson and Raman 1975; Williams and Knox 1982).

[e] The DNA measurements from these seeds were not sufficiently precise for unequivocal ploidy-level estimates.

[f] The embryos of these seeds appeared to be aneuploid, between 3*x* and 4*x*.

♀ parent	Endosperm ploidy levels, open pollination	♂ parent, controlled pollination	Endosperm ploidy levels
2*x*	3*x*[c](93 seeds)	2*x*	5*x*[a](1 seed)
		4*x*	3*x*(1 seed), 4*x*[c](40 seeds), 6*x*[a](2 seeds)
3*x*		2*x*	6*x*[f](1 seed), 7*x*(9 seeds), 8*x*(8 seeds), 11*x*(1 seed)
	6*x*[f](1 seed), 8*x*(16 seeds), 10*x*(9 seeds), 14–16*x*[e](2 seeds)	4*x*	8*x*(11 seeds), 10–11*x*[e](3 seeds), 13*x*(1 seed)
4*x* near-obligate apomict		2*x*, 4*x*[d]	6*x*(3 seeds), 10*x*(34 seeds), 12*x*(13 seeds), 14*x*[b](2 seed), 16*x*[b](1 seed)
	6*x*[c](1 seed), 10*x*(71 seeds), 12*x*(37 seeds), 14*x*(13 seeds), 16*x*[b](4 seeds), 17–19*x*(2 seeds)	4*x*	6*x*[c](1 seed), 10*x*(24 seeds), ?8*x*[e](1 seed), 12*x*(32 seeds), 14*x*[b](11 seeds), 16*x*[b](12 seeds)
4*x* facultative apomict		2*x*, 4*x*[d]	?6*x*[e](1 seed), 5*x*[c](14 seeds), 9*x*–10*x*[e](2 seeds)
	6*x*[c](6 seeds), 10–12*x*[e](3 seeds), 14*x*(1 seed)	4*x*	6*x*[c](1 seed), 10*x*(2 seeds), ?13*x*[e](1 seed)

Table 4: The origins of seed embryos of each ploidy level (summary of data from Talent and Dickinson 2007a, b).

Ploidy level of embryo	Maternal origin
Diploids	Sexual diploid (6 species)
	Facultatively apomictic tetraploid (parthenogenesis in sexual gametophytes, 1 species)
Triploids	Apomictic triploid (2 species)
	Diploid (2 species) pollinated from tetraploid (3 species, 5 combinations succeeded)
	Facultatively apomictic tetraploid (1 species) pollinated from diploid (2 species, 1 combination succeeded)
Tetraploids	Near-obligate apomictic tetraploid (7 species)
	Facultatively apomictic tetraploid (1 species)
	Apomeiotic triploid (2 species) pollinated from diploid (2 species, 1 combination succeeded)
Pentaploids	Apomeiotic triploid (1 species) pollinated from tetraploid (1 species)
	Facultatively apomictic tetraploid (1 species) pollinated from diploid (fertilization of apomeiotic egg cells, 1 species)
Hexaploids	Near-obligate apomictic tetraploid (2 species) or facultatively apomictic tetraploid (1 species)

References

Celotti N (1995) The pollen tube pathway and obturator in hawthorn sexual reproduction. BSc Honours thesis, Department of Biology, Queen's University, Kingston, ON

Dickinson TA, Phipps JB (1986) Studies in *Crataegus* (Rosaceae: Maloideae) XIV. The breeding system of *Crataegus crus-galli sensu lato* in Ontario. Am J Bot 73: 116–130

Greyson RI, Tepfer SS (1967) Emasculation effects on the stamen filament of *Nigella hispanica* and their partial reversal by gibberellic acid. Am J Bot 54: 971–976

Greyson RI, Raman K (1975) Differential sensitivity of “double” and “single” flowers of *Nigella damascena* (Ranunculaceae) to emasculation and GA_3. Am J Bot 62: 531–536

Muniyamma M, Phipps JB (1984) Studies in *Crataegus*. XI. Further cytological evidence for the occurrence of apomixis in North American hawthorns. Can J Bot 62: 2316–2324

Nogler GA (1984) Gametophytic apomixis. In: Johri BM (ed.) Embryology of angiosperms. Springer, Berlin, Germany, pp 475–518
Talent N, Dickinson TA (2007a) The potential for ploidy level increases and decreases in *Crataegus* (Rosaceae, Spiraeoideae, tribe Pyreae). Can J Bot 85: 570–584
Talent N, Dickinson TA (2007b) Endosperm formation in aposporous *Crataegus* (Rosaceae, Spiraeoideae, tribe Pyreae): Parallels to Ranunculaceae and Poaceae. New Phytol 173: 231–249
Williams EG, Knox RB (1982) Quantitative analysis of pollen tube growth in *Lycopersicon peruvianum*. J Palynol 18: 65–74