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Seed Dimension and Weight of Selected *Rubus* Species

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Abstract. **Many lesser-known wild *Rubus* species from Ecuador, the People's Republic of China, and North America have been obtained on recent U.S. Dept. of Agriculture plant-collecting expeditions. In this study, the seed size of 43 *Rubus* species was measured. An 80-fold range in seed weight was observed within the genus. Asian species in the subgenera *Idaeobatus* and *Malachobatus* had the lightest seed, ranging from 0.3 mg (*R. eustephanus* Focke ex Diels) to 1.2 mg (*R. coreanus* Miq.). The seeds of ≈80% of the species examined weighed <2 mg. Seeds of European species in the subgenera *Idaeobatus* and *Rubus* (formerly *Eubatus* of Focke) ranged from 1.3 to 3.0 mg. The South American *Orobatus* included several of the heaviest-seeded species. *Rubus megalococcus* Focke (subgenus *Rubus*) had the heaviest and largest seed weighing 24.2 mg. Seed weight was not related to ploidy level in wild species. Seed weight and length were positively correlated. Seed flatness was not related to seed length. Several of the smaller-seeded Asian species, such as *R. minusculus* A. Lev. & Van., *R. hirsutus* Thunb., and *R. eustephanus*, had more drupelets per fruit than did those of larger-seeded species. This heritable trait may be useful in breeding for increased fruit size.**

The U.S. Dept. of Agriculture (USDA) recently has sponsored expeditions to collect *Rubus* within Ecuador, the People's Republic of China, and North America. Many species collected during these trips represent taxa previously unavailable to American small-fruit researchers (Ballington et al., 1991, 1993; Thompson, 1991, 1992). The USDA's National Clonal Germplasm Repository, Corvallis, Ore., preserves these and additional species as seedlots and plants. While fruit of these wild species are unsuitable for direct commercial production, they need to be evaluated for specific characters to determine which qualities may benefit *Rubus* improvement. The repository will be collaborating with many scientists to evaluate these species and is beginning this effort by examining seed characteristics.

The seed size of cultivated *Rubus* is significant to the processing industry and for fresh-market production (Darrow and Sherwood, 1931; Moore et al., 1973). Size can be measured by mass (Darrow and Sherwood, 1931; Petersen, 1921) or by length dimensions (Churchill et al., 1991, 1992). Fruit with high pulp : seed ratios or with small, flat seeds are less objectionable for processing than thick-seeded fruit (Darrow and Sherwood, 1931). Large numbers of small seed are positively correlated with fruit firmness (Darrow and Sherwood, 1931).

The objective of this study was to determine seed weight and dimensions for a broad range of *Rubus* species and contrast these measurements with known North American and European blackberries (subgenus *Rubus*) and raspberries (subgenus *Idaeobatus*).

Materials and Methods

From 1988 through 1993, seeds of 43 wild *Rubus* species were collected as ripe fruit, cleaned, packaged, labeled, and stored at –20C upon receipt. Five replicates of 100 seeds were counted and weighed, except for three species where fewer than 500 seeds were available. Analysis of variance (ANOVA) was performed on the replicate weights. Mean separation was determined by least significant difference (LSD). The physical properties of drupelets were not examined because United States quarantine requirements state that foreign *Rubus* seed must be cleaned before entry into this country.

Seed size of economically important *Rubus* cultivars has been reported by Darrow and Sherwood (1931) and Moore et al. (1973). However, this information has not been compiled for many wild species. Seed dimensions were measured for 10 taxa representing the range of seed weight. Length (longitudinal axis), width, and thickness (transverse plane) were measured with electronic calipers on 10 randomly chosen seeds of each taxon. The seed length : thickness ratio ($R_{l/t}$) was calculated. ANOVA and mean separation (determined by LSD) were performed on the seed dimensions and $R_{l/t}$. Seed weight and length were correlated.

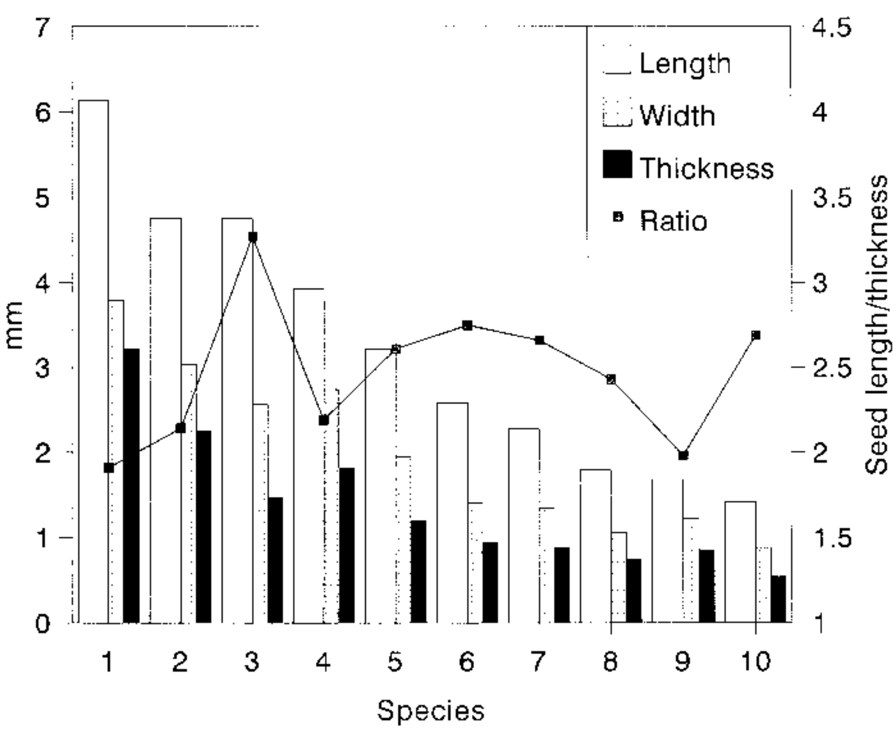

Fig. 1. Seed length, width, and thickness (Y1 axis) and the seed length : thickness ratio ($R_{l/t}$, Y2 axis) for 10 *Rubus* species. Each bar or point represents the mean of 10 seeds. The species represented are 1) *R. megalococcus*, 2) *R. bogotensis*, 3) *R. nubigenus*, 4) *R. chamaemorus*, 5) *R. procerus*, 6) *R. idaeus*, 7) *R. chingii*, 8) *R. ellipticus*, 9) *R. innominatus*, 10) *R. eustephanus*.

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Results and Discussion

The weight and length of seeds differed significantly among *Rubus* species (Fig. 1, Table 1). Seeds of two Ecuadorian species, *R. megalococcus* Focke and *R. bogotensis* H.B.K., were significantly heavier and longer than those of other *Rubus*. The average weight of the heaviest-seeded species, *R. meglococcus*, was 24.2 mg, while the next-heaviest seeds (9.5 mg) were of *R. bogotensis* H.B.K. (Table 1). Seeds of *R. nubigenus* H.B.K. from Ecuador and *R. chamaemorus* L. from Alaska were heavier (7.4 mg) than those of most species examined. These seeds also were longer, wider, and thicker than those of other species (Fig. 1). Seed length was correlated positively with seed weight ($r = 0.91$, $P < 0.01$).

The average seed weight of European and North American blackberry and raspberry species ranged from 1.3 to 2.7 mg. Seeds of both the North American blackberries *R. allegheniensis* Porter and *R. ursinus* Cham. & Schldl. and of the European blackberries *R. procerus* Muller and *R. caesius* L. were larger than those of the European raspberry *R. idaeus* L. (Table 1). Peterson (1921) observed that seed weight of blackberry species from the northeastern United States ranged from 1.59 to 3.86 mg. *Rubus procerus* seeds were longer and thicker than those of *R. idaeus* (Fig. 1).

Rubus ploidy ranges from diploid (Jennings, 1988) to 14-ploid (Nybom, 1986). Seed size is not related to ploidy level. Seeds of wild diploid *R. allegheniensis* are lighter than seeds of the many cultivated tetraploid blackberry selections of the same species. Moore et al. (1973) reported that seeds of the cultivated blackberry weigh up to 4.3 mg. Similarly, seeds of diploid Arctic raspberry species are much lighter than those of the octoploid *R. chamaemorus*, native to the same region (Table 1). However, the seed weight of most other *Rubus* species is unrelated to ploidy. For example, many of the smallest-seeded species are diploid, but seed of the second-heaviest species also is diploid. Both *R. roseus* and *R. nubigenus* are members of the subgenus *Orobatus*. Ploidy level for these species is unpublished. The seeds of *R. roseus* weigh less than one-third those of *R. nubigenus*. Seeds of *R. glabratus*, another *Orobatus* whose ploidy is unknown, weigh less than one-third those of *R. roseus*. Ploidy of the heaviest-seeded species, *R. megalococcus* (subgenus *Rubus*), is unreported.

The seeds of >80% of the species examined weighed <2 mg. Some of the smaller-seeded species included the Asian diploids *R. eustephanus* Focke ex Diels, *R. hirsutus* Thunb., *R. minusculus* A. Lev. & Van., *R. rosifolius* Smith, and *R. corchorifolius* L. Darrow and Sherwood (1931) pointed out that black raspberries seem seedy because the seeds, though small, are numerous. They concluded that seed size is only one of the factors contributing to seediness and that the proportion of seed weight to the total berry weight is more important than the seed size. These authors were referring to the cultivated raspberries and blackberries and not to the extremely large-seeded species: *R. megalococcus*, *R. bogotensis*, *R. nubigenus*, and *R. chamaemorus*.

We did not examine the seeds of *R. occidentallis* L. or *R. leucodermis* Doug. ex Tor. & Gray, the North American black raspberries, but the small-seeded Asian species of this study with high numbers of drupelets were of similar "seediness." While these species would have limited use for processors or fresh market, they may be of significance to berry breeders. One breeding strategy to increase fruit size includes preliminary crosses with wild species to increase the number of drupelets per fruit. The small-seeded Asian species would be good initial candidates for such a project. Moore et al. (1975) showed that seed size in blackberry is highly heritable and that small seededness is partly dominant.

Seed flatness of 10 *Rubus* species was not related to seed length (Fig. 1). Seed length varied from >3 to <2 times the thickness. *Rubus nubigenus* (species 3) and *R. idaeus* (species 6) had the largest $R_{l/t}$ values, i.e., the thinnest seeds for their length (Fig. 1). While *R. nubigenus* had the highest seed $R_{l/t}$, its seeds were thicker than the length of seeds of most species tested. The $R_{l/t}$ of *R. eustephanus* (the smallest seed), *R. chingii*, and *R. procerus* was <3. In contrast, the $R_{l/t}$ of *R. megalococcus* (the largest seed), *R. innominatus*, *R. bogotensis*, and *R. chamaemorus* was ≈2 (Fig. 1). This second group of seeds was more "round" than "flat" in cross section.

Generally, the heaviest seeds were members of the South American subgenera *Rubus* and *Orobatus*, although the monotypic, circumpolar-boreal subgenus *Chamaemorus* also had large seeds. Seeds of species in the economically important subgenus *Rubus* were slightly heavier than those of the European *Idaeobatus*. The Asian *Idaeobatus* and *Malachobatus* species had the lightest, shortest seeds.

In summary, the seeds of *R. megalococcus*, *R. bogotensis*, *R. nubigenus*, and *R. chamaemorus* were heavier and longer than those of other *Rubus*. We observed an 80-fold range in seed weight among species within the

Table 1. Seed weight of selected *Rubus* species, ordered from heavy to light.[z]

Corvallis accession no.	Species	Collection location	Seed wt (mg/seed)
1268	*R. megalococcus* Focke[y]	Azuay, Ecuador	24.2 a
1280	*R. bogotensis* H. B. K.	Loja, Ecuador	9.5 b
1249	*R. nubigenus* H. B. K.	Carchi, Ecuador	7.4 c
1757	*R. chamaemorus* L.	Alaska, USA	7.4 c
1262, 1270	*R. glabratus* Kunth	Carchi, Ecuador	3.7[x]
397	*R. procerus* Muller	Oregon, USA	3.0 d
1234	*R. caesius* L.	Tajikistan	2.7 e
495	*R. allegheniensis* Porter	Wisconsin, USA	2.7 e
1266	*R. roseus* Poir.	Carchi, Ecuador	2.4 e
1252, 1255, 1258	*R. coriaceus* Poir.	Carchi, Ecuador	2.3[w]
185	*R. ursinus* Cham. & Schldl.	Oregon, USA	2.1 f
1248	*R. robustus* C. Presl.	Carchi, Ecuador	1.8 g
239	*R. idaeus* L.	Scotland, UK	1.7 gh
407	*R. glaucus* Benth.	Hawaii, USA	1.7 h
399	*R. hawaiiensis* A. Gray	Hawaii, USA	1.5 i
1250	*R. adenothallus* Focke	Carchi, Ecuador	1.5 ij
626	*R. sachalinensis* A. Leveille	Jilin, China	1.5 ij
186	*R. parviflorus* Nutt.	Oregon, USA	1.4 jk
822	*R. caucasicus* Focke	Russian Federation	1.4 k
1630, 1634, 1635	*R. coreanus* Miq.	Guizhou, China	1.2 l
1658	*R. parvifolius* L.	Guizhou, China	1.1 lm
1277	*R. urticifolius* Poiret	Zamora, Ecuador	1.0 mn
1620, 1035	*R. chingii* Hu	Jiangsu, China	1.0 mn
1671	*R. swinhoei* Hance	Guizhou, China	1.0 mn
1064, 1061	*R. hoffmeisterianus* Knth & Bche	Gilgit, Pakistan	0.9 no
1073, 1068, 1650	*R. niveus* Thunb.	Swat, Pakistan	0.9 no
175	*R. kawakamii* Hayata	Taiwan	0.8 op
178	*R. hayata-koidzumii* Naruhashi	Taiwan	0.8 op
1645, 1642	*R. multibracteatus* A. Lev. & Van.	Guizhou, China	0.7 pq
246	*R. lasiostylus* Focke	Asia (through UK)	0.7 p–r
1039	*R. innominatus* S. Moore	Jiangxi, China	0.7 qr
160, 627	*R. crataegifolius* Bunge	China	0.7 qr
158	*R. microphyllus* L.	Japan	0.7 qr
181, 1183, 1710	*R. lambertianus* Ser.	Jiangsu, China	0.7 qr
174	*R. formosensis* Kuntze	Taiwan	0.6 rs
1695	*R. setchuenensis* Bureau & Fran.	Guizhou, China	0.5 st
1665	*R. pinfaensis* A. Lev. & Van.	Guizhou, China	0.5 st
394	*R. ellipticus* Smith	Nepal	0.5 st
1628	*R. corchorifolius* L.	Guizhou, China	0.5 tu
188	*R. rosifolius* Smith	Java, Indonesia	0.3 uv
161	*R. minusculus* A. Lev. & Van.	Japan	0.3 v
1040, 1037, 1038	*R. hirsutus* Thunb.	Jiangsu, China	0.3 v
1638,1639	*R. eustephanus* Focke ex Diels	Guizhou, China	0.3 v

[z]Mean of five replications of 100 seeds, mean separation by LSD, $P \leq 0.05$.
[y]Mean of five replicates of 50 seeds.
[x]Insufficient seed for analysis of variance (ANOVA); mean of 91 seeds.
[w]Insufficient seed for ANOVA; mean of 80 seeds.

genus. About 80% of species had seeds that weighed <2 mg. Seeds of blackberry species were longer and thicker than those of raspberry species. Many Asian species had smaller seeds than those of the European red raspberry *R. idaeus*. While seed length and weight were correlated, seed length was not related to seed flatness. Seed weight is not related to the ploidy level of wild *Rubus* species.

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