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Characteristics of the Falling Speed of Japanese Orchid Seeds

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Abstract

Orchid seeds, which are produced in abundance, are particularly small and light. Some orchid species are anemochorous, i.e., bear seeds that are dispersed by wind. To characterize the seeds of Japanese orchids, we measured the size of seeds and embryos of 68 Japanese orchid species. Most orchid seeds had a length of 0.3 to 2 mm and a width of 0.07 to 0.2 mm. Embryo length and width were 0.1 to 0.3 mm and 0.04 to 0.2 mm, respectively. Twenty-seven orchid species produced 1000 to 350000 seeds per pod. Speeds of fall of 34 Japanese orchid species were examined in order to obtain insight into their seed dispersal ability. Falling speeds ranged from 4 to 30 cm/s. These results strongly suggest that seeds of Japanese orchids are also dispersed by wind and thus that most Japanese orchids are anemochorous species.

Keywords: Japanese orchids, wind, speed of fall of seeds, anemochorous, seed size, seed number

1. Introduction

The dispersal of seeds to a suitable habitat is a crucial event in the plant life cycle. Three major mechanisms spread seeds; i.e., hitchhiking on animals, floating in water, and moving in the wind (Fenner, 1985). Most anemochorous species produce particularly small and light seeds (Burrows, 1975). In some cases, seeds have wings that enable them to travel long distances (Burrows, 1973). Mathematical models have been developed to predict the dispersal distances of various anemochorous seeds (Cremer, 1977; Murren & Ellison, 1996; 1998).

The orchid family is a morphologically diverse monocot. Because of their beautiful flowers, Orchidaceae plants are important not only for biologists but also in the marketplace (Sawa et al., 2006; Fukunaga et al., 2008; Ejima et al., 2011). The orchid produces dust seeds, with shapes that are adapted to the habitat of the orchid (Shimizu et al., 2012), and some orchids are considered to be anemochorous plants. However, orchid seeds have not been well characterized. Here, we characterized the seeds and embryos of Japanese orchids, and determined the speed of fall of the seeds. We discuss correlations between orchid habitat and properties of the seed, and comment on the evolution of this relationship.

2. Materials and Methods

2.1 Orchid Seeds

Orchid seeds were collected from their natural habitat in Japan. All seeds were dried using silica gel in a closed plastic box at least for two weeks at room temperature.

2.2 Seed Number

All of the dried seeds in one pod were weighed. Based on mass, the seeds were divided into ten groups, and the number of seeds was counted in one of these groups. The number of seeds per pod was calculated as being ten fold the counted number.

2.3 Seed Size

Seed size was examined using a stereomicroscope (Leica S8). Two-hundred seeds were evaluated per species. Mean value was shown in Table 1.

Table 1. Size and drop-speed of seeds on the native orchids in Japan

Species	Seed		Embryo		Seed No.	Drop-
	Length (/um)	Width (/um)	Length (/um)	Width (/um)	per pod (×1000)	Speed (cm/sec.)
Bletilla striata	1803	225	488	209	30.2	23.5
Bulbophyllum inconspicuum	199	80	149	70	-	11.9
C. reflexa	1142	134	144	86	-	8.9
C. tricarinata	1086	163	178	91	-	11.1
C. native hybrid (Satuma)	957	122	144	77	-	8.4
C. schlechteri	939	168	148	78	-	8.5
C. discolor	831	120	128	69	69.1	8.1
Cephalanthera erecta	1181	179	208	119	-	17.9
Cremastra appendiculata	2302	127	280	110	-	9.1
Cymbidium goeringii	1610	152	292	90	346.9	7.2
C. dayanum var.autro-japonicum	861	207	140	79	-	16.4
Dendrobium moniliforme	337	90	189	86	145.3	15.6
D. tosaense	429	87	175	86	-	7.8
Epipactis thunbergii	1923	234	259	137	42.6	11.8
Eria reptans	207	86	128	81	1.4	18.6
G. pubilabiata	2662	147	217	79	10.1	7.6
Gastrodia confusa	2619	109	201	68	-	6.0
G. nipponica	2384	102	193	72	48.8	4.9
Goodyera velutina	1814	78	257	91	1.1	5.9
G. macrantha	1738	81	226	76	-	6.5
G. shlechtendaliana	930	102	207	65	1.4	8.5
Habenaria radiata	601	230	238	190	2.4	29.8
Lecanorchis hokurikuensis	4560	127	168	84	-	4.5
L. japonica	4629	152	174	86	3.7	4.6
L. kiusiana	3760	98	120	64	3.1	4.3
Liparis formosana	708	94	104	54	-	5.5
L. nervosa	683	102	109	49	13.5	4.2
L. odorata	458	98	120	60	18.1	9.5
Microtis formoana	376	112	188	73	-	15.6
Neofinetia falcata	302	85	219	74	37.9	26.9
Nervilia nipponica	581	131	113	47	-	3.4
Phajus minor	752	112	-	-	90.6	3.6
Spiranthes sinensis var. anoena	459	95	183	84	1.8	11.5
Zeuxine agyokuana	1890	72	206	61	-	4.6

2.4 Speed of Fall of the Seeds

A triangular prism, 25 cm each side and 2 m in height, was prepared, one surface of which was constructed of paper and two of transparent vinyl. Top surface was made of paper. A hole, 5 mm in diameter, was made in the top surface. Seeds were dropped from the hole 20 times for each species, and measured the falling time. Falling speeds were calculated from the data of falling time and falling distance (25 cm). Mean value was shown in Table 1.

3. Results and Discussion

We measured the seed size of 68 Japanese orchid species (Table 1). Orchid seeds are known to be small. In this analysis, we found that the seeds of *Eria reptas* had a length and width of 0.2 and 0.086 mm, respectively. This size is almost twice that of *Zea mays* (corn) or chestnut pollen grains. On the other hand, the seeds of the *Lechanorchis* group were quite long, with *L. japonica* producing seeds that were 4.6 mm in length and 0.15 mm in width. However, the embryo size of *L. japonica* was almost the same as that of other species (Table 1).

Seed number was also examined. *Cymbidium goeringii* produced 346900 seeds per pod (Table 1). In contrast, *Amitostigma gracile, Ponerorchis kurokamiana,* and *Tulotis ussuriensis* produced only 900 seeds per pod. We could not establish any correlation between seed size and seed number per pod.

To characterize seed dispersal ability, we measured the speed of fall of seeds from 34 Japanese orchids. The speed of fall of the seeds of *Taraxacum japonicum,* which is a well-known anemochorous plant, was 30.0 cm/s. Most of the seeds had slow speeds of fall (Table 1). Especially in the case of *Habenaria dentata*, *Neofinetia falcate*, and *Bletilla striata*, the speed was 29.8, 26.9, and 23.5 cm/s, respectively. Thus, most of the Japanese orchids could also be considered to be anemochorous plants. However, there was variation in the speed of fall of Japanese orchid seeds, which suggests variation in their method of dispersal. In particular, *H. dentate* and *B. striata* thrive in damp areas and on riverbanks, and their seeds can also be dispersed by water. The wind on the forest floor is weak, and orchids that grow in this habitat have to adapt to the weak-wind environment to disperse their seeds. Thus, the seeds of orchids living on the forest floor may have evolved to be long, as increased length reduces the speed of fall and increases the chance that the seed will be swept up by winds (Table 1; Shimizu et al., 2012).

Here we characterize the falling speed of Japanese orchid seeds. Most of the Japanese seeds can be considered as anemochorous plants. However, they seemed to evolve the seed shape to adapt their habitat environment, i.e. long and thin to reduce the seed falling speed. More detailed analysis of the seed shape will reveal how orchid adapt various environment in the world.

References

Burrows, F. M. (1973). Calculation of the primary trajectories of plumed seeds in steady winds with variable convection. *New Phytologist, 72*, 647-664. http://dx.doi.org/10.1111/j.1469-8137.1973.tb04414.x

Burrows, F. M. (1975). Calculation of the primary trajectories of dust seeds, spores and pollen in unsteady winds. *New Phytologist, 75*, 389-403. http://dx.doi.org/10.1111/j.1469-8137.1975.tb01403.x

Cremer, K. W. (1997). Distance of seed dispersal in eucalyptus estimated from seed weights. *Australian Journal of Forest Research, 7*, 225-228.

Ejima, C., Kobayashi, Y., Honda, H., Shimizu, N., Kiyohara, S., Hamasaki, R., & Sawa, S. (2011). A Phalaenopsis variety with floral organs showing C class homeotic transformation and its revertant may enable Phalaenopsis as a potential molecular genetic material. *Gene Genet. Sys., 86*, 93-95 http://dx.doi.org/10.1266/ggs.86.93

Fenner, M. (1985). Seed ecology. Chapman and Hall, New York. http://dx.doi.org/10.1007/978-94-009-4844-0

Fukunaga, H., Sawa, S., & Sawa, Y. (2008). A new form of Lecanorchis kiusiana (Orchidaceae) from Kochi, Japan. *The Orchid Review, 116*, 106-108.

Murren, C. J., & Ellison, A. M. (1996). Effects of habitat, plant size, and floral display on male and female reproductive success of the neo-tropical orchid. *Brassavola nodosa. Biotropica, 28*, 30-41. http://dx.doi.org/10.2307/2388769

Murren, C. J., & Ellison, A. M. (1998). Deed dispersal characteristics of Brassavola nodosa (Orchidaceae). *American Journal of Botany, 85*, 675-680. http://dx.doi.org/10.2307/2446537

Sawa, S., Fukunaga, H., & Sawa, Y. (2006). *Lecanorchis amethystea* (Orchidaceae), A New species from Kochi. *Acta Phytotax. Geobot, 57*, 123-128.

Shimizu, N., Sawa, Y., & Sawa, S. (2012). Adaptation and evolution of seed shape on bleeding area in Japanese orchids. *International Journal of Biology*, in press.