Adaptation and Evolution of Seed Shape on Bleeding Area in Japanese Orchids

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Abstract

In order to spread the breeding area in the Orchidaceae, seed shapes and seed coat patterns are important to ride upon the winds. Here we report the shapes of the seeds of 61 Japanese orchid species. We compared the seed shape and breeding area, epiphytic on dry place, wet place, and terrestrial in grassland place, damp place, and in bright forest, and dark forest. As a result, In the case of orchid family grown in dark forest, the seed shape is tends to long and narrow. This shape may be evolved in order to adapt in the dark forest with weak wind growing with many other trees and grasses for expanding their breeding area.

Keywords: Orchid, Seed shape, Bleeding area, Wind, Evolution, Adaptation, Wind

1. Introduction

Orchid family is morphologically diverse monocot. Because of the beautiful flower, the Orchidaceae plants are important not only for biologists but also in market places (Sawa et al., 2006; Fukunaga et al., 2008; Ejima et al., 2011). In usual, orchid family plants produce tiny seeds that number in the hundreds of thousands. When capsule dried and open, the tiny seeds are spread by the wind. Each seed is so small and it contains only a very little stored food probably to reduce seed weight.

On the other hand, orchid family plants grow in various places, epiphytic on dry place, wet place, and terrestrial in grassland place, damp place, and in bright forest, and dark forest. It means that orchids grow in various environmental conditions. Seed shape evolution may be affected by the situation of the wind and other environmental conditions. In order to unveil the relationship between bleeding places and seed shapes, we observed various Japanese orchid seed shapes by the scanning electron microscope. Here we found that some of the seeds of orchids grown in dark forest are quite long and narrow compare with other orchid plants. This shape may be the results of evolution in order to adapt to grown in the specific environmental places.

2. Materials and Methods

2.1 Scanning microscope analysis

The seed samples were coated with gold and observed with a scanning electron microscope (model JSM-T20; Nippon Denshi, Tokyo, Japan) at an accelerating voltage of 20 kV. The images were photographed on Neopan SS 120 film (Fuji, Tokyo, Japan).

3. Results and Discussion

We prepared seeds of *Bulbophyllum inconspicuum*, *Cleisostoma scolopendrifolium*, *Cymbidium dayanum var. austro-japonicum, Dendrobium moniliforme*, *Dendrobium tosaense*, *Eria japonica*, *Gastrochilusjaponicus japonicum*, *Neofinetia falcate*, *Oberonia japonica*, *Sedirea japonica*, *Taeniophyllum glandulosum*, *Sarcochilus japonicus Amitostigma lepidum, Amitostigma keiskei, Orchis graminifoliam, Bletilla formosana*, *Gymnadenia conopsea*, *Liparis odorata*, *Platanthera mandarinorum var. brachycentron*, *Pogonia minor*, *Spathoglottis plicata*, *Spiranthes sinensis, Spiranthes sinensis var. amoena*, *Bletilla striata*, *Epipactis thunbergii*, *Habenaria dentate*, *Habenaria iyoensis*, *Habenaria radiata*, *Platanthera tipuloides var. niponica*, *Cephalanthera erecta, Cephalanthera falcate*, *Oreorchis patens*, *Tulotis iinumae*, *Pterostylis nana*, *Calanthe amamiana, Calanthe discolor*, *Calanthe discolor*, *Calanthe masuca*, *Calanthe sieboldii*, *Calanthe triplicata*, *Cremastra appendiculata*, *Cymbidium goeringii*, *Cymbidium goeringii var. angustatum, Hetaeria sikokiana*, *Cymbidium lancifolium*, *Hetaeria yakusimensis*, *Gastrodia nipponica*, *Gastrodia pubilabiata*, *Liparis nervosa*, *Liparis formosana*, *Lecanorchis hokurikuensis*, *Lecanorchis japonica*, *Goodyera viridiflora*, *Lecanorchis suginoana*, *Gastrodia verrucosa*, *Lecanorchis kiusiana*, *Lecanorchis nigricans*, *Hetaeria agyokuana*, *Phaius flavus, Liparis kumokiri*, and *Galeola septentrionalis*, and observed seed coats by using scanning electron microscope. These orchids species were categorised into six groups by an index of breeding places, epiphytic on dry place, wet place, and terrestrial in grassland place, damp place, and in bright forest, and dark forest (Table 1).

Seed coat patterns can be categorized into two groups, striped and netted pattern (Figure 1-6). All of the seed coat patterns, grown on the epiphytic on wet places was netted pattern. However, the seed coat pattern seems to be random.

Most of the seeds of orchid plants grown on the epiphytic places, grown in the terrestrial damp places and bright forests are oval shaped (Figure 1, 2). In some seeds of the plants grown in terrestrial dark forests are extremely long and narrow (Figure 6N, O, R, S, U, W, X, and Y). Especially, all of the seed of *Lecanorchis* group were long and narrow. Only the seed of *Galeola septentrionalis* was disc shaped and the center region was bulged out (Figure 6. AB).

In the dark forests in Japan, humidity is relatively high. Further, the wind in the dark forests is weak because other trees and grasses are growing. So, the orchid seeds were difficult to be carried away by the wind. For the orchid plants, long and narrow seed shape seems to have advantages to ride weak wind in order to spread the bleeding area.

Further wind scatter experiments of the orchid seeds would open up a new insight to the field of orchid seed shape evolution and adaptation to various environment growing conditions.

(Figure 1-6)

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Table 1. Orchid species categorized by bleeding area

epiphytic on dry place	*Bulbophyllum inconspicuum* *Cleisostoma scolopendrifolium* *Cymbidium dayanum var. austro-japonicum* *Dendrobium moniliforme* *Dendrobium tosaense* *Eria japonica* *Gastrochilusjaponicus japonicum* *Neofinetia falcate* *Oberonia japonica* *Sedirea japonica* *Taeniophyllum glandulosum* *Sarcochilus japonicus*
epiphytic on wet place	*Amitostigma lepidum* *Amitostigma Keiskei* *Orchis graminifolia*
terrestrial in grassland place	*Bletilla formosana* *Gymnadenia conopsea* *Liparis odorata* *Platanthera mandarinorum var. brachycentron* *Pogonia minor* *Spathoglottis plicata* *Spiranthes sinensis* *Spiranthes sinensis var. amoena*
terrestrial in damp place	*Bletilla striata* *Epipactis thunbergii* *Habenaria dentata* *Habenaria iyoensis* *Habenaria radiata* *Platanthera tipuloides var. niponica*
terrestrial in bright forest	*Cephalanthera erecta.* *Cephalanthera falcata* *Oreorchis patens* *Tulotis iinumae*
terrestrial in dark forest	*Pterostylis nana* *Calanthe amamiana* *Calanthe discolor* *Calanthe discolor* *Calanthe masuca* *Calanthe sieboldii* *Calanthe triplicata* *Cremastra appendiculata* *Cymbidium goeringii* *Cymbidium goeringii var. angustatum* *Hetaeria sikokiana* *Cymbidium lancifolium* *Hetaeria yakusimensis* *Gastrodia nipponica* *Gastrodia pubilabiata* *Liparis nervosa* *Liparis formosana* *Lecanorchis hokurikuensis* *Lecanorchis japonica* *Goodyera viridiflora* *Lecanorchis suginoana* *Gastrodia verrucosa* *Lecanorchis kiusiana* *Lecanorchis nigricans* *Hetaeria agyokuana* *Phaius flavus* *Liparis kumokiri* *Galeola septentrionalis*

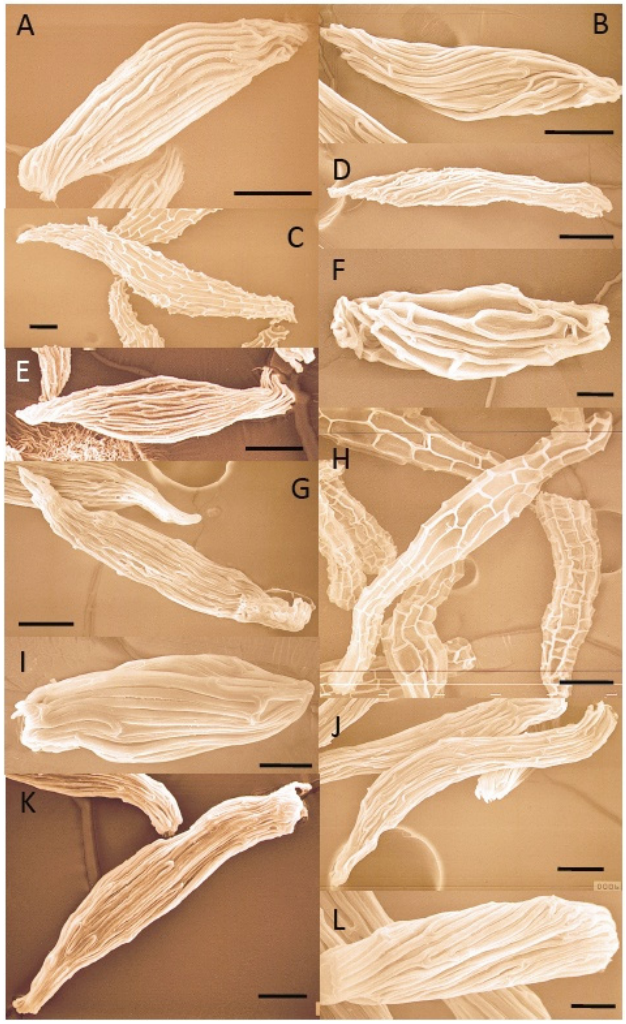

Figure 1. SEM images of the orchid seeds grown on the epiphytic on dry place

A. *Bulbophyllum inconspicuum*, B. *Cleisostoma scolopendrifolium*, C. *Cymbidium dayanum var. austro-japonicum,* D. *Dendrobium moniliforme*, E. *Dendrobium tosaense*, F. *Eria japonica*, G. *Gastrochilusjaponicus japonicum*, H. *Neofinetia falcate*, I. *Oberonia japonica*, J. *Sedirea japonica*, K. *Sarcochilus japonicus,* L. *Taeniophyllum glandulosum.* Bars: A, B, G, J, K 50µm, C-E, H 100µm, F, I, L 25µm.

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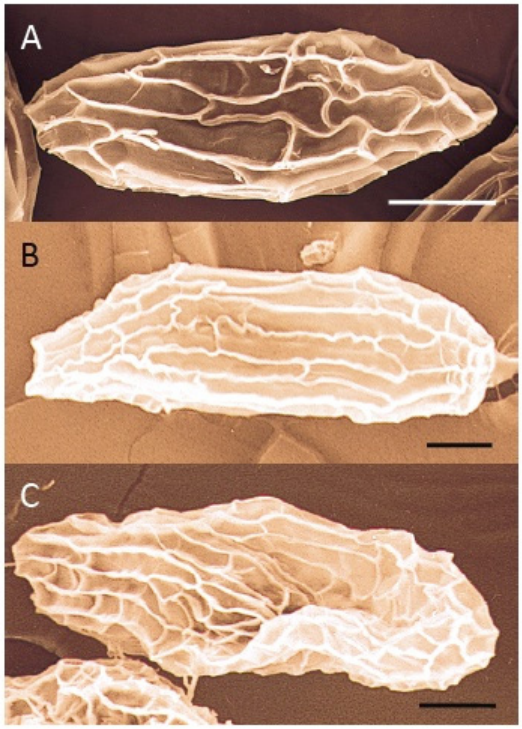

Figure 2. SEM images of the orchid seeds grown on the epiphytic on wet place

A. *Amitostigma lepidum,* B. *Amitostigma keiskei,* C. *Orchis graminifoliam.* Bars: A, C 50μm, B 100μm.

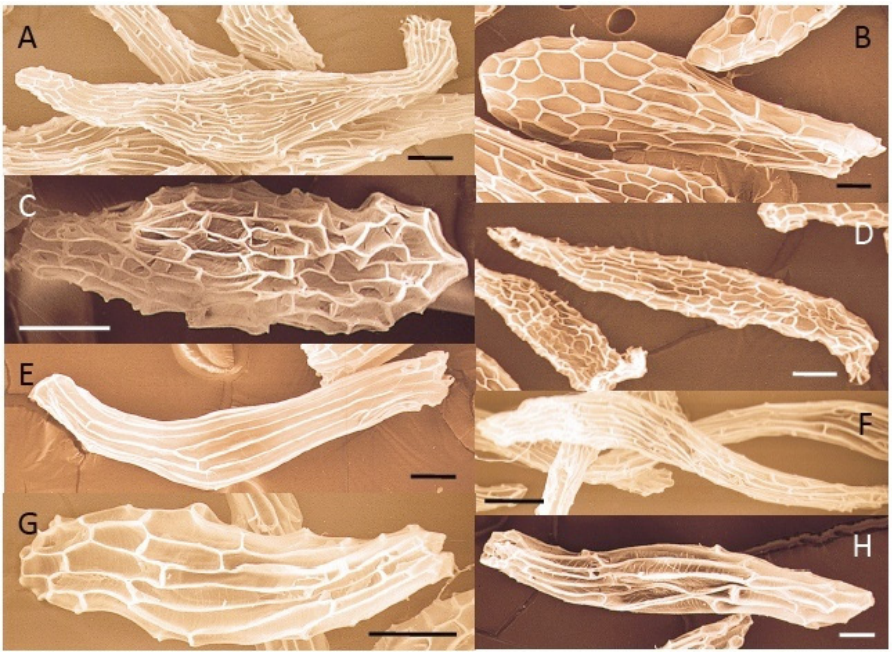

Figure 3. SEM images of the orchid seeds grown in terrestrial grassland place

A. *Bletilla formosana*, B. *Gymnadenia conopsea*, C. *Liparis odorata*, D. *Platanthera mandarinorum var. brachycentron*, E. *Pogonia minor*, F. *Spathoglottis plicata*, G. *Spiranthes sinensis,* H. *Spiranthes sinensis var. amoena.* Bars: A, B, D-H 100μm, C, 50μm.

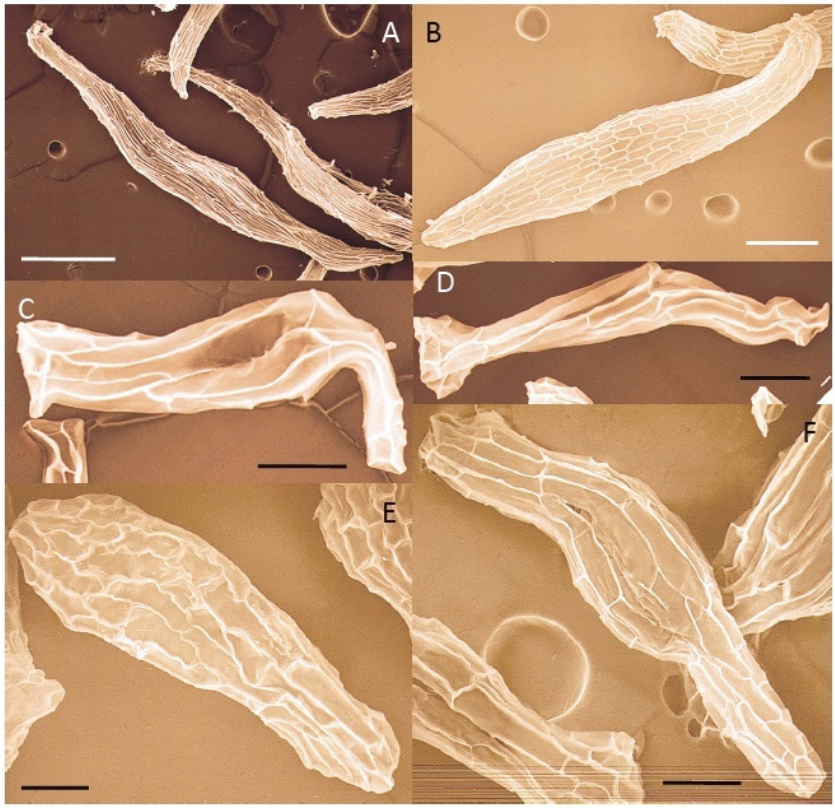

Figure 4. SEM images of the orchid seeds grown in terrestrial damp place

A. *Bletilla striata*, B. *Epipactis thunbergii*, C. *Habenaria dentate*, D. *Habenaria iyoensis*, E. *Habenaria radiata*, F. *Platanthera tipuloides var. niponica.* Bars: A 50μm, B 200μm, C-F 100μm.

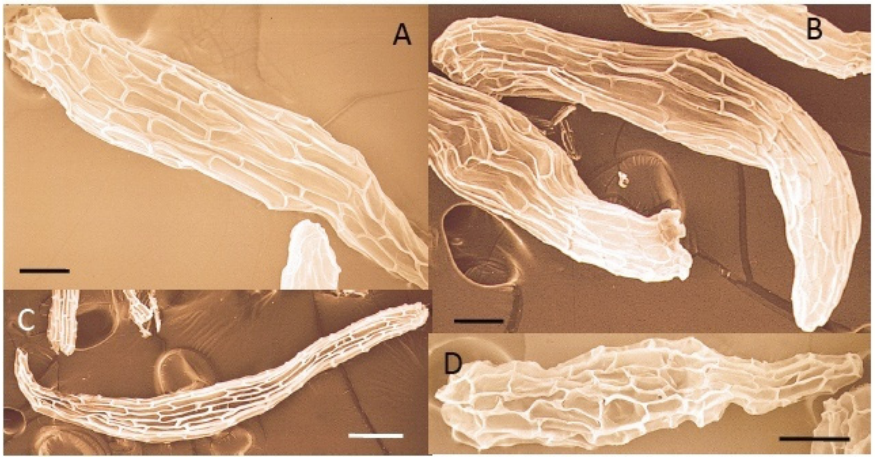

Figure 5. SEM images of the orchid seeds grown in terrestrial bright forest

A. *Cephalanthera erecta,* B. *Cephalanthera falcate*, C. *Oreorchis patens*, D. *Tulotis iinumae*. Bars: A, B, D, 100μm, C, 200μm.

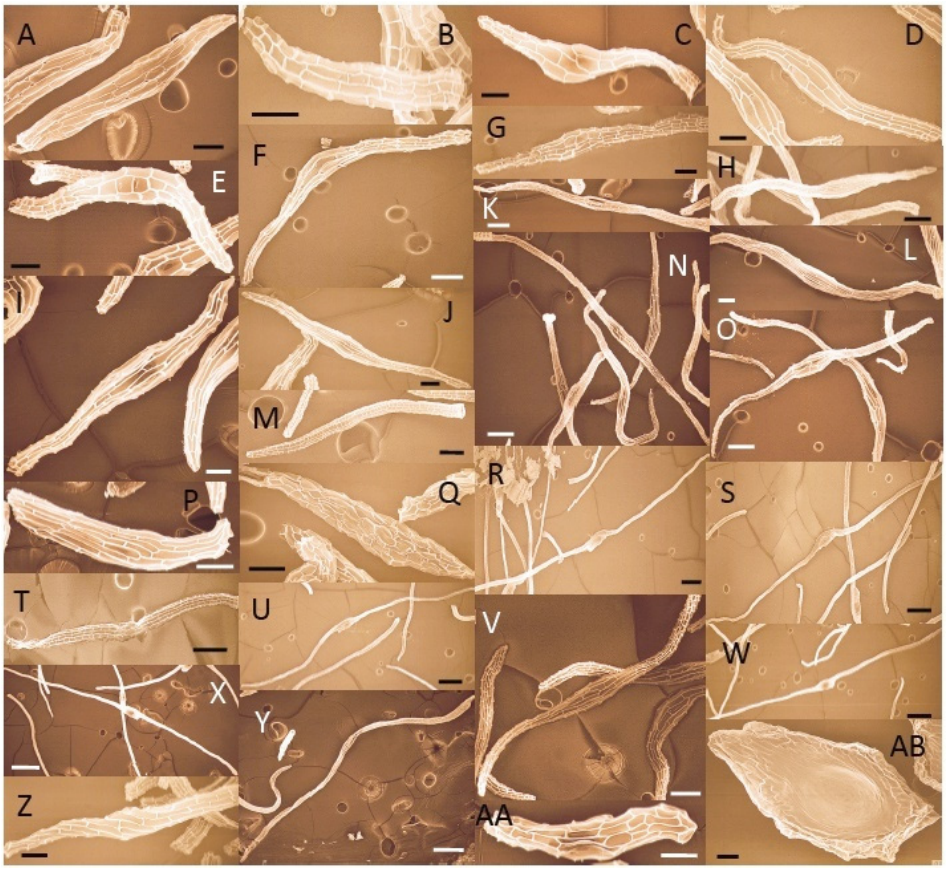

Figure 6. SEM images of the orchid seeds grown in terrestrial dark forest

A. *Pterostylis nana*, B. *Calanthe amamiana,* C. *Calanthe discolor*, D. *Calanthe discolor*, E. *Calanthe masuca*, F. *Calanthe sieboldii*, G. *Calanthe triplicata*, H. *Cremastra appendiculata*, I. *Cymbidium goeringii*, J. *Cymbidium goeringii var. angustatum,* K. *Hetaeria sikokiana*, L. *Cymbidium lancifolium*, M. *Hetaeria yakusimensis*, N. *Gastrodia nipponica*, O. *Gastrodia pubilabiata*, P. *Liparis nervosa*, Q. *Liparis formosana*, R. *Lecanorchis hokurikuensis*, S. *Lecanorchis japonica*, T. *Goodyera viridiflora*, U. *Lecanorchis suginoana*, V. *Gastrodia verrucosa*, W. *Lecanorchis kiusiana*, X. *Lecanorchis nigricans*, Y. *Hetaeria agyokuana*, Z. *Phaius flavus,* AA. *Liparis kumokiri*, AB. *Galeola septentrionalis.* Bars: A-D, G, I-M, P, Q, Z, AA, AB 100μm, F, H, N, O, R-Y 200um, E 25μm.