

Michio TAMURA* & Yoko MIZUMOTO** : **Stages of embryo development in ripe seeds or achenes of the Ranunculaceae**

田村道夫*・水本陽子** : キンポウゲ科の種子または
閉果における胚の發育段階

It is commonly known that in the Ranunculaceae embryos often do not complete their growth and differentiation morphologically by the time of shedding of seeds or achenes. In some of these cases, the immature embryos may continue the unbroken development till germination within the seeds or achenes after shedding, if the environmental condition is adequate. The period from shedding to germination is usually longer, compared to that of the seeds with mature embryos. That is, the seeds or achenes which fall on the ground from early summer to autumn usually do not germinate until the coming spring. The endosperm is of nuclear type and precedes the embryo in development. The stages of embryo and endosperm development at shedding are various within the family. And it is a point in question whether the stages are constant or variable within some taxa owing to the environmental condition under which the plants grow.

The purpose of this paper is to show the stages of embryo and endosperm development in ripe seeds or achenes in various species of the Ranunculaceae and to discuss their significance in phylogeny and their relation to the habit and habitat. The authors are deeply grateful to Mr. H. Kubota of the Nikko Botanic Garden, Tokyo University, who kindly offered us valuable materials.

Materials and Method Fresh mature seeds or achenes collected were fixed in FAA or Buin's fluid as soon as possible. In *Calathodes polycarpa* collected in Mt. Noko, and *Thalictrum rochebrunianum* and *T. aquilegifolium* collected in Sugadaira, however, the seeds or achenes preserved for 2 to 4 years were used. In *Anemone coronaria* and *Nigella damascena*, the seeds

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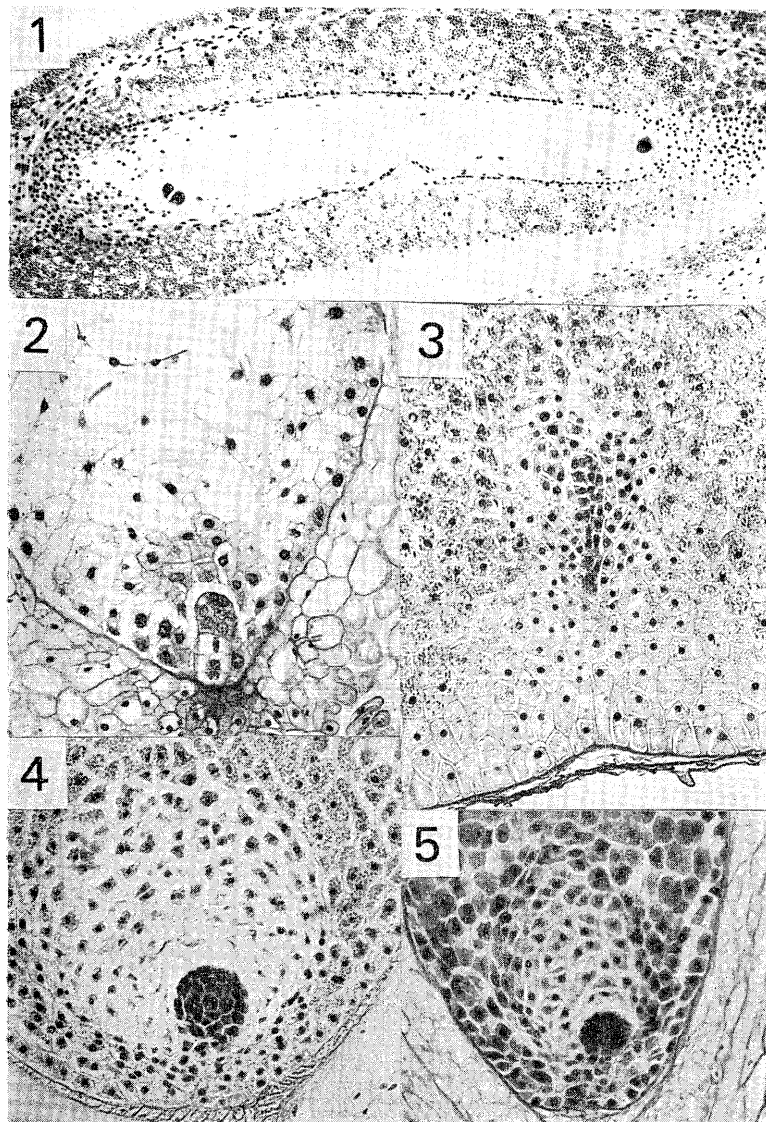
or achenes on sale were used.

Fixed materials were processed through usual alcohol-xylol series for embedding into paraplast. Serial longisections were cut at 15–20 μ and stained with Meyer's hematoxylin. Hard seed coats or pericarps were trimmed to facilitate dehydration and infiltration of fluids.

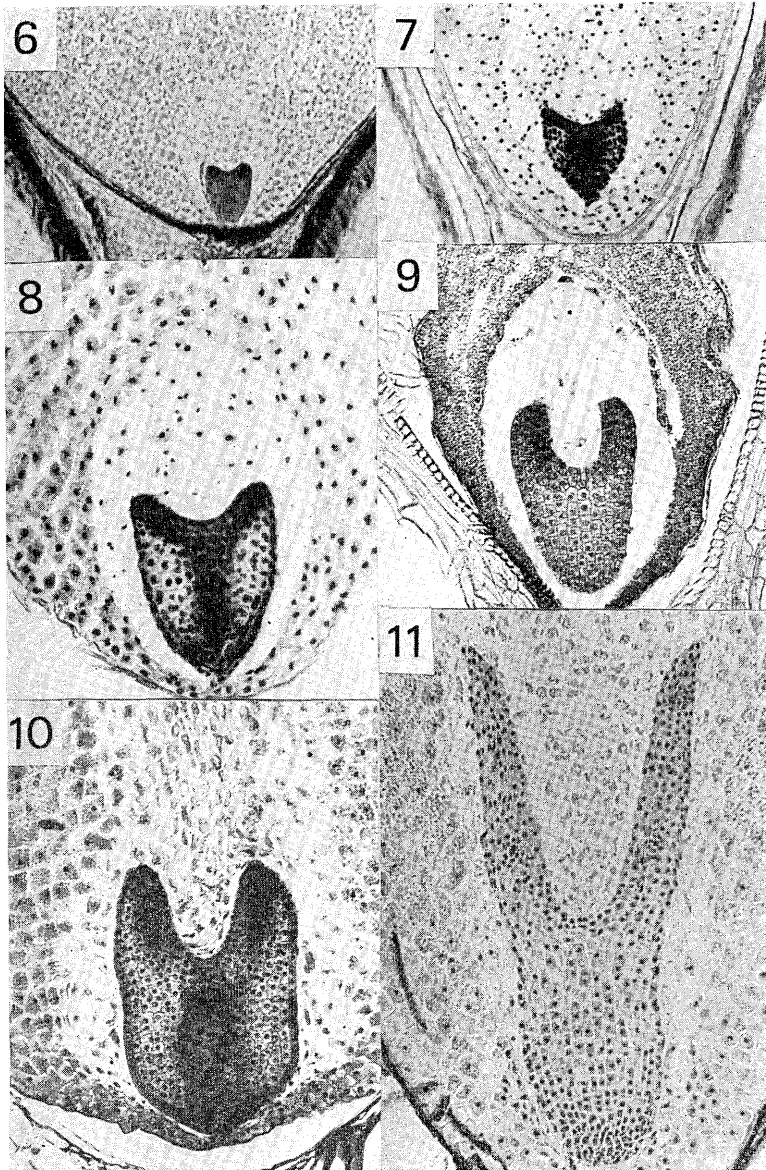
Observations The endosperm development proceeds from the periphery to the centre, and at the time of shedding of seeds or achenes, usually the endosperm finishes at least the wall formation. But in some cases the endosperm development is not completed at that time. That is: (1) The central part of embryo sac is vacuolated and dividing endosperm-nuclei are found in the peripheral cytoplasm: *Anemone flaccida*. (2) The central part of embryo sac is still occupied by a large vacuole, but the wall formation occurs in the peripheral part: *Anemone nikoensis* and *A. pseudoaltaica*. (3) The embryo sac is filled with cytoplasm including numerous nuclei and the wall formation is in process from the periphery: *Anemone stolonifera*. In all other species examined, the wall formation is finished.

At the time of shedding, the following stages in embryogenesis are observed. (1) Fertilized egg: *Anemone flaccida* (Fig. 1). (2) Club-shaped proembryo consisting of a few cells: *Anemone pseudoaltaica* (Fig. 2), *A. nikoensis*, *A. stolonifera*, *Shibateranthis pinnatifida* (Fig. 3). (3) Globular stage, i. e. embryo proper is spherical and distinctive from the suspensor: *Adonis amurensis* (Fig. 4), *Anemone debilis* (Fig. 5), *Hepatica nobilis*, *Coptis japonica*. (4) Heart stage, in which embryo is somewhat flattened and two swellings which will develop into two cotyledons become apparent: *Dichocarpum trachyspermum* (Fig. 6), *D. numajirianum*, *Anemone virginiana* (Fig. 7), *Caltha palustris* (Fig. 8), etc. (5) Turpedo stage, in which two cotyledons are elongating: *Batrachium nipponicum* (Fig. 9), *Aconitum gigas* (Fig. 10), *Halerpestes kawakamii*, *Cimicifuga simplex*, etc. (6) Mature embryo, stopping the growth and lying dormant: *Consolida ajacis* (Fig. 11), *Nigella damascena*, *Ranunculus muricatus*, *R. cantoniensis*, etc.

The stages of embryogenesis at shedding are examined in 46 species and the results are shown in the Table 1. The stages are shown by the length of embryos and of cotyledons, the ratio of embryo length to endosperm length and the ratio of cotyledon length to embryo length. The embryo length does not include the suspensor's. Embryo—endosperm ratio may in-



Figs. 1-5. Embryos in ripe seeds or achenes I. 1. *Anemone flaccida* var. *tagawae*. 2. *Anemone pseudo-altaica*. 3. *Shibateranthis pinnatifida*. 4. *Adonis amurensis*. 5. *Anemone debilis*. 1: $\times 40$, 2-5: $\times 80$.



Figs. 6-11. Embryos in ripe seeds or achenes II. 6. *Dichocarpum trachyspermum*. 7. *Anemone virginiana*. 8. *Callia palustris* var. *nipponica*. 9. *Batrachium nipponicum* var. *submersum*. 10. *Aconitum gigas* var. *hondoense*. 11. *Consolida ajacis*. 6-11: $\times 70$.

dicating the degree of embryo growth and cotyledon—embryo ratio may indicate the degree of embryo differentiation. In these columns, '0.00' indicates the value below 0.01 mm and '—' indicates that the part which should be measured does not appear yet. That is, in the column of embryo length '—' indicates a fertilized egg and '0.00' a proembryo whose length is less than 0.01 mm, while '—' in the column of cotyledon length indicates a young embryo without visible cotyledonary swellings and '0.00' a young heart embryo whose two swelling cotyledons are visible but do not reach up to 0.01 mm.

Although some species examined are annuals, biennials or scandent suffrutexes, a majority is perennial, including hydrophytes, helophytes, hemicryptophytes and geophytes. Some of the geophytes, such as *Anemone flaccida*, *A. pseudo-altaica*, *A. nikoensis*, *Shibateranthis pinnatifida* and *Adonis amurensis*, are so-called spring ephemerals which bloom in early spring at the same time as sprouting and wither in late spring or early summer when the deciduous forests or thickets become crowded with their leaves.

The embryos are various in size and that of *Dichocarpum* is remarkably small. It should be noted that in some species of *Anemone*, such as *A. flaccida*, *A. nikoensis*, *A. stolonifera* and *A. pseudo-altaica*, the delay of embryo and endosperm development, compared to achene development, is quite remarkable. Especially in *Anemone flaccida*, at the time of achene shedding the fertilized egg does not cleave yet and 3 antipodal cells are still surviving, though 2 synergids have already disappeared. The dividing endosperm nuclei are arranged in peripheral cytoplasm and the central vacuole is present in the embryo sac. In *A. stolonifera*, the antipodal cells sometimes persist at shedding, though synergids always disappear. In *Shibateranthis pinnatifida*, *Adonis amurensis*, *Anemone debilis*, *Hepatica nobilis* and *Coptis japonica*, the embryo is small and undifferentiated, but the endosperm completes its development at shedding.

Discussion Although the stages of embryo and endosperm development in shedding seeds or achenes are variable within a species, generally the extent of variation does not seem to be so wide. Accordingly the stages can be regarded to be characteristic of the species. In some genera, these characters are constant considerably, but in others, especially in *Anemone*, they

Table 1. Stages of embryo development at shedding in the Ranunculaceae

Plant's Name Locality	No. of Samples	Length of Endosperm (A) mm	Length of Embryo (B) mm	Length of Cotyledon (C) mm	B/A	C/B	Life form Florescence
<i>Caltha palustris</i> var. <i>nipponica</i> Mt. Bandai (Pref. Fukushima)	5	1.42 (1.33-1.48)	0.27 (0.19-0.32)	0.06 (0.03-0.10)	0.19 (0.13-0.24)	0.22 (0.15-0.31)	Helophyte May-Jun.
<i>Trollius japonicus</i> Sugenuma (Pref. Gunma)	5	1.37 (1.25-1.46)	0.40 (0.33-0.42)	0.20 (0.17-0.23)	0.29 (0.23-0.34)	0.51 (0.42-0.65)	Hemicryptophyte Jul.-Aug.
<i>Calathodes polycarpa</i> Mt. Noko (Taiwan)	4	1.54 (1.48-1.60)	0.25 (0.23-0.28)	0.07 (0.06-0.08)	0.16 (0.14-0.18)	0.28 (0.24-0.35)	Hemicryptophyte Jul.-Aug.
<i>Anemonopsis macrophylla</i> Mt. Mitake (Pref. Tokyo)	3	2.31 (2.17-2.42)	0.30 (0.25-0.36)	0.12 (0.11-0.14)	0.13 (0.12-0.15)	0.42 (0.39-0.44)	Geophyte Aug.-Sep.
<i>Cimicifuga simplex</i> Mt. Tsurugi (Pref. Tokushima)	3	1.84 (1.79-1.87)	0.16 (0.14-0.17)	0.04 (0.03-0.04)	0.08 (0.08-0.09)	0.23 (0.21-0.25)	Geophyte Aug.-Oct.
<i>Shibateranthis pinnatifida</i> Mt. Ibuki (Pref. Shiga)	3	2.68 (2.49-3.03)	0.11 (0.08-0.13)	—	0.04 (0.03-0.05)	—	Geophyte Mar.-Apr.
<i>Nigella damascena</i> Cult.	3	2.54 (2.49-2.62)	1.08 (1.06-1.10)	0.55 (0.53-0.56)	0.43 (0.41-0.44)	0.50 (0.48-0.52)	Annual Jun.-Jul.
<i>Aconitum gigas</i> var. <i>hondoense</i> Nikko (Pref. Tochigi)	5	2.11 (1.96-2.31)	0.39 (0.36-0.43)	0.12 (0.07-0.14)	0.18 (0.17-0.22)	0.30 (0.19-0.37)	Geophyte Jul.-Aug.
<i>A. longecassidatum</i> Mt. Palkong (Korea)	6	2.20 (2.06-2.39)	0.41 (0.29-0.51)	0.11 (0.04-0.16)	0.19 (0.13-0.25)	0.26 (0.15-0.32)	Geophyte Sep.-Oct.
<i>A. koreanum</i> Mt. Chunma (Korea)	6	2.55 (2.42-2.63)	0.49 (0.31-0.56)	0.29 (0.10-0.36)	0.19 (0.13-0.23)	0.46 (0.32-0.64)	Geophyte Sep.-Oct.

<i>Consolida ajacis</i> Cult. in Toyonaka (Pref. Osaka)	4	1.95 (1.62-2.11)	0.70 (0.53-0.83)	0.40 (0.21-0.48)	0.36 (0.33-0.39)	0.56 (0.40-0.67)	Annual Jul.-Aug.
<i>Anemone pseudo-altaica*</i> Mt. Fujiwara (Pref. Mie)	3	2.35 (2.21-2.56)	0.05 (0.02-0.06)	—	0.02 (0.01-0.03)	—	Geophyte Apr.-May
<i>A. nikoensis*</i> Mt. Ryozen (Pref. Shiga)	5	2.07 (1.94-2.26)	0.04 (0.00-0.07)	—	0.02 (0.00-0.03)	—	Geophyte Apr.-May
<i>A. stolonifera*</i> Mt. Shirane (Pref. Tochigi)	6	1.11 (0.93-1.40)	0.03 (0.00-0.06)	—	0.02 (0.00-0.06)	—	Geophyte May-Jul.
<i>A. debilis</i> Sapporo (Pref. Hokkaido)	6	1.58 (1.21-1.96)	0.07 (0.06-0.08)	—	0.04 (0.04-0.05)	—	Geophyte Jun.-Jul.
<i>A. flaccida</i> var. <i>tagawae*</i> Mt. Ryozen (Pref. Shiga)	11	1.37 (0.86-1.82)	—	—	—	—	Geophyte Apr.-May
<i>A. coronaria</i> Cult.	5	1.40 (1.32-1.46)	0.30 (0.27-0.34)	0.14 (0.11-0.16)	0.22 (0.19-0.26)	0.46 (0.41-0.50)	Geophyte Apr.
<i>A. virginiana</i> Cult. in Nikko (Pref. Tochigi)	5	1.70 (1.59-1.82)	0.16 (0.12-0.23)	0.04 (0.03-0.06)	0.09 (0.08-0.13)	0.27 (0.21-0.33)	Hemicryptophyte Jun.-Jul.
<i>A. narcissiflora</i> var. <i>nipponica</i> Mt. Akanagi (Pref. Tochigi)	5	2.94 (2.89-2.99)	0.54 (0.47-0.61)	0.23 (0.17-0.28)	0.18 (0.16-0.21)	0.42 (0.36-0.50)	Hemicryptophyte Jul.-Aug.
" Mt. Kitadake (Pref. Yamanashi)	5	2.90 (2.63-3.13)	0.23 (0.19-0.29)	0.05 (0.01-0.10)	0.07 (0.07-0.09)	0.22 (0.08-0.35)	"
<i>Hepatica nobilis</i> var. <i>nipponica</i> Mt. Fujiwara (Pref. Mie)	5	2.43 (2.26-2.60)	0.06 (0.04-0.08)	—	0.03 (0.02-0.03)	—	Geophyte Mar.-Apr.
<i>Pulsatilla cernua</i> Cult. in Toyonaka (Pref. Osaka)	6	1.89 (1.79-1.99)	0.31 (0.27-0.39)	0.15 (0.11-0.20)	0.16 (0.14-0.20)	0.49 (0.41-0.63)	Hemicryptophyte Apr.-may
<i>Clematis lasiandra</i> Mt. Koya (Pref. Wakayama)	4	1.64 (1.51-1.72)	0.13 (0.11-0.16)	0.02 (0.01-0.03)	0.08 (0.07-0.11)	0.15 (0.09-0.20)	Suffrutex Aug.-Oct.

<i>C. apiifolia</i> Hitoyoshi (Pref. Kumamoto)	7	2.76 (1.89-3.06)	0.56 (0.39-0.68)	0.25 (0.18-0.32)	0.20 (0.18-0.24)	0.45 (0.37-0.50)	Suffrutex Aug.-Sep.
" Mt. Dukyu (Korea)	4	2.25 (2.10-2.49)	0.47 (0.37-0.73)	0.21 (0.17-0.33)	0.21 (0.17-0.29)	0.45 (0.43-0.49)	"
<i>C. brachyura</i> Mt. Chunma (Korea)	3	4.16 (3.74-4.45)	0.73 (0.67-0.77)	0.56 (0.51-0.60)	0.18 (0.17-0.18)	0.76 (0.75-0.78)	"
<i>Callianthemum hondoense</i> Mt. Kitadake (Pref. Yamanashi)	5	1.89 (1.78-2.21)	0.22 (0.14-0.29)	0.03 (-0.09)	0.11 (0.08-0.13)	0.12 (-0.30)	Hemicryptophyte Jul.
<i>Adonis amurensis</i> Mt. Fujiwara (Pref. Mie)	5	2.44 (2.17-2.70)	0.13 (0.11-0.14)	—	0.05 (0.05-0.06)	—	Geophyte Mar.-May
<i>Halerpestes kawakamii</i> Ichinomiya (Pref. Chiba)	8	0.78 (0.70-0.85)	0.29 (0.14-0.34)	0.11 (0.04-0.12)	0.38 (0.20-0.45)	0.36 (0.29-0.39)	Helophyte Jul.-Aug.
<i>Ranunculus scerelatus</i> Mozu (Pref. Osaka)	5	0.65 (0.50-0.72)	0.16 (0.14-0.18)	0.05 (0.04-0.06)	0.25 (0.21-0.32)	0.31 (0.28-0.38)	Biennial Apr.-Jun.
<i>R. reptans</i> var. <i>flagellifolius</i> Nikko (Pref. Tochigi)	7	0.83 (0.75-0.91)	0.17 (0.11-0.26)	0.05 (0.01-0.10)	0.18 (0.14-0.35)	0.21 (0.13-0.39)	Helophyte Jul.-Sep.
<i>R. acer</i> var. <i>nipponicus</i> Sugenuma (Pref. Gunma)	4	1.93 (1.71-2.10)	0.17 (0.14-0.23)	0.03 (0.01-0.07)	0.10 (0.07-0.13)	0.16 (0.10-0.31)	Hemicryptophyte Jul.-Aug.
<i>R. cantoniensis</i> Mozu (Pref. Osaka)	8	2.05 (1.65-2.50)	0.39 (0.28-0.46)	0.16 (0.14-0.18)	0.19 (0.15-0.25)	0.41 (0.37-0.54)	Biennial May-Jun.
<i>R. tachiroei</i> Kwangnung (Korea)	6	1.75 (1.64-1.89)	0.32 (0.29-0.34)	0.15 (0.11-0.21)	0.19 (0.17-0.22)	0.47 (0.33-0.65)	Annual Aug.-Sep.
<i>R. muricatus</i> Kitashirakawa (Pref. Kyoto)	8	3.00 (2.89-3.13)	0.48 (0.41-0.58)	0.24 (0.21-0.30)	0.16 (0.14-0.20)	0.51 (0.46-0.58)	Biennial Apr.-May
<i>Batrachium nipponicum</i> var. <i>submersum</i> Nikko (Pref. Tochigi)	5	1.24 (1.20-1.28)	0.29 (0.27-0.31)	0.10 (0.09-0.11)	0.23 (0.21-0.25)	0.35 (0.29-0.39)	Hydrophyte Jul.-Aug.

<i>Trautvetteria japonica</i> Mt. Shirane (Pref. Tochigi)	4	2.08 (2.03-2.11)	0.84 (0.81-0.89)	0.36 (0.32-0.39)	0.40 (0.38-0.43)	0.42 (0.39-0.44)	Geophyte Jul.-Aug.
<i>Dichocarpum numajirianum</i> Mt. Otaki (Pref. Kagawa)	3	1.05 (1.00-1.09)	0.07 (0.06-0.08)	—	0.06 (0.06-0.08)	—	Geophyte Apr.-Jun.
<i>D. trachyspermum</i> Kibune (Pref. Kyoto)	21	0.95 (0.78-1.03)	0.08 (0.06-0.09)	0.01 (0.00-0.02)	0.08 (0.06-0.11)	0.07 (0.00-0.20)	Geophyte Mar.-May
<i>Aquilegia flabellata</i> var. <i>pumila</i> Mt. Hakkoda (Pref. Aomori)	3	1.52 (1.50-1.56)	0.31 (0.30-0.32)	0.11 (0.09-0.14)	0.20 (0.20-0.21)	0.37 (0.30-0.44)	Hemicyptophyte Jul.-Aug.
<i>A. buergeriana</i> Sugenuma (Pref. Gunma)	6	1.51 (1.42-1.60)	0.23 (0.20-0.26)	0.05 (0.04-0.06)	0.15 (0.13-0.16)	0.22 (0.19-0.27)	Hemicyptophyte Jun.-Aug.
<i>Thalictrum rochebrunianum</i> Sugadaira (Pref. Nagano)	5	2.06 (1.53-2.31)	0.35 (0.31-0.38)	0.14 (0.13-0.16)	0.18 (0.15-0.24)	0.40 (0.36-0.45)	Hemicyptophyte Aug.
<i>T. grandisepalum</i> Cult. in Kwangnung (Korea)	8	1.93 (1.78-2.14)	0.14 (0.09-0.26)	0.04 (0.00-0.10)	0.07 (0.04-0.14)	0.18 (0.00-0.39)	Hemicyptophyte Aug.-Sep.
<i>T. baicalense</i> Nikko (Pref. Tochigi)	4	1.89 (1.70-2.14)	0.22 (0.21-0.24)	0.06 (0.06-0.07)	0.12 (0.10-0.13)	0.28 (0.26-0.29)	Hemicyptophyte Jun.-Jul.
<i>T. filamentosum</i> var. <i>glabrescens</i> Nikko (Pref. Tochigi)	3	1.93 (1.85-1.99)	0.12 (0.07-0.20)	0.01 (- -0.04)	0.06 (0.04-0.10)	0.07 (- -0.21)	Geophyte Jun.-Aug.
<i>T. uchiyamae</i> Cult. in Seoul (Korea)	5	2.63 (2.31-2.92)	0.45 (0.41-0.53)	0.18 (0.16-0.20)	0.17 (0.10-0.20)	0.39 (0.38-0.40)	Geophyte Aug.
<i>T. aquilegifolium</i> var. <i>sibiricum</i> Sugadaira (Pref. Nagano)	10	3.49 (3.10-3.77)	0.36 (0.32-0.39)	0.16 (0.14-0.18)	0.10 (0.09-0.12)	0.46 (0.41-0.50)	Hemicyptophyte Jul.-Sep.
<i>Coptis japonica</i> var. <i>dissecta</i> Yatate (Pref. Wakayama)	4	2.19 (2.14-2.24)	0.10 (0.07-0.14)	0.01 (0.01-0.02)	0.05 (0.03-0.07)	0.12 (0.07-0.20)	Hemicyptophyte Mar.-Apr.

* Wall formation of the endosperm not completed. () Range of values.

are quite variable. In *Anemone*, they seem to be fairly constant within subgenera. That is, the species belonging to subgen. *Anemone* have extremely immature embryos before heart stage in shedding achenes as far as examined and often immature endosperms before or under wall formation. A majority of the species whose seeds contain immature embryos is geophytic with well developing rhizomes. Especially in spring ephemerals, the seeds or achenes have extremely immature embryos. In these plants, the embryos may continue to grow after shedding under the protection from strong sunlight, heat and drying of summer by crowded leaves and humus rich soil in the deciduous forests or thickets. On the contrary, annuals or biennials, as *Nigella damascena*, *Consolida ajacis*, *Ranunculus muricatus*, *R. cantoniensis*, etc. produce the seeds containing well developed embryos. The hemicryptophytes with well developing rosette leaves such as species of *Aquilegia*, *Pulsatilla*, etc. have also generally well developed embryos in shedding seeds or achenes. In *Anemone*, *A. narcissiflora* belonging to subgen. *Homalocarpa*, *A. virginiana* belonging to subgen. *Eriocephalus*, etc. which grow in open grassland and produce well developing radical leaves have embryos later than heart stage in ripe achenes. The species of *Coptis* are hemicryptophytes, but they are adapted to the mossy ground under needle forests and produce the seeds containing immature embryos. The condition of immature embryo in ripe seed or achene may be related rather to the life form of the plant or environmental conditions of its habitat than to taxa. The coincidence of this character with taxa, as in the case of *Anemone* subgen. *Anemone*, may be due to the fact that the species of the taxa have the similar life form, habit and habitat.

It should be noted that the immature embryo in the shedding seed or achene is correlated to the slow growth of the plant. That is, the plant whose embryo grows slowly also grows slowly after germination. In *Anemone flaccida*, *Adonis amurensis* and *Shibateranthis pinnatifida*, the organ produced in the year of germination is only the cotyledon, and in *Anemone pseudoaltaica* in which the cotyledons remain in the achene under the ground, it is only the first leaf. In spring ephemerals in which achenes contain extremely immature embryos, in spite of the slow growth of rhizome, the aerial shoot expands rapidly as soon as snow melts and soon withers leaving the achenes or seeds. The duration from sprouting to withering may

be too short for them to complete the embryogenesis.

Rao (1938) cited examples in which the ripe seed contains only an undifferentiated embryo, taken from previously published papers, as follows: *Peperomia pellucida*, *Diospyros virginiana*, *Magnolia*, *Thismia americana*, *Hedyosmum nutans*, *Linaria vulgaris*, *Christisonia*, *Sarcodes sanguinea*, *Striga lutea* and *Eriocaulon septangulare*, and stated that in those plants in which the embryo grows rapidly and is differentiated early, the endosperm is almost always non-cellular, while if the growth of the embryo is very slow or if the ripe seed contains only an undifferentiated embryo, then the endosperm is cellular. Maheshwari (1950) countered the suggestion by stating that numerous examples can be cited in which there is no such correlation. In the Ranunculaceae, though the endosperm is non-cellular, there are many species in which the embryo is undifferentiated at shedding, and such correlation is not shown.

The immature embryos at shedding are also reported in *Degeneria vitiensis* (Swamy 1949, Wardraw 1955), *Chloranthus japonicus* (Yoshida 1957), *C. serratus* (Yoshida 1959), *Sarcandra glabra* (Yoshida 1960a), *Piper futo-kazura* (Yoshida 1960b), *Saururus loureiri* (Yoshida 1961), *Schisandra chinensis* (Yoshida 1962), *S. repanda* (Hayashi 1963b), *Illicium anisatum* (Hayashi 1963a), *Kadsura japonica* (Hayashi 1963b), etc. Eames (1961) enumerated the plants whose seeds contain undifferentiated embryos as in the following: *Cocos nucifera*, *Crocus*, several genera of the Fumariaceae, Papaveraceae, Umbelliferae, *Fraxinus*, etc., and suggested that the intraseminal growth seems to be restricted largely to the more primitive taxa and to herbaceous, geophilous genera. Further he (1955) considered that *Ginkgo* shows an important step of the transfer of fertilization from the ground, as presumed in Pteridospermae, to the mother sporophyte, and as well as the cycads, it shows a step in the establishment of dormancy of the embryo in the seed. It seems to be generally accepted that the immature embryo in the ripe seed and the continuous intraseminal growth without dormancy may represent a primitive condition. But in the cases as in many species of the Ranunculaceae, it should not be overlooked that these characters are closely related to the ecological conditions.

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キンボウゲ科の種子または閉果には、胚が未分化のまま脱落するものがあることが知られているが、落下時における種子または閉果中の胚の発育程度は属や種などの分類群で一定し、これらの分類群の一つの特徴となる性質であるのか、あるいは生育している環境条件によって生じた性質であるのかなどを検討するために、46種のキンボウゲ科の種子または閉果を脱落時に採集して胚と胚乳の分化の程度をしらべ、各植物の性状や生活型との関連について考察してみた。

1. これらの種子や閉果には胚が (1) 受精卵のままのもの (ニリンソウ) (2) 数回

の分裂により棍棒状になったもの(キクザキイチゲ, セツブンソウ, サンリンソウ, イチリンソウ) (3) さらに分裂して球状を呈するもの(フクジュソウ, ヒメイチゲ, スハマソウ) (4) 子葉の原基が分化しハート型になったもの(トウゴクサバノオ, コウヤシロカネソウ, リュウキンカ, *Anemone virginiana* など) (5) 子葉が伸長してターピド型になったもの(バイカモ, オオレイジンソウ, ツルヒキノカサなど) (6) 完熟胚を有するもの(トゲミクツネノボタン, ケミクツネノボタン, ヒエンソウ, クロタネソウなど) など, 種々の段階のものがみられた。

2. 胚乳形成に関しては, (1) 胚嚢の中央に大きな液胞があり周辺部で胚乳の遊離核分裂が進行しているもの(ニリンソウ) (2) 胚嚢の周辺部では胚乳細胞の膜形成がはじまっているが中央部では未だ液胞が残っているもの(イチリンソウ, キクザキイチゲ) (3) 液胞は消失し, 周辺部では膜形成が進んでいるが中央部ではまだ遊離核が残っているもの(サンリンソウ) などがあり, (4) その他のものは少くとも胚乳細胞の膜形成は終了していた。

3. 上記のような成熟種子や閉果中の胚や, 胚乳の発育程度は, 多少の変異はあるが, 大体, 種のレベルでは安定しているようである。属のレベルではいろいろの場合があるが, イチリンソウ属では特に著しい多様性がみられた。

4. 球状胚以前の未分化胚を有するものには, 落葉樹林の下草でよく発達した地下茎をもつ地中植物, 特に夏期には地上部が枯れてしまう早春開花性の植物が多い。それに対して, 1年性, 2年性植物では親の植物体から離れるとき胚はすでに充分分化しているものが多い。またオキナグサのような草原に生えるものは比較的よく発育した胚をもっていることが多い。

裸子植物との比較より, 未分化胚のまま脱落し地中で種子内生長をする植物は原始的な特徴を残していると一般に考えられているが, キンボウゲ科の場合, この特徴は分類群との関係よりもむしろその植物の生活型や生活環境に密接な連りがあるように思われる。

□金平亮三: 南洋群島植物誌, *Flora Micronesia*. 19×26.5 cm, 索引共 505 頁, 図版 211, プレート 21, 1972 年 5 月 20 日, 井上書店発行, 11,000 円, 200 部限定。1933 年 6 月に発行されたものの再版である。ミクロネシアの大部分の樹木が詳細な図で示されている, 金平氏の不朽の名著である。ミクロネシアの樹木図鑑は他に類書がなく, 最近南方の植物に関心が高まりつつある時であるが, 入手困難な本であった。原書にくらべるとプレート写真がおとるのは製版上やむをえないことである。巻末にミクロネシアの全植物のリストがある。40 年も前の出版なので, その後の研究により訂正すべき学名がかなりあるが, 古典としての本書の貴重な価値には変りない。

(山崎 敬)