

SEEDLING MORPHOLOGY IN SOME THAI *IMPATIENS* AND ITS TAXONOMIC SIGNIFICANCE

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The seedlings of the genus *Impatiens* (Balsaminaceae) have been virtually neglected from the viewpoint of taxonomy. The seedling morphology of only a few species among the several hundred of the genus has been studied, invariably showing two epigeal cotyledons and an elongated epicotyl¹⁾ (Fig. 1, cf. Csapody 1968). However, I have found that the seedlings of *Impatiens* are much diversified in morphology, and have come to realize the importance of seedling morphology for classification.

The present paper aims to illustrate the morphological diversity of the *Impatiens* seedlings and to discuss its taxonomic significance, mainly based upon the materials raised from the seeds obtained through the 1979 Botanical Expedition to Thailand.

Materials and Methods

In this paper, seedling morphology is reported in regard to 20 species of the Thai *Impatiens*. The seeds of these species were collected in Thailand through the Shinshu University Botanical Expedition from October to December in 1979, except those of *I. phuluangensis* which were obtained in January 1981 and immediately sent to me.

All the seeds had been kept in an ice box at about 2°C in Matsumoto until sown in pots at the middle of May 1981. The seedlings were observed between late July and early September, according to the species and the degree of development.

The species and the sources of seeds are alphabetically shown as follows. The voucher specimens of seedlings are all preserved in the herbarium of Shinshu University (SHIN).

Impatiens calcicola CRAIB Saraburi : Tham Pra Photisat, Kaeng Khoi Distr. , T.

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1) In this text, the term is used for the first internode of the stem above the hypocotyl.

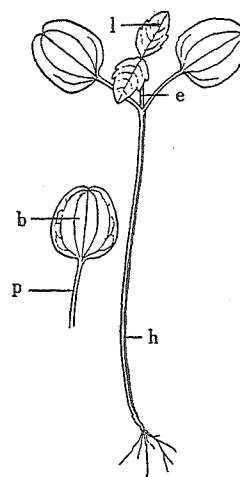


Fig.1 Seedling of *Impatiens nolitangere* (Csapody 1968)
b: cotyledonary blade,
e: epicotyl, h: hypocotyl,
l: leaf, p: cotyledonary petiole

- Shimizu 29503.
- I. charanii* T. SHIMIZU Saraburi : Khao Talu, Na Pra Larn Distr. , T. Shimizu 29504.
- I. Chiangdaoensis* T. SHIMIZU Chiang Mai : Doi Chiang Dao, Chiang Dao Distr. , T. Shimizu 29505.
- I. chinensis* L. Loei : Phu Kradung, Phu Kradung Distr. , T. Shimizu 29506.
- I. griffithii* HOOK. f. et THOMS. var. *sarcantha* (HOOK. f.) T. SHIMIZU Songkhla : Ton Nga Chang Waterfall, Hat Yai Distr. , T. Shimizu 29518.
- I. hongsonensis* T. SHIMIZU Mae Hongson : Doi Padeng, Pai Distr. , T. Shimizu 29507.
- I. kerriae* CRAIB Chiang Mai : Doi Chiang Dao, Chiang Dao Distr. , T. Shimizu 29508.
- I. larsenii* T. SHIMIZU Surat Thani : Khao Sok, Khao Sok National Park, Pa Nom Distr. , T. Shimizu 29509.
- I. longiloba* CRAIB Chiang Mai : Doi Inthanon, Chom Thong Distr. , T. Shimizu 29520.
- I. macrosepala* HOOK. f. Satun : Kuam Sato, Satun Distr. , T. Shimizu 29510.
- I. masoni* HOOK. f. Khon Kaen : Nam Nao National Park, Chum Phae Distr. , T. Shimizu 29521.
- I. muscicola* CRAIB Chiang Mai : Doi Chiang Dao, Chiang Dao Distr. , T. Shimizu 29511.
- I. patula* CRAIB Tak : Khao Phra War, Mae Sot Distr. , T. Shimizu 29512.
- I. phuluangensis* T. SHIMIZU Loei : Phu Luang, T. Shimizu 29513.
- I. pseudochinensis* T. SHIMIZU Loei : Phu Kradung National Park, Phu Kradung Distr. , T. Shimizu 29514.
- I. psittacina* HOOK. f. Chiang Mai : Doi Chiang Dao, Chiang Dao Distr. , T. Shimizu 29515.
- I. racemosa* HOOK. f. Chiang Mai : Doi Inthanon, Chom Thong Distr. T. Shimizu 29522.
- I. salaengensis* T. SHIMIZU Phitsanulok : Kang So Pa Waterfall, Tung Salaeng Luang National Park, T. Shimizu 29516.
- I. santisukii* T. SHIMIZU Chiang Mai : Doi Chang, Mae Taeng Distr. , T. Shimizu 29517.
- I. violae flora* HOOK. f. Chiang Mai : Doi Sutep, Chiang Mai Distr. , T. Shimizu 29519.

Three of these species, *I. charanii*, *I. salaengensis*, and *I. santisukii* are as yet taxonomically undescribed. They will be published in an other journal in the very near future,

Description

The seedlings of the Dicotyledons are generally classified into two groups, viz. those with epigeal germination and those with hypogeal germination (cf. Leonard 1957).

Both the groups are recognized also in the Thai *Impatiens* studied. Most of them, 17 species, belong to the first group, while the rest, *I. longiloba*, *I. masoni* and *I. pseudochinensis*, are members of the latter. Here the morphological description of seedlings is given in each major group. Within each group, the species with similar seedlings are put side by side to form the subgroups (A-H).

Group with epigeal germination (Group I) The cotyledons are opposite, foliaceous, petiolate, above the soil surface and mostly borne on a long hypocotyl and become exposed to light.

A-1. *I. calcicola* (Figs. 2 & 3) Hypocotyl indefinitely elongating, reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage; petiole up to 20mm long, with dense minute hairs on the adaxial side; blade thick, nearly orbicular, up to 22 mm by 22mm, bilobed at apex, obscurely trinerved near the base, cornute below to hold the testa. Internodes never elongating. Leaves congested on top of the hypocotyl, minutely pubescent on both sides. First and second leaf with petiole 15-25mm long; blade 2.5-3cm long. The upper leaves bearing shorter petioles, longer blades and more obvious serration.

A-2. *I. charanii* (Figs. 4 & 5) Hypocotyl indefinitely elongating, reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage; petiole up to 17mm long, with dense minute hairs on the adaxial side; blade thick, nearly orbicular, up to 17mm by 17mm, bilobed at apex, minutely pubescent above near the base, cornute below to hold the testa. Internodes never elongating. Leaves congested on top of the hypocotyl, minutely pubescent on both sides, usually whitened along the midrib above. First and second leaf with petioles 0.7-2.2cm; blade 3.5-4cm long. The upper leaves bearing shorter petioles, longer blades and more serrated.

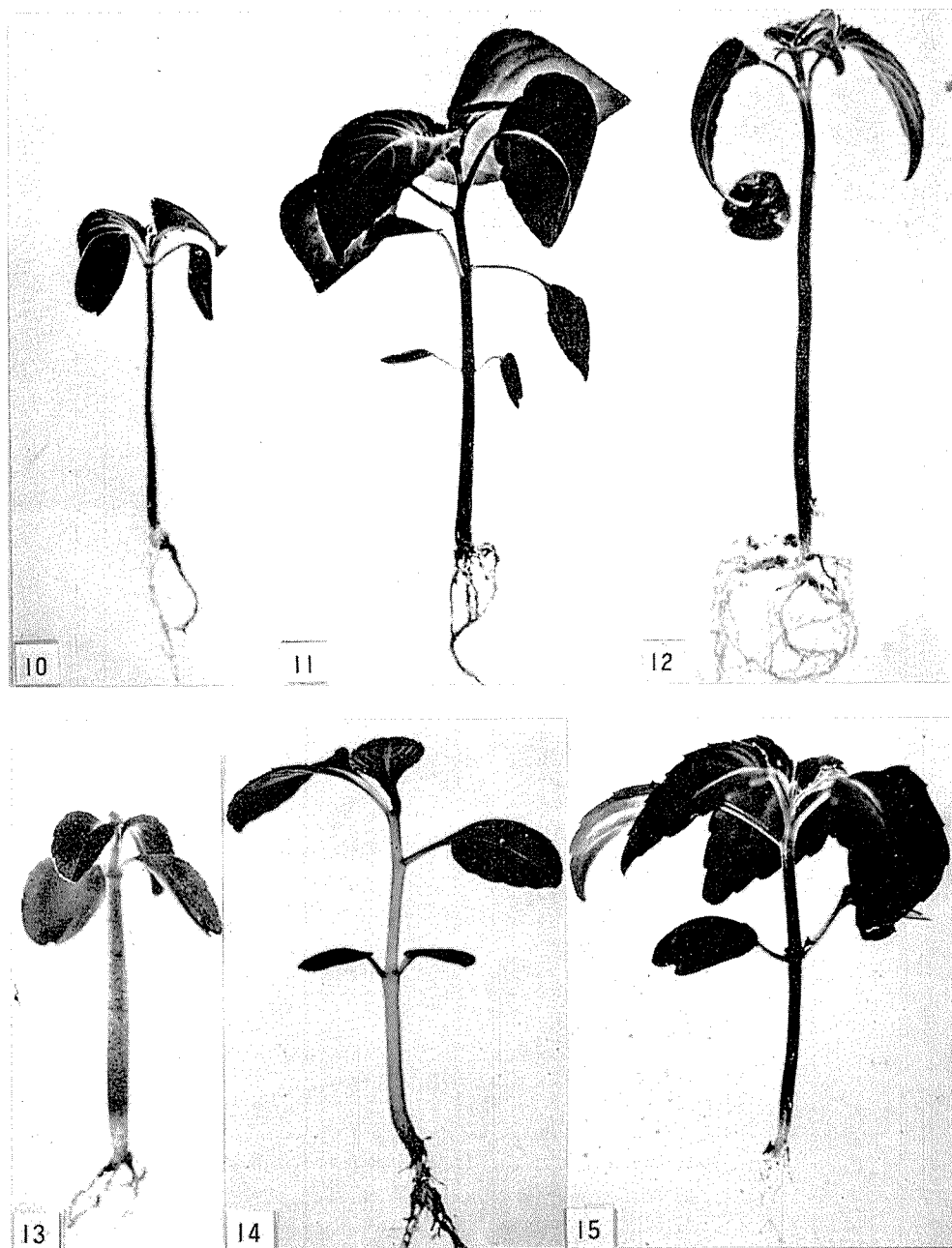
A-3. *I. salaengensis* (Figs. 6 & 7) Hypocotyl indefinitely elongating, reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage; petiole 10-20mm long, with dense minute hairs on the adaxial side; blade thick, nearly orbicular up to 20mm by 20mm, bilobed at apex, cornute below to hold the testa. Internodes never elongating. Leaves congested on top of the hypocotyl, minutely pubescent above, glabrous beneath; midrib yellowish above. First and second leaf with petiole 13-15mm long; blade 3-3.5cm long. The upper leaves bearing shorter petioles, longer blades and more obvious serration.

A-4. *I. macrosepala* (Figs. 8 & 9) Hypocotyl indefinitely elongating, reddish. Co-

tyledons grown and dropped in the 7th to 8th leaf stage; petiole up to 17mm long, twith dense minute hairs on the adaxial side; blade thick, nearly orbicular, cuneate toward base, often distorted and irregularly incised, up to 15mm by 15mm, bilobed at apex, minutely pubescent above near the base, cornute below to hold the testa. Epicotyl hardly elongating, but the upper internode the longer, up to 3mm long in the 7th internode. Leaves almost congested on top of the hypocotyl, minutely pubescent above, glabrous beneath. First and second leaf opposite, with petioles about 25mm long; blades 25–30mm long, thicker than the upper ones. Upper leaves bearing shorter petioles, longer blades and more obvious serration, apparently alternate.

- B-1. *I. hongsonensis* (Figs. 10 & 11) Hypocotyl 3–3.5cm long, reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage, entirely glabrous; petiole up to 6mm long, patent; blade chartaceous, nearly orbicular, up to 10mm by 10mm, shallowly bilobed at apex. Epicotyl hardly elongating in the 2nd or 3rd leaf stage, then elongated up to 15mm or so long, glabrous; upper internodes shorter than the epicotyl. Leaves glabrous; first and second leaf nearly but not strictly opposite, the others apparently alternate.
- B-2. *I. psittacina* (Fig. 12) Hypocotyl 3–3.5cm long, reddish. Cotyledons grown and dropped in the 3rd to 4th leaf stage, entirely glabrous; petiole about 3.5mm long, patent; blade chartaceous, nearly orbicular, up to 8.5mm by 8.5mm, shallowly bilobed at apex. Epicotyl elongating up to 10mm long, glabrous; upper internodes shorter than the epicotyl. Leaves glabrous; first and second leaf opposite, the others alternate.
- B-3. *I. kerriae* (Figs. 13 & 14) Hypocotyl 2.5cm or so long, reddish in the 2nd to 3rd leaf stage, faded later. Cotyledons grown and dropped in the 3rd leaf stage, entirely glabrous; peotile about 3mm long, patent; blade chartaceous, nearly orbicular, up to 12mm by 12mm, shallowly bilobed at apex, scabrous on the margin. Epicotyl elongating up to 20mm, glabrous; upper internodes shorter than the epicotyl. Leaves all alternate, glabrous.
- B-4. *I. larsenii* (Fig. 15) Hypocotyl about 1.5cm long, dark purple. Cotyledons grown and dropped in the 5th to 6th leaf stage, entirely glabrous; petiole about 1cm long, patent; blade chartaceous, nearly orbicular, up to 10mm by 10mm, shallowly bilobed at apex. Epicotyl hardly elongating in the 2nd leaf stage, then elongated up to 15mm long, glabrous; upper internodes shorter than the epicotyl. Leaves all alternate, dark purplish, glabrous.
- C-1. *I. chiangdaoensis* (Fig. 16) Hypocotyl 5cm or so long, reddish. Cotyledons grown and dropped in the 5th to 6th leaf stage; entirely glabrous, petiole 5–6mm long, patent; blade chartaceous, nearly orbicular, up to 11mm by 11mm, shallowly bilobed at apex. Epicotyl elongating up to 4cm, glabrous; upper internodes

Figs. 2~9 Seedlings of the Thai *Impatiens*-Subgroup A2, 3: *I. calcicola* (2: $\times 0.6$, 3: $\times 0.3$)4, 5: *I. charanii* (4: $\times 0.9$, 5: $\times 0.3$)6, 7: *I. salaengensis* (6: $\times 1.2$, 7: $\times 0.4$)8, 9: *I. macrosepala* (8: $\times 0.9$, 9: $\times 0.6$)



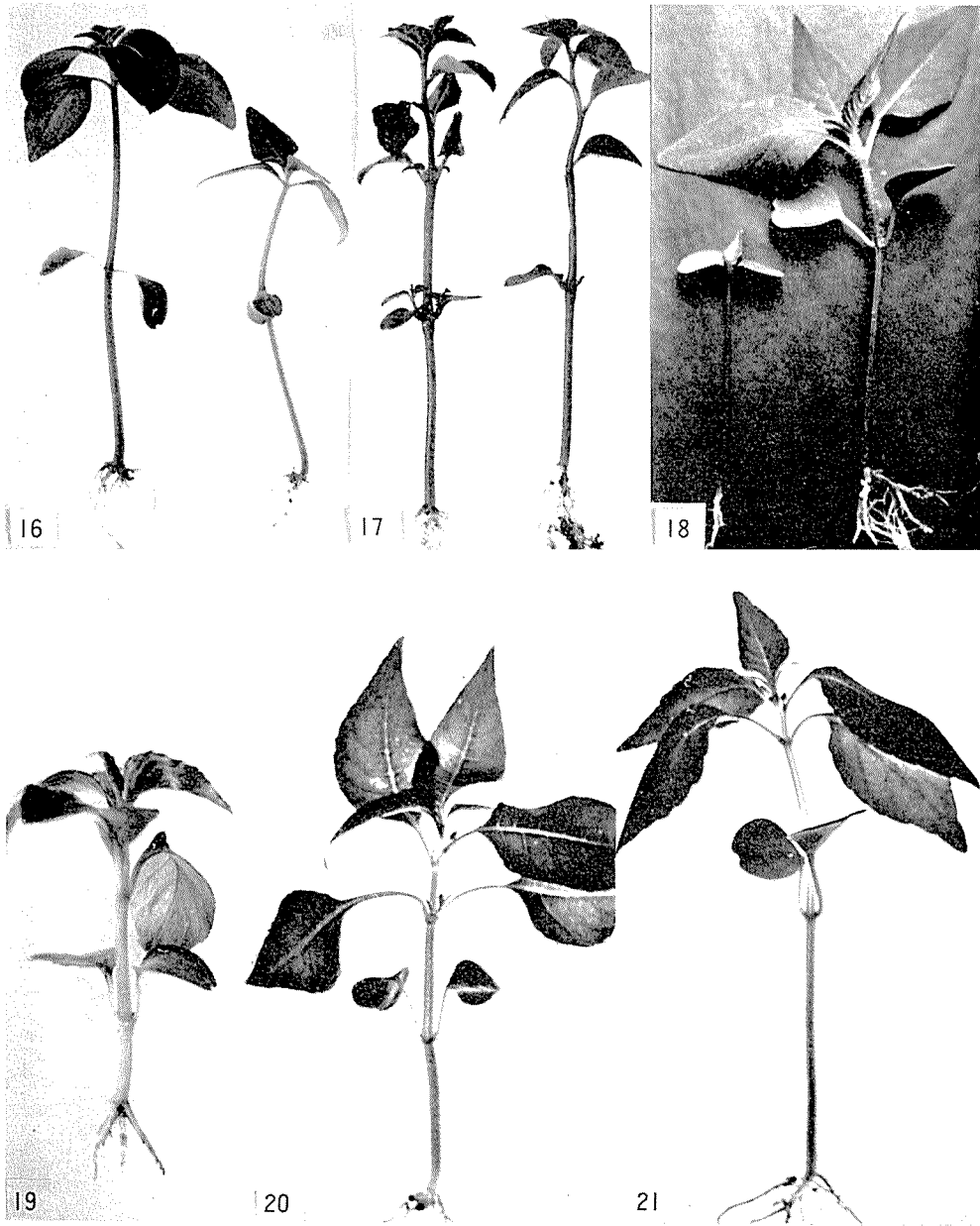
Figs. 10~15 Seedlings of the Thai *Impatiens*-Subgroup B

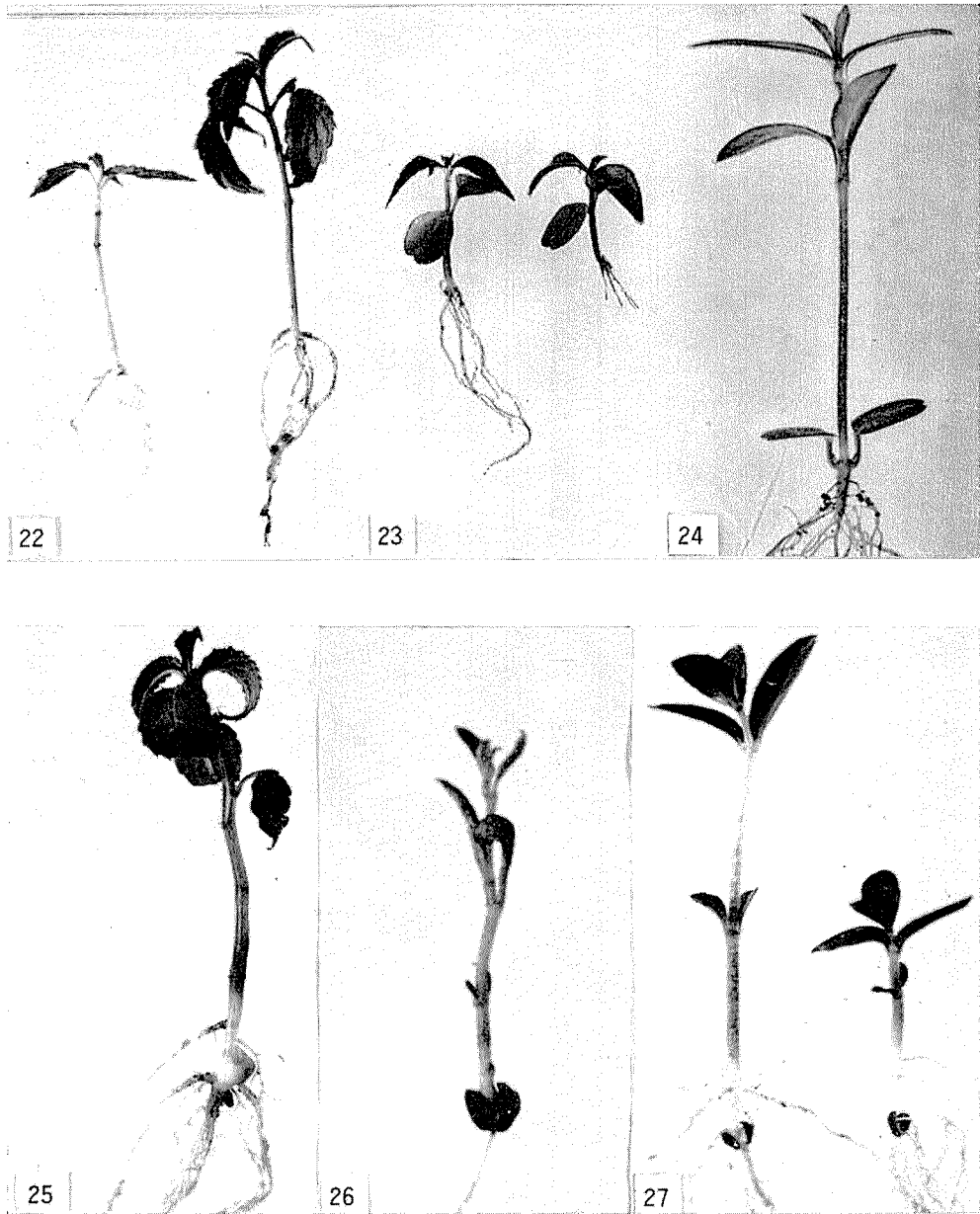
10, 11: *I. hongsonensis* (10: $\times 1.3$, 11: $\times 0.7$)

12: *I. psittacina* $\times 1.3$

13, 14: *I. kerriae* (13: $\times 1.3$, 14: $\times 0.9$)

15: *I. larsenii* $\times 1.3$

Figs. 16~21 Seedlings of the Thai *Impatiens*-Subgroup C16: *I. chiangdaoensis* $\times 0.6$ 17: *I. muscicola* $\times 0.6$ 18: *I. patula* $\times 0.7$ 19: *I. phuluangensis* $\times 0.8$ 20: *I. santisukii* $\times 0.7$ 21: *I. violaeiflora* $\times 0.8$



Figs. 22~27 Seedlings of the Thai *Impatiens*-Subgroup D (22),
E (23), F (24), G (25) and H (26, 27)

22: *I. racemosa* $\times 1.1$

23: *I. griffithii* var. *sarcantha* $\times 0.6$

24: *I. chinensis* $\times 0.9$

25: *I. longiloba* $\times 0.8$

26: *I. masoni* $\times 1.5$

27: *I. pseudochinensis* $\times 0.8$

- shorter than epicotyl. Leaves pubescent above as well as on leaf margin and on adaxial side of the petioles; first and second leaf opposite, the others alternate.
- C-2. *I. muscicola* (Fig. 17) Hypocotyl 3-3.5cm long, reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage; petiole 3-5mm long, patent; blade chartaceous, nearly orbicular, up to 10mm by 8mm, shallowly bilobed at apex, minutely pubescent beneath. Epicotyl elongating up to 3.5cm, glabrous, reddish; upper internodes shorter than epicotyl. Leaves pubescent above as well as on leaf margin and on midrib beneath; first and second leaf opposite, the others alternate.
- C-3. *I. patula* (Fig. 18) Hypocotyl 4.5-6.5cm long reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage, entirely glabrous; petiole about 10mm long, patent; blade chartaceous, nearly orbicular, up to 15mm by 15mm, shallowly bilobed at apex. Epicotyl elongating up to 2.5cm long, apparently pubescent with patent hairs; upper internodes also pubescent, shorter than epicotyl. Leaves pubescent above as well as on leaf margin and on midrib beneath; first and second leaf opposite, the others alternate.
- C-4. *I. phuluangensis* (Fig. 19) Hypocotyl 1.5-3cm long, pale green. Cotyledons grown and dropped in the 7th to 8th leaf stage, entirely glabrous; petiole about 10mm long, erect; blade chartaceous, nearly orbicular, up to 20mm by 20mm, shallowly bilobed at apex. Epicotyl elongating up to 2.5-3.5cm; upper internodes shorter than epicotyl. Leaves pubescent above as well as on leaf margin; first and second leaf opposite, the others alternate.
- C-5. *I. santisukii* (Fig. 20) Hypocotyl 2-3.5cm long, reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage, entirely glabrous; petiole 8-12mm long, patent; blade chartaceous, nearly orbicular, up to 12mm by 12mm, shallowly bilobed at apex. Epicotyl elongating, 2.5cm or so long, glabrous; upper internodes shorter than epicotyl, often unilaterally pubescent. Leaves pubescent above, sparsely pubescent on nerves beneath; first and second leaf opposite, the others alternate.
- C-6. *I. violaeiflora* (Fig. 21) Hypocotyl up to 5cm long, reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage, entirely glabrous; petiole 7-12mm long, patent; blade chartaceous, nearly orbicular, up to 15mm by 15mm, shallowly bilobed at apex. Epicotyl elongating, about 3.5cm long, unilaterally pubescent with minute curved hairs; upper internodes shorter than epicotyl, densely pubescent as well. Leaves pubescent above as well as on adaxial side of the petioles, pubescent on nerves beneath; first and second leaf opposite, the others alternate.
- D-1. *I. racemosa* (Fig. 22) Hypocotyl 2-2.5cm long, reddish. Cotyledons grown and dropped in the 2nd leaf stage, entirely glabrous. Epicotyl elongating up to 11mm long, glabrous; upper internodes shorter than the epicotyl. Leaves glabrous; first and second leaf opposite, caducous; second and third leaf nearly opposite, the

others alternate.

E-1. *I. griffithii* var. *sarcantha* (Fig. 23) Hypocotyl 1-1.5cm long, reddish. Cotyledons grown and dropped in the 7th to 8th leaf stage; petiole 3-5mm long, patent, sparsely pubescent on adaxial side; blade chartaceous, nearly orbicular, up to 12mm by 10mm, shallowly bilobed at apex. Epicotyl elongating, about 10mm long, sparsely pubescent; upper internodes shorter than epicotyl, pubescent as well. Leaves all opposite, pubescent above as well as on adaxial side of the petioles, nearly glabrous beneath.

F-1. *I. chinensis* (Fig. 24) Hypocotyl never elongated. Cotyledon grown and long persistent, entirely glabrous; petioles about 5mm long, erect; blade herbaceous, nearly orbicular, up to 8mm by 8mm, shallowly bilobed at apex. Epicotyl elongating up to 7cm long, glabrous; upper internodes shorter than the epicotyl. Leaves minutely hispid above, all opposite; first pairs 1.5-2.5cm long, shorter than upper ones.

Group with hypogeal germination (Group II) The cotyledons are lateral to the axis, fleshy, sessile, under the soil surface, without hypocotyl and long remain together with testa.

G-1. *I. longiloba* (Fig. 25) Cotyledons nearly square in shape, swollen up to 6mm by 6mm. Epicotyl about 1cm long, glabrous; upper internodes reddish, glabrous but sometimes sparsely glandular. First and second leaf opposite, caducous; the others alternate.

H-1. *I. masoni* (Fig. 26) Cotyledons nearly orbicular, hardly grown, about 3mm by 3mm. Epicotyl about 1cm long, glabrous, reddish; upper internodes except the second pale green, glabrous. First and second leaf very small, opposite; the others nearly opposite, showing short internodes between the paired leaves.

H-2. *I. pseudochinensis* (Fig. 27) Cotyledons nearly orbicular, hardly grown, about 3mm by 3mm. Epicotyl up to 3cm long, glabrous, reddish; upper internodes except the second pale green, glabrous. First and second leaf very small; all leaves opposite.

Discussion

As described, the seedlings of *Impatiens* are of high diversity in shape and development. In my opinion, the 20 species studied would be classified into 2 major groups (I & II) and 8 subgroups (A-H). The diagnostic characters of these groups and subgroups are shown in the following key and schematic illustration (Fig. 28).

1. Cotyledons epigeal, opposite and petiolate. Group I
2. Hypocotyl elongated; cotyledons above soil surface.
3. Hypocotyl indefinitely elongated; epicotyl never elongated; cotyledonary

- blade cornute beneath. Subgroup A
3. Hypocotyl definitely elongated, up to 5cm long; epicotyl elongated.
4. Epicotyl much shorter than hypocotyl. Leaves all alternate, except *I. psittacina*. Subgroup B
4. Epicotyl well elongated up to nearly as long as hypocotyl. Leaves all or partly opposite.
5. First and second leaf opposite; the others alternate.
6. Cotyledons not caducous. First and second leaf persistent. Subgroup C
6. Cotyledons and first two leaves caducous. Subgroup D
5. Leaves all opposite. Subgroup E
2. Hypocotyl never elongated; cotyledons on soil surface. Subgroup F
1. Cotyledons hypogeal, lateral and sessile. Group II
2. Cotyledons swollen up to 6mm long. Leaves alternate, except first and second one. Subgroup G
2. Cotyledons hardly swollen. Leaves all opposite. Subgroup H

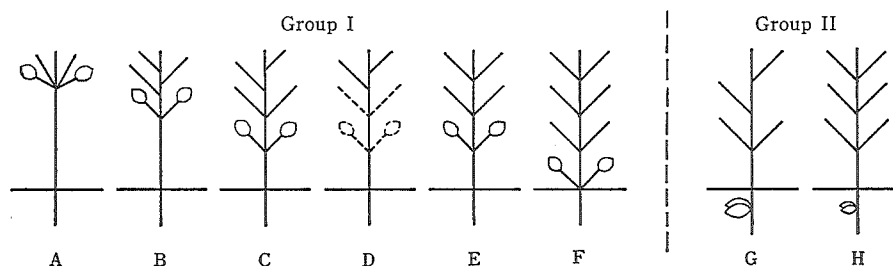


Fig. 28 Seedling classification in the Thai *Impatiens*, showing 2 major groups (I and II) and 8 subgroups (A-H)

The relation between seedling types and the previous taxonomic divisions of the Thai *Impatiens* (Shimizu 1979) is summarized in Table 1.

The major group, Group I, corresponds to the *Macaranga* type in the sense of Vogel (1980), characterized by the long persistent leaf-like cotyledons which become free and spread in the air and have photosynthetic function. The Group II, on the other hand, corresponds to his *Sloanea* type-*Palaquium* subtype, characterized by the fleshy food-storing cotyledons which are without an elongating hypocotyl and more or less subterranean. As shown in the table, these major groups do not well accord with the taxonomic divisions. Above all, Sect. *Enantiophyllon*-Group A is separated into two major groups in the seedling type. I put *I. chinensis*, *I. masoni* and *I. pseudochinensis* together in Group A of Sect. *Enantiophyllon* based on phyllotaxis and seed type. They have all opposite leaves and global smooth seeds. Judging from the seedling type, this group must be again revised.

Table 1. Relation between the seedling types and the previous taxonomic divisions in the Thai *Impatiens*

Seedling type		Species	Taxonomic division (Shimizu 1979)
Major group	Subgroup		
I	A	<i>I. calcicola</i> <i>I. charanii</i> <i>I. salaengensis</i> <i>I. macrosepala</i>	Sect. Microcentron-Group B
	B	<i>I. hongsonensis</i> <i>I. psittacina</i> <i>I. kerriae</i> <i>I. larsenii</i>	Sect. Microcentron-Group B
	C	<i>I. Chiangdaoensis</i> <i>I. patula</i> <i>I. phuluangensis</i> <i>I. santisukii</i> <i>I. violaeiflora</i>	Sect. Macrocentron-Group A
		<i>I. muscicola</i>	Sect. Macrocentron-Group B
	D	<i>I. racemosa</i>	Sect. Longecalcaratae
	E	<i>I. griffithii</i> var. <i>sarcantha</i>	Sect. Enantiophyllon-Group B
	F	<i>I. chinensis</i>	Sect. Enantiophyllon-Group A
II	G	<i>I. longiloba</i>	Sect. Megalocentron
	H	<i>I. masoni</i> <i>I. pseudochinensis</i>	Sect. Enantiophyllon-Group A

Sect. Microcentron-Group B which is represented by the species bearing large round outer sepals, a short-spurred saccate lip and connate wing petals, can be divided into Subgroup A and B in the seedling type. Subgroup A is much homogeneous, characterized by indefinitely elongated hypocotyl, no epicotyl and cornute cotyledonary blade. On the other hand, the diagnoses of Subgroup B are in alternate leaves and epicotyls shorter than hypocotyls. However, *I. psittacina* has the first and second leaf opposite, the cotyledons being caducous, while *I. kerriae* has elongated epicotyls and fairly long persistent cotyledons. Therefore, Subgroup B should be regarded as rather heterogeneous.

Sect. Macrocentron, contrariwise, is uniform in seedling morphology. As far as the Thai species of Group A and B are concerned, Sect. Macrocentron seems to be a natural group in seedling type as well as floral characters, i. e. red-purple

flowers usually bearing a long spur and separate wing petals. Only *I. muscicola* is exceptionally spurless.

The members of the other sections, Sect. Longicalcaratae and Sect. Megalocentron, seem to be different in seedling type, Subgroup D and G, respectively. Since only one example was observed in each case, however, further examination should be made in future.

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Summary

The seedlings were observed in 20 species of the Thai *Impatiens*. They are so diversified as to require classification into 2 major groups and 8 subgroups.

In some cases, the seedling type is well concordant with the infrageneric taxa previously proposed, as exemplified by the species of Sect. Macrocentron Warb. and partly by Sect. Microcentron Warb. On the other hand, the same section is represented by different seedling types, as shown in the case of Sect. Enantiophyllon Warb. The taxonomy of the genus *Impatiens* should be further revised through seedling morphology.

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