Size Structure and Critical Plant Size for the Flowering of Ainsliaea apiculata in Yakushima Island, Japan

Yoshimichi HORI*, Tomoko YOKOI* and Tetsukazu YAHARA**

: Size Structure and Critical Plant Size for the Flowering of *Ainsliaea apiculata* in Yakushima Island, Japan

堀　良通*・横井朝子*・矢原徹一**：

屋久島のキッコウハグマの個体群構造と開花の臨界サイズ

Ainsliaea apiculata SCH. -BIP. (Compositae) is an evergreen understory herb widely distributed throughout the Japan Archipelago, with its southern distribution limit on Yakushima Island (OHWI, 1972). The leaves of this plant on Yakushima are variously shaped in a manner differing from that at other habitats. On this island this species has been divided into six varieties (MASAMUNE, 1934) or four forms (SUGIMOTO, 1957) mainly according to leaf shape. The six varieties are var. *scapifolia* (Tozaki-kikkohaguma), var. *multiscapa* (Tagyo-kikkohaguma), var. *acerifolia* (Momiziba-kikkohaguma), var. *typica* (Kikkohaguma), var. *ovatifolia* (Tamagoba-kikkohaguma) and var. *rotundifolia* (Maruba-kikkohaguma). The four forms are f. *apiculata* (Kikkohaguma), f. *rotundifolia* (Maruba-kikkohaguma), f. *ovatifolia* (Tamagoba-pikkohaguma) and f. *acerifolia* (Momoiziba-kikkohaguma). In addition to leaf shape a remarkable plant size variation of *A. apiculata* is known on Yakushima Island.

However, there are no previous reports on the ecological significance of leaf shape and plant size variation of *A. apiculata* on Yakushima Island. In the present report, we examined the characteristics of size structure and critical plant size for the flowering of *A. apiculata* with reference to leaf shape variation.

Table 1. Study site altitude and number of plants harvested.

Study site		Altitude	Number of plants
Mt. Aikodake	A1	230m	147
	A2	400	238
	A3	540	253
	A4	720	122
	A5	830	198
	A6	900	87
	A7	1050	290
Mt. Tatyuudake	T1	1450	45
Yakusugi Land	Y1	1050	57
Yodogawa Lodge	Y2	1380	378

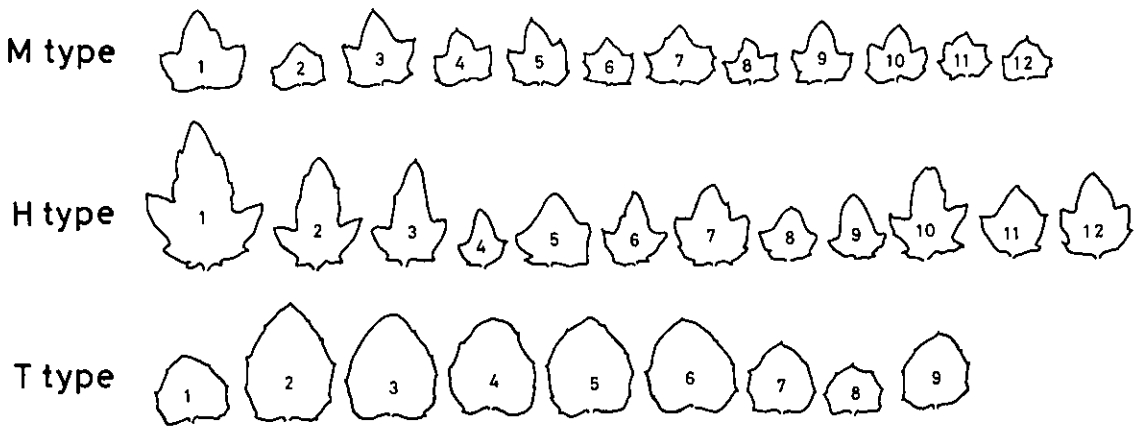

Fig. 1. Examples of the leaf shapes of Momiziba, Hokoba and Tamagoba types of *A. apiculata*. Numerals in the figure were numbered in order of leaf appearance.

*Department of Biology, Faculty of Science, Ibaraki University, Mito 310.
〒310　水戸市文京2-1-1　茨城大学理学部生物学教室
**Botanical Gardens, Nikko, Faculty of Science, University of Tokyo, Nikko 321-14.
〒321-14　日光市花石町1842　東京大学理学部附属植物園日光分園

Study Sites

The present research was conducted along a path leading to the top of Mt. Aikodake (altitude 1235m above sea level) and along a road near Yodogawa Lodge on Yakushima Island from July 11 to 17, 1985. Supplementary research was also carried out from December 1 to 4, on Mt. Aikodake, Mt. Tachudake (altitude 1497m) and Yakusugi Land. The altitude of each research site is shown in Table 1.

Methods

Quadrats 1 to 2m in width were set up in areas where *A. apiculata* occurred densely; all the

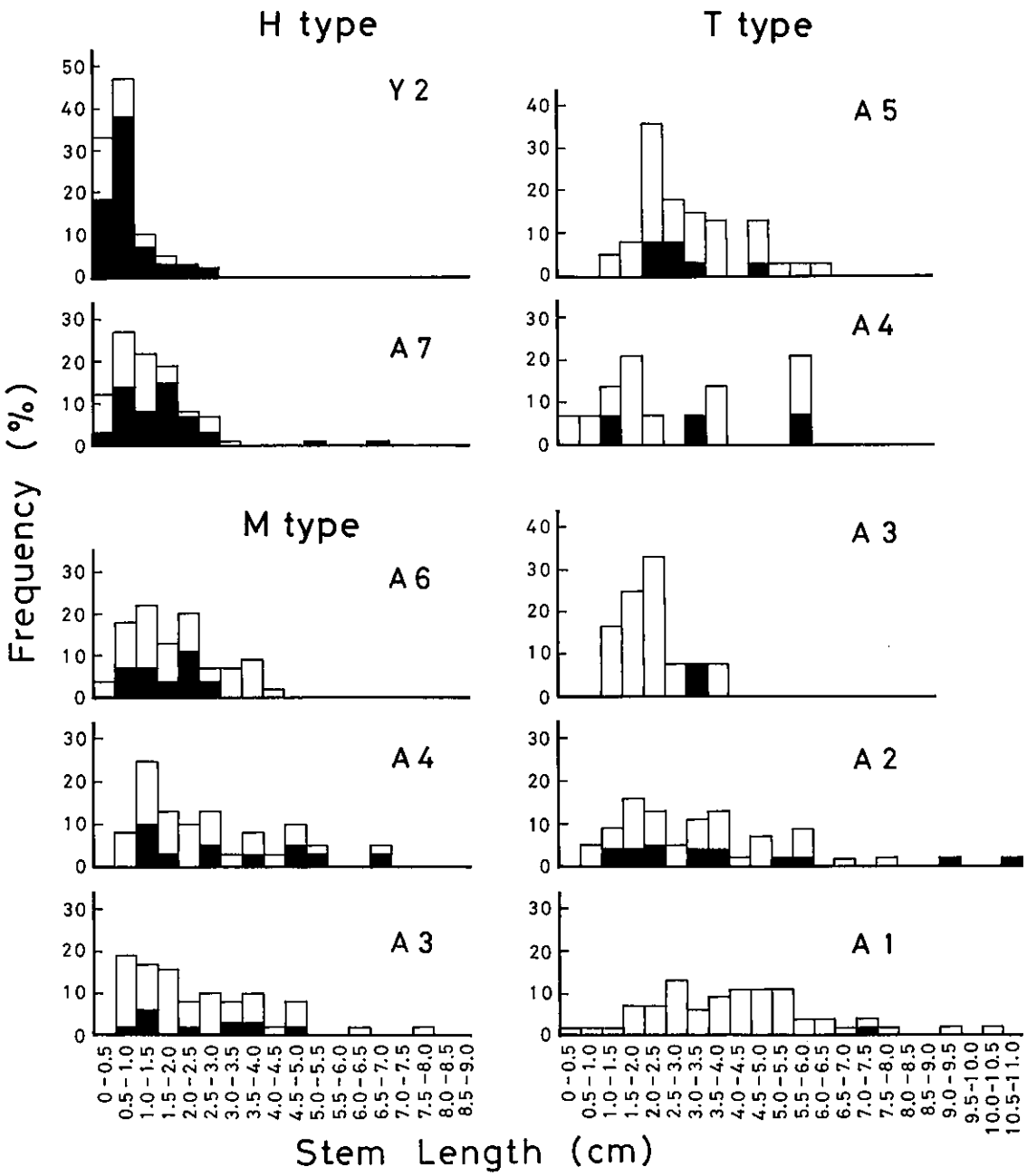

Fig. 2. Frequency of stem length of Momiziba (M), Hokoba (H) and Tamagoba (T) types of *A. apiculata* at various study sites. Solid bars indicate the flowering plants. See Table 1 for abbreviations of study sites in the figure.

plants in the quadrats were harvested. The number of plants harvested from each plot are shown in Table 1. Leaf shape and number, the presence or absence of flower stalks and the diameter of stems below the lowest leaf were measured for each plant harvested. Stem length, leaf area and the weights of plant organs, i.e., flower stalks, leaves, stems, rhizomes and roots, were measured for some of the plants. Stem diameter and leaf area were measured with a digimatic caliper (Mitsutoyo 500-110) and a 0.25 cm^2 grid net on a transparent sheet, respectively. For the aerial part, measurements were made only using current organs with no consideration given to old leaves or old stems. When the ordinary mode of measurement was not carried out, leaf area and the weight of each organ were estimated on the basis of the allometric relation between the product of stem diameter and leaf number and the weight of each organ for each type at all the sites. In supplementary research, stem diameters and the weights of plant organs for each plant harvested were not measured.

Results and Discussion

In the present study *A. apiculata* was divided into four types according to leaf shape: Momiziba with deep palmate lobes (M type), Tamagoba without distinct lobes (T type), Kikko with shallow lobes (K type) and Hokoba with an elongate terminal lobe (H type). The Hokoba type was found primarily at heights exceeding ca. 1000m and leaf shape resembled that of a scabbard. The K type is regarded as typical f. *apiculata* and the T type may include both f. *ovatifolia* and f. *rotundifolia*. The M and H types may possibly be included in f. *acerifolia*.

All the small plants less than about 3 years of age resembled the K type in leaf shape and large size plants of the K type were rare. Thus, the K type was excluded from the present analysis. Leaf shapes representative of M, H and T types are shown in Fig. 1.

(1) Frequency distribution of stem length

The stem length of the H type was very short, being in most cases less than 1cm at either site (Fig. 2). In the T type the stem was much longer, mostly 1.5-6cm. In the M type the stem length was intermediate between the H and T types. At lower latitude, larger plants of all three types

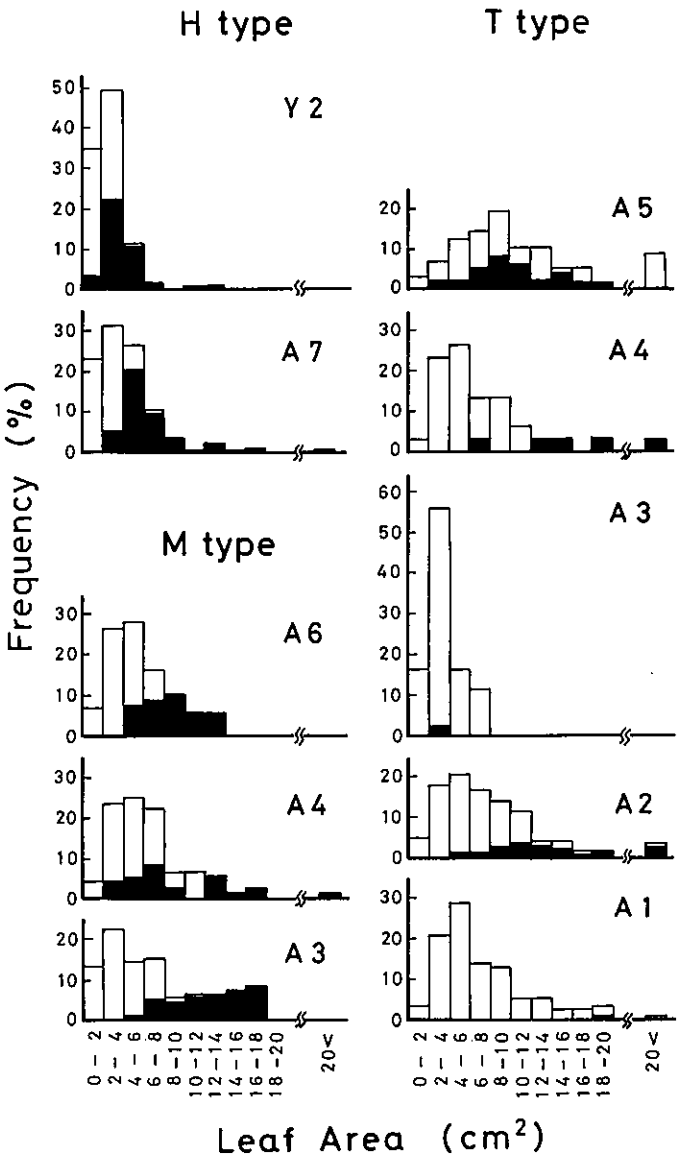

Fig. 3. Frequency of leaf area of Momiziba (M), Hokoba (H) and Tamagoba (T) types of *A. apiculata* at various study sites. Solid bars indicate the flowering plants. See Table 1 for abbreviations of study sites in the figure.

increased.

(2) Frequency distribution of leaf area

In the T type, leaf area was often greater than 10cm² (Fig. 3). In the H type, plants with less than 6cm² predominated. In plot Y2, 52 per cent of the plants had leaves less than 4cm². In the M type, plant size was intermediate between that of the H and T types. Leaf area decreased in the order of T>M>H.

(3) Critical plant size for flowering

To examine the relationship between flowering rate and plant size, the harvested plants were arranged in the order of leaf area and then in the order of aerial part weight. They were divided into 10 groups. For each group, the mean leaf area, aerial part weight and the percentage of flowering plants were calculated. The parcentage values were used as indicators of flowering rate probability. The leaf area and aerial part weight for flowering were found to increase in the order of H<M<T (Fig. 4). The size for a 50 per cent flowering rate was termed the critical size for flowering. The critical sizes for both leaf area and aerial part weight clearly became greater in the order of H<M<T (Fig. 5). Moreover, the critical plant size for flowering decreased with increasing altitude within the same types.

Many perennial herbs have a critical size for flowering (e.g. WERNER, 1975; BASKIN and BASKIN, 1979; HIROSE and KACHI, 1982). This critical size is closely related to the instrinsic rate of natural increase (KACHI and HIROSE, 1985). The critical size for leaf area and aerial part weight for the T type was three to five times greater than that of the H type. This suggests large differences in the population maintenance mechanisms among these types.

In conclusion, the size structures and critical plant size for flowering were notably different among the M, H and T types of *A. apiculata* on Yakushima Island. Further studies on especially the physiological ecology of these types are needed to understand why these difference have evolved and are maintained on Yakushima island.

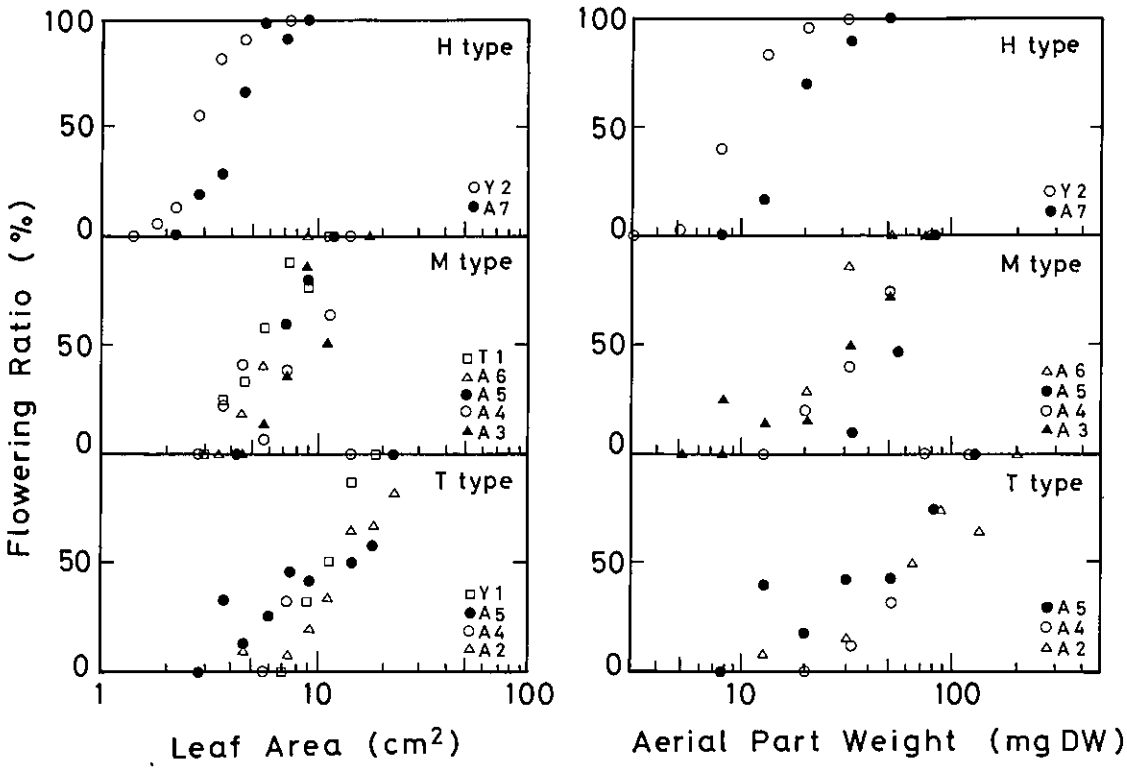

Fig. 4. Relationship between flowering rate and leaf area and aerial part weight of Momiziba (M), Hokoba (H) and Tamagoba (T) types of *A. apiculata* at various study sites. See Table 1 for abbreviations of study sites in the figure.

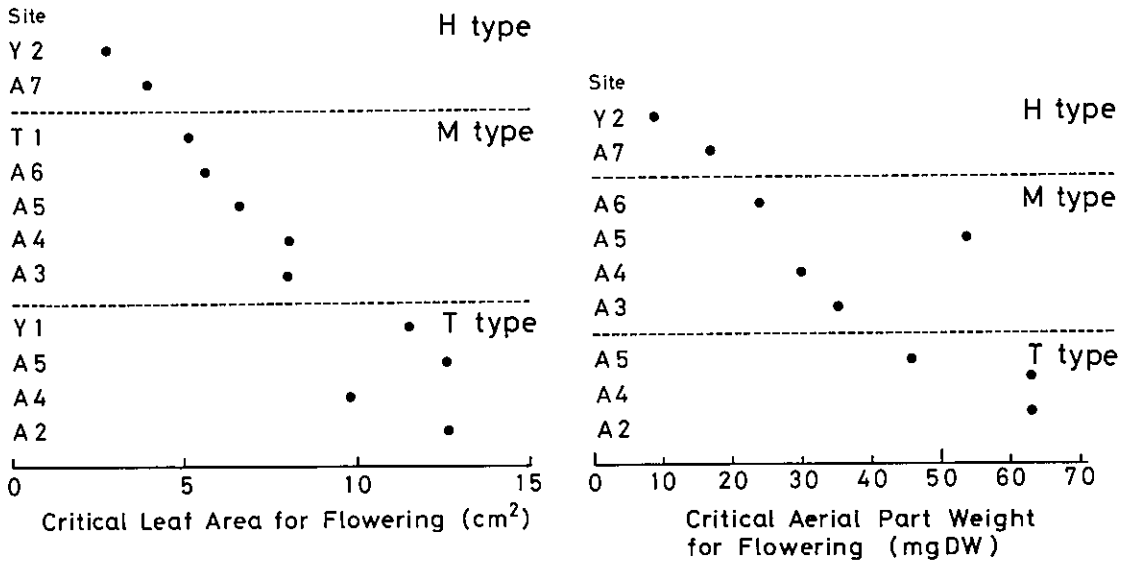

Fig. 5. Relationship between study sites and critical leaf area and critical aerial part weight for the flowering of Momiziba (M), Hokoba (H) and Tamagoba (T) types of *A. apiculata*.

Acknowledgments

This study was supported in part by a grant for the Nissan Science Foundation. The authors gratefully acknowledge the assistance of Miss. M. MISHIO, Mr. A. ISHIDA and Mr. Y. TAKAHASHI in the field and permission for collecting the plants within the special reserved area in the national park by the Environment Agency.

References

BASKIN, J. M. and BASKIN, C.C. 1979. Studies on the autecology and population biology of the weedy monocarpic perennial, *Pastinaca sativa*. J. Ecol. **67**: 601-610.

HIROSE, T and KACHI, N. 1982. Critical plant size for flowering in biennials with special reference to their distribution in a sand dune system. Oecologia **55**: 281-284.

KACHI, N. and HIROSE, T. 1985. Population dynamics of *Oenothera glazioviana* in a sand-dune system with special reference to the adaptive significance of size-dependent reproduction. J. Ecol. **73**: 887-901.

MASAMUNE, G. 1934. Floristic and geobotanical studies on the island of Yakushima. Mem. Fac. Sci. Agr. Taihoku Imp. Univ. **11**: 1-637 (in Japanese).

OHWI, J. 1972. Flora of Japan. Shibundou, Tokyo (in Japanese).

SUGIMOTO, J. 1957. Variation of *Ainsliaea apiculata* Sch.-Bip. Journ. Jap. Bot. **32**: 62-64 (in Japanese).

WERNER, P.A. 1975. Predictions of fate from rosette size in teasel (*Dipsacus fullonum* L.) Oecologia **20**: 197-201.

摘　要

屋久島はキッコウハグマの分布の南限にあたり，他の分布地にはみられない葉形の多形現象がみられる。葉形によって，6変種（正宗，1934）あるいは4品種（杉本，1957）に分類されている。本研究では，タマゴバ型，モミジバ型，それと狭義のキッコウ型のキッコウハグマについて個体群構造，開花の臨界サイズについて調査した。ホコバ型は約1,000 m以上の高度の所に出現する全体に小型で，葉形が鉾型の個体である。タマゴバ型はタマゴバキッコウハグマとマルバキッコウハグマの品種を含み，モミジバ型とホコバ型はモミジバキッコウハグマに含まれた。また，キッコウ型はキッコウハグマに相当した。キッコウ型については，いずれの型も，約3年齢以下の小個体がキッコウ型となる点や，出現個体数が少なかった点を考慮して解析から省いた。

調査は愛子岳の登山道沿いを中心に，太忠岳の登山道及び淀川林道沿いに点在する個体群について行われ，調査個体群の全個体の茎直径，葉数，花茎の有無を測定し，更に一部の個体については，茎長，葉面積，各器官重を測定した。茎直径と葉数のみを測定した個体の葉面積と各器官重は，（茎直径²×葉

数）との相対成長関係式から推定した。

個体群中の葉面積の大きな個体の割合は，ホコバ型→モミジバ型→タマゴバ型の順に多くなった。茎長も葉面積と同様の傾向を示した。開花の臨界葉面積及び臨界地上部重はホコバ型→モミジ型→タマゴバ型の順に大きくなり，タマゴバ型はホコバ型より3～5倍と著しく大きくなった。屋久島のキッコウハグマはホコバ型，モミジバ型，タマゴバ型間で形態および個体群構造，開花の臨界サイズについて明瞭な差異が認められた。　(Received July 17, 1987)

正　　誤

Vol. XXXV No. 2 p. 84　右上から11行目　Appendi × acinacea → Appendix acinacea

Vol. XXXV No. 2 p. 170　図の説明　s：小根；スケールは1mm長→s：小穂；スケールは1mm長（長田武正描画）

住所変更及び訂正（昭和62年12月～63年4月）

阿部　直樹　〒930　富山市五福四区4997　呉立荘→〒380　長野市七瀬646-1　サンハイツ七瀬102号（中部）

藤原　陸夫　〒014　秋田県大曲市金谷町26-9　県立大曲農業高等学校→〒010　秋田県秋田市中通6-6-36　県立秋田東高等学校（東北）

原　慶太郎　〒980　仙台市荒巻字青葉　東北大学理学部生物学教室（東北）→〒280-01　千葉市谷当町1200-2　東京情報大学生物学研究室（関東）

原田　　昭　〒211　川崎市中原区西加瀬163　至誠寮→〒175　東京都板橋区高島平2-33-2，1206（関東）

端山　重男　〒156　世田谷区桜丘1-1　東京農業大学植物学教室→〒242　大和市南林間6-22-6（関東）

堀井　雄治郎　〒010　秋田市仁井田二ツ屋2-13-31→〒019-18　秋田県仙北郡南外村字梨木田259（東北）

政谷　徳治　〒920-21　石川郡鶴来町坂尻町ヘ97-8→〒927-06　珠洲郡内浦町字松波（中部）

路川　宗夫　〒305　茨城県新治郡桜村天王台1-1-1　筑波大学生物科学系→〒305　茨城県つくば市天王台1-1-1　筑波大学生物科学系（関東）

南木　睦彦　〒558　大阪市住吉区杉本3-3-138　大阪市立大学理学部生物学教室→〒673　神戸市西区学園西町3-1　流通科学大学（近畿）

西川　洋子　〒080　札幌市東6条南7丁目　コーポ・サンタモニカ307号→〒080　札幌市東4条南6丁目　シャトー脇坂206号（北海道）

大沢　達郎　〒086-16　北海道目梨郡羅臼町礼文町9-3　北海道羅臼高校→〒003　札幌市白石区川北2261　札幌白石高校（北海道）

佐藤　孝敏〒410　沼津市高島本町1-3　静岡県東部農林事務所→〒410　沼津市西沢田1044-4（中部）

杉野　孝雄　〒436　静岡県掛川市神代池231-21→〒436　静岡県掛川市南1-4-18（中部）

横内　　茂　〒468　名古屋市天白区天白町八事裏山69-49　名城大学農学部植物学研究室→〒468　名古屋市天白区塩釜口1-501　名城大学農学部植物学研究室（中部）

新　入　会　員（昭和62年12月～63年4月）

昭和63年1月30日　近藤　健児　〒920　金沢市丸の内1-1　金沢大学理学部分類地理講座（中部）

2月5日　原　　信彦　〒158　東京都世田谷区深沢2-1-1　東京都立大学理学部牧野標本館（関東）

4月4日　谷川　智彦　〒920　金沢市長町3-1-10　白樺荘7号（中部）

退　会　会　員（昭和62年12月～63年4月）

昭和62年1月5日　阿部　達雄　〒018-33　秋田県北秋田郡鷹巣町綴子字字佐戸岱4-7（東北）

1月10日　小林　　薫　〒890　鹿児島市与次郎1-7-15　鹿児島熱帯植物園（九州）

昭和63年1月25日　政本　正信　〒729-16　東広島市高屋町大字高屋堀730-2（中国）

3月30日　原沢伊世夫　〒192-03　八王子市中山3-59-7（関東）死去