ボルネオ キナバル山のRubus satotakashii とその関連種の分類学的研究 II. 花と果実

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Cheksum TAWAN*, Takashi SATO** and Naohiro NARUHASHI***: Taxonomical Studies of *Rubus satotakashii* and Related Species in Mt. Kinabalu, Borneo II. Flower and Fruit****

チェクスム　タワン*・佐藤　卓**・鳴橋直弘***：
ボルネオ　キナバル山の *Rubus satotakashii* とその関連種の
分類学的研究 II．花と果実****

Abstract

Rubus satotakashii NARUHASHI et CHEKSUM, endemic to and exclusively found on Mount Kinabalu, Sabah, in Borneo, is possibly a hybrid of *R. lineatus* REINWARDT ex BLUME and *R. lowii* STAPF. Not only is *R. satotakashii* found growing near population of *R. lineatus* and *R. lowii*, it exhibits many characters which are intermediate to both the latter species. Flower and fruit morphology including number of flowers per flowering twig, number and size of petals, number and length of stamens and pistils, and number of fruitlets per fruit were compared. Although many characters were intermediate in value, some characters such as stout inflorescences, incised sepals, divided stigmata and dark red fruits are unique to *R. satotakashii*. Because of these unique characters there is difficulty in confirming whether *R. satotakashii* is a natural hybrid.

Key Words: Flower — Fruit — *Rubus lineatus* — *Rubus lowii* — *Rubus satotakashii*

According to NARUHASHI and SATO (1983), the plant now known as *Rubus satotakashii* NARUHASHI et CHEKSUM was determined to occur only on Mount Kinabalu, Sabah, Borneo. A year later this plant was described and named as a new species (NARUHASHI, SATO and CHEKSUM, 1984). In the 1983 investigation populations of this plant were found together with populations of both *R. lineatus* REINWARDT ex BLUME and *R. lowii* STAPF at altitudes of 3300m and 3480m. It has been proposed that *R. satotakashii* may be a hybrid of *R. lineatus* and *R. lowii* (NARUHASHI and CHEKSUM, 1985). This study was initiated to compare the three species and explore the possibility that *R. satotakashii* is a hybrid of the other two species. A comparison of fruits and flowers of *R. satotakashii, R. lineatus,* and *R. lowii* is reported.

Materials and Methods

All the materials used in this study were collected from several populations between 2200m and 3800m in altitude in Mt. Kinabalu, Sabah, Borneo. Some of the specimens were dried, while others were fixed in FAA (five parts stock formalin: five parts glacial acetic acid: 90 parts 70% ethanol). Examinations of the external characters of the flowers and fruits were carried out in the field and in the laboratory.

For the analysis using common statistical methods (F-test, t-test), the following characters were chosen: the number of flowers per flowering twig, number of petals, length and width of the petals, number of stamens, length of the stamens, number of pistils, length of the pistils, and number of fruitlets per fruit.

Results of Comparison of Floral Characters

1. Flowering twig

The number of flowers per flowering twig in many plants is normally treated as the number of

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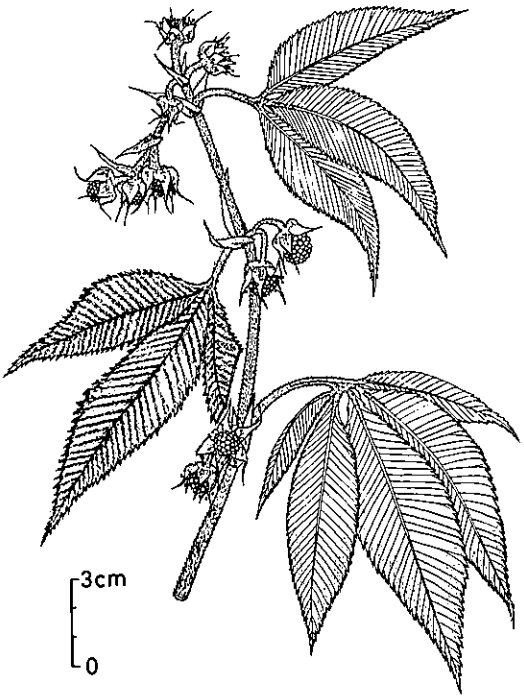

Fig. 1. Flowering twig of *Rubus lineatus*.

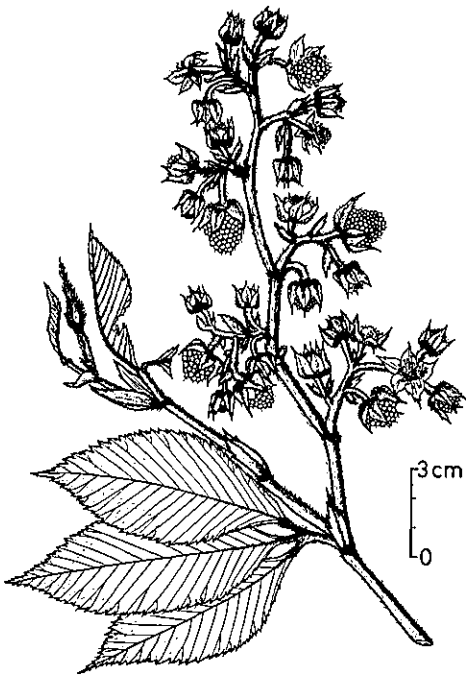

Fig. 2. Flowering twig of *Rubus satotakashii*.

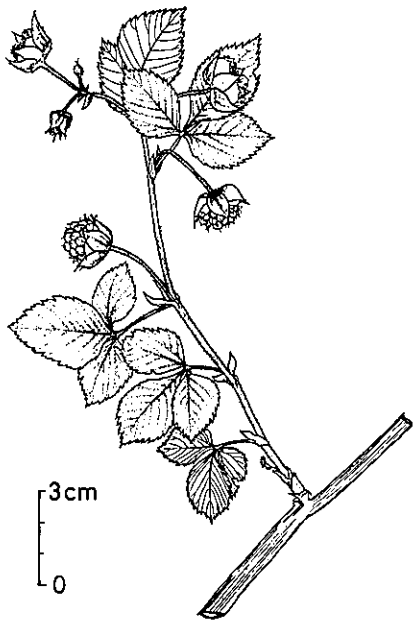

Fig. 3. Flowering twig of *Rubus lowii*.

flowers per inflorescence. Because both *R. lineatus* and *R. lowii* do not possess the so-called true inflorescence as remarkably exhibited by *R. satotakashii* (see Figs. 1, 2 and 3), the term flowering twig is used for the purpose of homogeneous analytical comparison for the three species.

The number of flowers per flowering twig in each species was examined in populations at different altitudes. It has been observed that there is no apparent difference in the flower number in *R. lineatus* from populations at different altitudes. However, there is a slight difference in the number of flowers, varying from 2 to 35, in *R. lowii* at 3100m, 3300m, 3480m, and 3600m altitudes. As for *R. satotakashii,* the number of the flowers is extremely low in populations of higher altitudes. For instance, the number of *R. satotakashii* flowers in the populations at 3300m and 3600m are 30 and 6, respectively. Table 1 shows the number of flowers per flowering twigs in the three species. In particular, *R. satotakashii* shows the highest number of flowers. *Rubus lineatus* shows an intermediate number, and *R. lowii* has the fewest flowers.

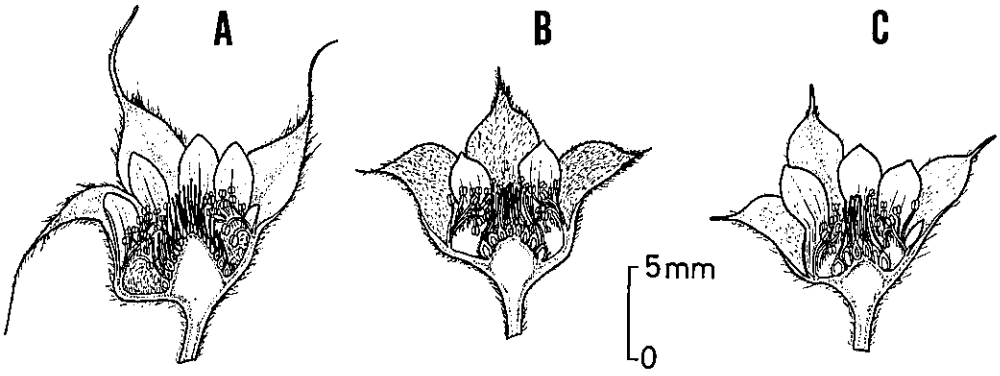

Fig. 4. Longitudinal section of flower. A: *R. lineatus*; B: *R. satotakashii*; C: *R. lowii*.

lowii has the fewest flowers. Based on the coefficient variation in the number of flowers per flowering twig from the different populations, there is a significant difference among the three species according to F-test results (F = 121.59***).

Table 1. Number of flowers per flowering twig.

Species	n	no. of flowers	Mean±SD	SE	CV(%)
R. lineatus	62	6-39	16.0± 7.5	1.0	40.6
R. satotakashii	23	2-58	21.6±12.6	2.6	59.7
R. lowii	125	2-35	6.2± 4.0	0.4	63.7

n: number of samples; SD: Standard Deviation; SE: Standard Error; CV: Covariance

2. Flower

Figure 4 illustrates the longitudinal sections of the three species concerned. The hypanthium of *R. lineatus* is a well developed campanulate form compared to the shallow cupular shape in *R. lowii*; whereas, *R. satotakashii* shows an intermediate structure between the two species. In *R. lineatus* the receptacle is elongate and conical in shape, while *R. lowii* is small and ovoid shape.

3. Sepals

The shapes of the sepals of the three species vary from lanceolate-oblong to deltoid-ovoid (Fig. 5). *Rubus lineatus* has typical long aristate and entire sepals. In *R. satotakashii*, the sepals are shortly aristate and sometimes incised at the apex. On the other hand, sepals of *R. lowii* are caudate toward apex and commonly incised.

The outer surface of the sepal of *R. lineatus* is generally covered with long woolly hairs and short tomentose hairs on the inner surface. Basically the sepal indumentum of *R. satotakashii* is similar to *R. lineatus* but differs by its shorter woolly hairs covering the outer surface and somewhat longer tomentose hairs on the inner surface. *Rubus lowii* has pilose hairs on the outer surface of the sepal and short tomentose hairs at the inner surface.

The results of the measurements of the length and the width of the sepals of the three species are shown in Fig. 6. There is a difference in length and width in both *R. lineatus* and *R. lowii*. *Rubus satotakashii* shows a wide variation in its length and width including the range in variation of the other two species. The correlation coefficient between the length and width of the sepals has a value of $r^2 = 0.33$ for *R. lineatus*, $r^2 = 0.45$ for *R. lowii*, and $r^2 = 0.21$ for *R. satotakashii*. The small correlation coefficient value of *R. satotakashii* implies that correlation between the length and width of the sepals in this species is considerably low.

4. Petals

The petals of *R. lineatus* are oblong to rhomboid-oblong, which are similar to the petals of *R. satotakashii*, but *R. lowii* has deltoid-ovoid to broad obovate petals. The petal apices of the former two species are apiculate with simple reticulations, whereas the petals of *R. lowii* have rounded apices with complex reticulated veins (Fig. 7). The petals of *R. lineatus* are white compared to a greenish-white in both *R. lowii* and

*** means probability more than 99.9%

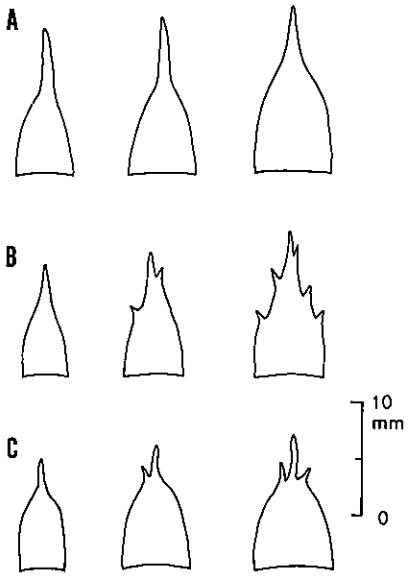

Fig. 5. Shape of sepal. A: *R. lineatus*; B: *R. satotakashii*; C: *R. lowii*.

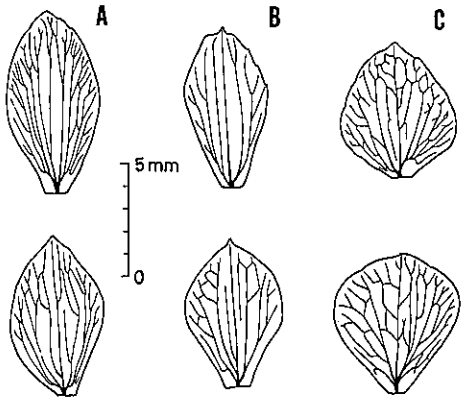

Fig. 7. Petals of three species. A: *R. lineatus*; B: *R. satotakashii*; C: *R. lowii*.

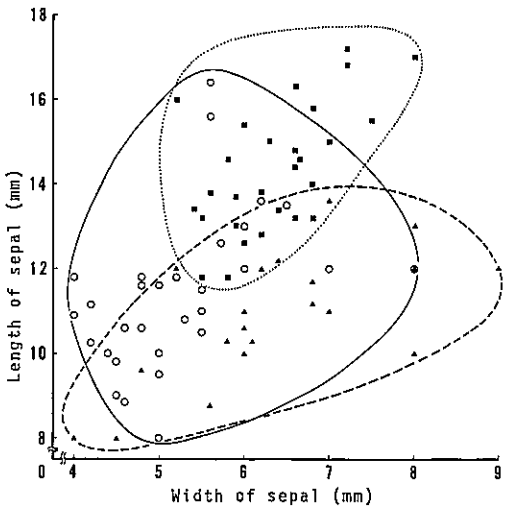

Fig. 6. The relationship between length and width of sepal. Solid square: *R. lineatus*; open circle: *R. satotakashii*; solid triangle: *R. lowii*.

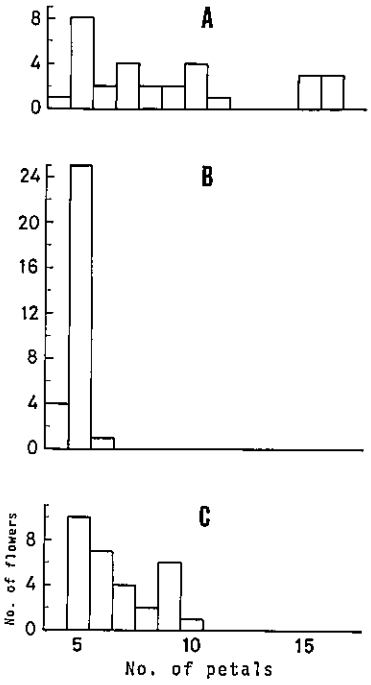

Fig. 8. Histogram on number of petals. A: *R. lineatus*; B: *R. satotakashii*; C: *R. lowii*.

The number of petals per flower of the three species is shown in Fig. 8 and Table 2. Normally the species belonging to the genus *Rubus* possess five petals; however, in these three species the number of petals is variable, especially in *R. lineatus* and *R. lowii*. For example in *R. lineatus* petal number varies from four to sixteen. *Rubus lineatus* also has the highest coefficient of variability value among the three species. The number of petals in this species does not reflect the expected 5, 10, 15 petals of a typical 5-merous flower. The variation in the number of petals in *R. satotakashii* is small.

Table 2. Number of petals.

Species	n	no. of petals	Mean±SD	SE	CV(%)
R. lineatus	30	4-16	8.7±3.9	0.72	45.1
R. satotakashii	30	4-6	4.9±0.4	0.07	8.2
R. lowii	30	5-10	6.7±1.7	0.30	24.7

There is no significant difference in the petal length among the three species ($F = 2.52 < 3.07$). There is a significant difference ($F = 50.81^{***}$) in the width of the petal among the three species. The petal width of *R. lowii* is comparatively wider compared with the other species. The relationship between the length and the width of the petals from the three species is shown in Fig. 9. Based on this relationship, *R. lowii* shows a higher coeffient of correlation ($r^2 = 0.574$) than *R. lineatus* ($r^2 = 0.176$) and *R. satotakashii* ($r^2 = 0.100$). The petal shapes of *R. lineatus* and *R. lowii* differ, and the petal shape of *R. satotakashii* is intermediate.

5. Stamens

The stamens of the three species are illustrated in Fig. 10. Their filaments are basically linear-lanceolate and the anthers are narrow oblong to deltoid-ovoid. In *R. lineatus* the filament is attached at the base of the anther,

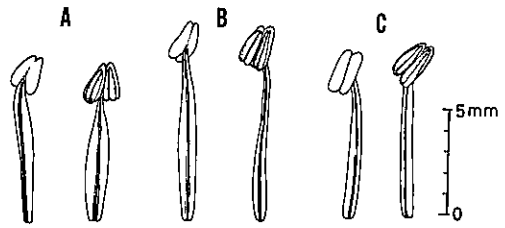

Fig. 10. Stamens of three species. A: *R. lineatus*; B: *R. satotakashii*; C: *R. lowii*.

whereas in *R. lowii* the filament is attached near the center of the anther. The attachment point in *R. satotakashii* is located in an intermediate position compared to the two species above.

The number of stamens of the three species is shown in Table 3 and Fig. 11. Results of the F-test ($F = 83.41^{***}$) show there is a significant difference in the number of stamens among the three species. However, according to Fig. 11, there is a population of *R. satotakashii* which has the same

Table 3. Number of stamens.

Species	n	no. of stamens	Mean±SD	SE	CV(%)
R. lineatus	30	82-139	116.4±12.5	2.5	11.6
R. satotakashii	30	21-122	79.1±33.8	6.2	42.7
R. lowii	30	35-54	42.9±5.5	1.0	12.8

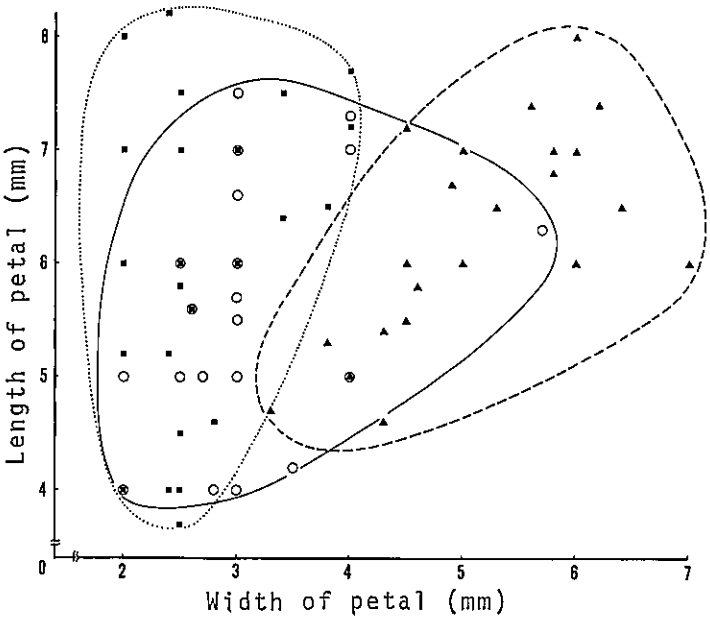

Fig. 9. The relationship between length and width of petal.
Solid square: *R. lineatus*; open circle: *R. satotakashii*; solid triangle: *R. lowii*.

few numbers of stamens as *R. lowii*. This population was found at a very high altitude (3600m) and few stamens may be related to environmental conditions. As for the length of stamens, there is very little variation among the three species. The only difference is that the stamen length of *R. lineatus* is somewhat shorter than *R. lowii* and *R. satotakashii* (see Table 4). *Rubus lineatus* has the most abundant number of stamens and *R. lowii* has the least.

Table 4. Length of stamen.

Species	n	Length(cm)	Mean±SD	SE	CV(%)
R. lineatus	30	0.25-0.50	0.38±0.07	0.01	17.7
R. satotakashii	30	0.30-0.60	0.45±0.07	0.01	15.6
R. lowii	30	0.30-0.70	0.46±0.09	0.02	18.4

6. Pistils

There is a significant difference in the number of pistils between the three species (see Table 5 and Fig. 11). There are approximately 200 pistils in *R. lineatus*, 100 in *R. satotakashii*, and 30 in *R. lowii*. An exceptional case was encountered in a population at 3600m altitude in which *R. satotakashii* had only 30 pistils which is the same number normally exhibited by *R. lowii* (see Fig. 11, lower-left portion of graph).

The general structures of the pistils as illustrated in Fig. 12 are the same in the three species except for the size, vestiture and stigma shape. The size of the *R. satotakashii* pistil is intermediate between *R. lineatus* and *R. lowii* (Table 6). According to Table 6 *R. lineatus* has a 20.8% CV, which means that there is a considerable variation in its pistil length. The ovaries and the lower portions of the styles of *R. lineatus* and *R. satotakashii* are covered with densely pilose hairs but in *R. lowii* the ovaries have sparsely pilose hairs and the styles are entirely glabrous. The narrowly clavate stigma of *R. lineatus* is distinct compared to the centrally concave bifid stigma of *R. lowii* and the tuberculate stigma of *R. satotakashii*.

Table 5. Number of pistils.

Species	n	no. of pistils	Mean±SD	SE	CV(%)
R. lineatus	30	179-261	209.6±18.8	3.5	9.0
R. satotakashii	30	24-122	77.4±31.9	5.8	18.3
R. lowii	30	21- 41	26.9±5.3	1.0	19.5

Table 6. Length of pistil.

Species	n	Length(cm)	Mean±SD	SE	CV(%)
R. lineatus	30	0.20-0.70	0.48±0.10	0.02	20.8
R. satotakashii	30	0.30-0.60	0.50±0.05	0.01	16.0
R. lowii	30	0.50-0.70	0.58±0.05	0.01	8.6

7. Fruit

The aggregate fruits of the three species are similar in shape, globose-ovoid, but differ in color from each other. The fruits are reddish orange in *R. lineatus*, dark red in *R. satotakashii* and red in *R. lowii*. The styles in the matured ovaries are persistent in all the three species (Fig. 13). There is no significant difference among two populations of *R. lineatus*, in the number of fruitlets per aggregate fruit (t-test: $t = 0.28 < 2.02$). Also, there is no significant difference in the number of

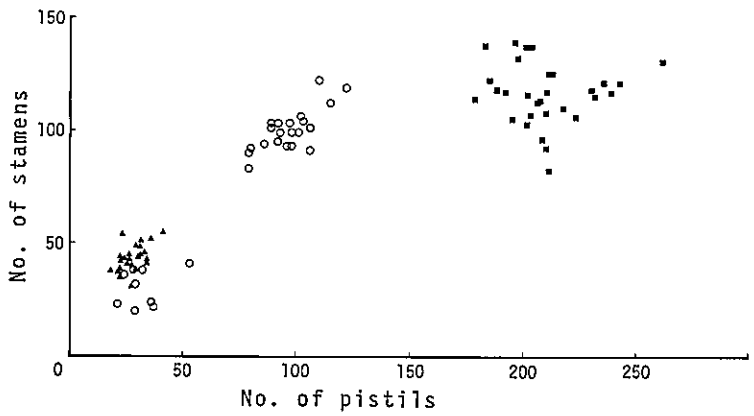

Fig. 11. The relationship between number of stamens and pistils per flower. Solid square: *R. lineatus*; open circle: *R. satotakashii*; solid triangle: *R. lowii*.

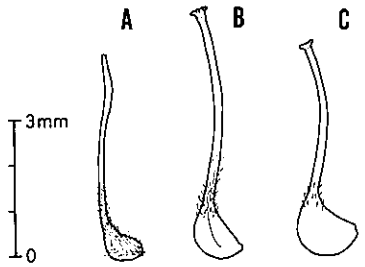

Fig. 12. Pistils of three species. A : *R. lineatus* ; B : *R. satotakashii* ; C : *R. lowii.*

fruitlets among three populations of *R. lowii* by the F-test ($F = 0.07 < 3.23$). Only one population was examined in *R. satotakashii* since few individuals occurred at the higher altitude (3480m - 3600m) and no fruits were observed during the period of investigation (June 1982 - March 1983). Generally there is a significant difference in the number of fruitlets per fruit between the three species (F-test: $F = 431.67^{***}$). Moreover, *R. lowii* shows the largest CV value which indicates that it has a wider variation in the number of fruits within the species (Table 7).

Table 7. Number of fruitlets per fruit.

Species	n	no. of fruitlets	Mean±SD	SE	CV(%)
R. lineatus	37	67-177	138.9±25.4	4.2	18.3
R. satotakashii	40	17-102	77.4±16.7	2.7	21.6
R. lowii	40	9- 27	20.3± 6.2	1.0	30.4

Discussion

The complexity of hybrid species in any plants has long created taxonomic problems (STEBBINS, 1950 ; DAVIS and HEYWOOD, 1963 ; WAGNER, 1968 ; GRANT, 1971 ; STACE, 1989). Even with these problems, the occurrence of hybrid species in the genus *Rubus* has been reported by several authors including REITERSON (1921), GUSTAFFSON (1942), LARSSON (1957), JINNO (1957, 1958), BAMMI and OLMO (1966), HASKELL (1966), NARUHASHI (1976), AHOKAS (1979), NARUHASHI and MASAKI (1980), and NARUHASHI (1990).

The character index of the hybrid is usually the average value attained by divergences of the parents (NARUHASHI and MASAKI, 1980). Several authors have reported that many characters of the hybrid species such as numbers of stamens, pistils, and fruitlets are numerically intermediate between the numbers occurring in the parent species (BAMMI and OLMO, 1966 ; NARUHASHI, 1976 ; NARUHASHI and MASAKI, 1980). A specific example of an intermediate character of *R. satotakashii* when compared to *R. lineatus* and *R. lowii* was given by NARUHASHI and CHEKSUM (1985). In this investigation, the fruitlet stone surface of each species was examined using electron microscopy. It was shown that *R. lineatus* has weak reticulum meshes compared to large and strong reticulum meshes in *R. lowii,* whereas the stone surface reticulation of *R. satotakashii* is intermediate.

This investigation also shows that *R. satotakashii* has characters of intermediate value. For example, the flower shape of *R. satotakashii* is intermediate between the campanulate and shallow-cupular forms of *R. lineatus* and *R. lowii,* respectively. In addition, the petal shape of *R. satotakashii* is intermediate. Also, the attachment point of filament to anther ; the number of stamens and pistils, except at very high altitudes ; and the size of the pistils are all characters that are intermediate in value for *R. satotakashii.* Many of the other characters examined were

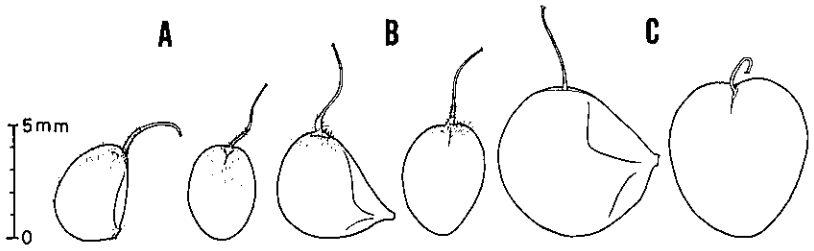

Fig. 13 Fruitlets of three species. A : *R. lineatus* ; B : *R. satotakashii* ; C : *R. lowii.*

shared or differed only slightly in two or more of the three species. Altogether these characters point towards the possibility of hybridization.

Although hybridization may have occurred, there is evidence that sugggests otherwise. For example, *R. satotakashii* has some characters which are very distinct (*i.e.*, not intermediate) when compared to *R. lineatus* and *R. lowii*. These distinct characters include a robust inflorescence, incised sepal, tuberculate stigma, and dark red fruits. Moreover, as mentioned before, at high altitude, the number of stamens and pistils deviated from those expected intermediate numbers of a hybrid species. This phenomenon may be due to unsuitable growing conditions for *R. satotakashii* at higher altitudes.

From this morphological study of floral and fruit characters and with interpretations of statistical analyses, it has been determined that *R. satotakshii* has many intermeditae characters as well as distinct and unique characters in comparison to *R. lineatus* and *R. lowii*. As such, it is difficult to confirm whether *R. satotakashii* is actually a natural hybrid of *R. lineatus* and *R. lowii*.

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摘要

ボルネオ産キイチゴ属植物 *Rubus satotakashii* は外部形態上 *R. lineatus* と *R. lowii* の中間の形をし

を行った。取り扱った形質は、花茎当たりの花数、花弁数、花弁の幅、雄ずい数、雄ずい長、雌ずい数、雌ずい長、および集合果当たりの小果実数などである。

その結果、基本的にはやはり *R. satotakashii* の示す各数値は *R. lineatus* と *R. lowii* の中間またはそれに似た値であった。しかし、頑丈な花序、有きょ歯のがく片、細分した柱頭、および暗赤色の果実は2種にない *R. satotakashii* のみの特徴であった。

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○ 初島住彦：**日本新産植物2種** Sumihiko HATUSIMA: Two Species Newly Found in Japan.

1．**ナガバヒゼンマユミ**（新称）(Fig. 1) 本種の日本における発見のきっかけは1922年にさかのぼる。すなわち，「田代善太郎日記」の大正編 (1972) 299頁によると，田代は1922 (大正11) 年7月18日の大分県における植物調査で次のように述べている。「東院内の谷を下り，5名の八坂神社境内にヒゼンマユミを見るは珍なり，ヒゼンマユミ5，中，実のなりたる2，境内の森林はアラカシ，ウラジロガシ，イチイガシ，ムクノキ，エノキ，タブノキ，ヤブニッケイ，シロダモ，アオガシ，イスノキ，クスドイゲ，ナナメノキ，クロガネモチ，ヤブツバキ，アオキ，アリドウシなどが生えている」。元来ヒゼンマユミは近海地に生えるもので，大分県では東部の津久見島や沖黒島などに知られている。これが海岸から約20 kmも内陸にある院内町の八坂神社に生えているということは，いかにもふしぎに思われた。またヒゼンマユミの果実は2月頃熟するが，上記の田代の記事では7月中旬が果期となっており，大分時期がずれている。以上二つの疑問から別府市の荒金正徳氏に調査方を依頼したが，なかなか見つからず，あきらめかけていたが，1989年11月3日，田代が発見した八坂神社から北方約3 kmの所にある高並神社境内で幼木が発見され，同年12月16日八坂神社でも発見，つづいて12月23日，ついに果実の着いた木が高並神社で発見された。この採品を色々調べた結果，中国(云南，四川，湖北，江西，安徽，浙江，福建，広西）に広く分布する下記の学名の樹木であることがわかった。本種とヒゼンマユミの区別点をあげると次のようになる。

A．葉は長楕円形で長さ10～12 cm，鋭尖頭，側脈は6対位で下面で著しく突出し，細鋸歯縁，果序は長さ5 cm位で，総果梗はやや細く，果実は大きさ裂開前で1 cm×1 cm位，7～11月頃成熟，低木または小高木で高さ4～7 m。……ナガバヒゼンマユミ

A．葉は楕円形～広楕円形で長さ7 cm位，鈍頭または短鈍尖頭鈍端，側脈は4～5対で下面ではやや不明，低い鈍鋸歯縁，果序は長さ5—7 cm，総花梗はやや太く，果実は大きさ裂開前で1.5～1.8 cm×1.5 cm，幹の直径50～80 cmに達する高木。……ヒゼンマユミ

元来日本の西南部には中国産のナナメノキ，シイモチ，タラヨウ，カナメモチ，タニワタリノキ，クスドイゲなどの，いわゆる日華要素と称する常緑樹が数多く知られているが，本種もその一例と思われる。

なお問題になるのは上記の津久島産のもので，ここのものは葉の特徴は院内町のものと一致しているが，生育地が島であり，かつ大木となる由であるから今後の研究にまちたい。

2．**マンセンビシ** 従来鹿児島県の薩摩湖，川内市の上池などに果実に4個の角を有するヒメビシが知られていたが，最近大口市の宮人の池で採集したヒメビシは角が2個しかないので，ふしぎに思い調べたところ朝鮮，満州，北支に分布する下記学名の植物であることがわかった。両者は葉だけではほとんど区別できないが，果実を見ればすぐわかる。九州各県でヒメビシが報告されているが，上記のマンセンビシも混入されているかも知れないので注意していただきたい。

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