Floral Morphology and its Systematic Implications in *Drypetes integerrima* (Koidz.) Hosok. (Euphorbiaceae, tribe Drypeteae) from Bonin Islands, Japan

TORU TOKUOKA¹ and CHING-I PENG²

¹Graduate School of Human and Environmental Studies, Kyoto University, Kyoto 606–8501, Japan; ²National Museum of Natural Science, 1 Kuan Chien Rd., Taichung, Taiwan.

Abstract. Flowers of the species of Drypeteae in Bonin islands have been very poorly understood with respect to their morphology and structure. Both male and female flowers in flowering stage of the species from Bonin islands, as well as of the three African species of *Drypetes* and two East Asian species of *Putranjiva* (including *P. matsumurae*), were examined by stereoscopy and on the basis of microtome sections as well as of scanning electron micrographs. Contrary to all earlier taxonomic treatment placing the two Japanese species in the same genus, the species from Bonin islands greatly differs in floral morphology from *Putranjiva matsumurae*, another Japanese species in Ryukyu islands. The species from Bonin islands has the nectariferous "disk" which is lacking in *Putranjiva matsumurae* and has 5–8 stamens in staminate flowers in contrast to 2(−3) stamens in those of *P. matsumurae*. Following the latest system of classification of Euphorbiaceae, two Japanese species of Drypeteae should be placed separately in two distinct genera, i.e., the species from Bonin islands as *Drypetes integerrima* and, the other from Ryukyu islands as *Putranjiva matsumurae*. It is also shown anatomically that the disk of *Drypetes* is a nectary composed of small, densely stained cells with rich cytoplasm and, having stomata-like pores on surface of the adaxial side.

Key words: *Drypetes*, Drypeteae, Euphorbiaceae, floral nectary, *Putranjiva*, taxonomy

Received May 27, 1997; accepted October 30, 1997

Tribe Drypeteae, comprising three closely related genera *Drypetes* (ca. 200 spp.), *Putranjiva* (3–4 spp.), and *Sibangea* (3 spp.), and one anomalous African genus Lingelsheimia (1–6 spp.) (Webster, 1994; McPherson, pers. comm.), is known to be an unusual taxon in Euphorbiaceae (Meeuse, 1990). Two species of this tribe were first recorded by Koidzumi (1919) from Japan: one is *Putranjiva integerrima* Koidz. from Bonin islands, Tokyo, and the other *P. matsumurae* Koidz. from Ryukyu islands, Okinawa Prefecture. After the first descriptions, both *Putranjiva matsumurae* and *P. integerrima* have had a similar taxonomic history and have usually been placed in the same genus, that is, in *Drypetes* as *D. matsumurae* (Koidz.) Kaneh. (Kanehira, 1936) and *D. integerrima* (Koidz.) Hosok. (Hosokawa, 1938; Hurusawa, 1954; Ohba, 1989), and in *Liodendron* as *L. matsumurae* (Koidz.) H. Keng and *L. integerrimum* (Koidz.) H. Keng (Keng, 1951). Hurusawa (1954) assigned the two species even in the same section of *Drypetes* (sect. *Matsumuraeanae*).

In his latest system of classification, Webster (1994, p. 48) indicated
that *Putranjiva* is clearly distinguished from *Drypetes* in the lack of the "disk" and having fewer number of stamens (mostly 2 or 3), and accepted the species from Ryukyu islands as *Putranjiva matsumurae*, rather than as *Drypetes matsumurae*.

On the other hand, the species from Bonin islands was reported to have eight stamens (Ohba, 1989). Judging only from the stamen number, the species from Bonin island should be placed in *Drypetes* rather than *Putranjiva* in Webster's system. This taxonomic treatment contradicts all earlier taxonomic treatments in which the two species have been always placed in the same genus. However, since we have very limited information available on the floral morphology of the species from Bonin islands, it is still not clearly shown whether the species from Bonin islands has the disk or not and further it is still not clearly resolved whether the species belongs to *Drypetes* or not.

The purpose of this paper is to present details of the floral morphology in the species from Bonin islands (which will be treated as *Drypetes integerrima* in the subsequent discussion) and to discuss in which genus it is exactly assigned, *Drypetes* or *Putranjiva*. For comparison with other species of *Drypetes* and *Putranjiva*, three African species of *Drypetes* and two species of *Putranjiva* (including *P. matsumurae*) from Taiwan and Ryukyu islands were also examined.

**Materials and Methods**

Collection data of *Drypetes integerrima* from Bonin islands, as well as of the other species of Drypeteae examined for comparison, are presented in Table 1. Both male and female flowers in flowering stages were observed by stereoscopy and on the basis of microtome sections as well as on the basis of scanning electron micrographs. Microtome sections were prepared following the standard paraffin methods. Flowers were dehydrated through a *t*-butyl alcohol series and embedded in Paraplast with melting point 56–58°C. Sections cut at 8–10 μm thick were stained by hematoxylin, safranin, and fastgreen FCF, and mounted in Entellan. For scanning electron microscopy, flowers were dissected to expose the "disk," and were dehydrated and critical-point dried. After coated with gold, the flowers were observed with a Hitachi S–2150.

**Observations**

Staminate flowers of *Drypetes integerrima* are 3.8–6.5 mm long and 3.9–5.1 mm in diameter, having four oval sepals and five to eight stamens (Fig. 1). Pistillate flowers of *Drypetes integerrima* are 4.7–6.3 mm long and 6.3–9.4 mm in diameter, having four sepals and a pistil (Fig. 3). The pistil has a very short style and is thus stigmatiform (Fig. 4). In both staminate and pistillate flowers the disk is present. In the staminate flower the disk is positioned intrastaminal and dilated at the center of the flower (Figs. 1, 2), while in the pistillate flower it is more or less tubular.
The Japanese Society for Plant Systematics

The Japanese Society for Plant Systematics

The Japanese Society for Plant Systematics

December 1997

TOKUOKA & PENG: Flower of Drypetes integerrima

Table 1. Species studied of Drypeteae and collections

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drypetes integerrima (Koidz.) Hosok.</td>
<td>JAPAN. Chichijima, Ogasawara (Bonin islands), Tokyo. Yasui s. n. in 1992 (KYO).</td>
</tr>
<tr>
<td>D. gerrardinioides A. Radcliffe-Smith</td>
<td>TANZANIA. Lulanda Forest. Lovett &amp; Thomas 2452, 2463 (MO).</td>
</tr>
<tr>
<td>P. matsumurae Koidz.</td>
<td>JAPAN. Okinawa Pref. Hsien s. n. No voucher.</td>
</tr>
</tbody>
</table>

(Figs. 3, 4). The disk has a vascular tissue with a height of about 0.8–1.7 mm, and its basal part is united with the sepal on the abaxial side (Fig. 5). The disk, particularly on its adaxial side, is composed of small, densely stained cells with rich cytoplasm (Fig. 5). It has stomata-like pores on the adaxial side (Fig. 6) but lacks them on its abaxial side. Both the microtome section (Fig. 5) and scanning electron micrograph (Fig. 6) indicate that the disk is nectary.

The nectariferous disk is found in any of the three African species of Drypetes, i.e., D. arguta, D. gerrardini, and D. gerrardinioides. In case of staminate flowers of Drypetes gerrardinioides, stamens are 13 to 14 in number, and the disk is hairy and intrastaminal and is longitudinally folded (Figs. 7, 8). In pistillate flowers of Drypetes gerrardinioides, a style is short and stigmatiform, and the tubular disk is present inside the sepal (Fig. 9). However, unlike that in the staminate flowers, the disk in the pistillate flowers is not longitudinally folded. Microtome sections show that the adaxial side of the disk is composed of small, densely stained cells rich with cytoplasm (Fig. 10). In both the staminate and pistillate flowers, stomata-like pores are dispersed on the adaxial side of the disk (Figs. 11, 12).

In Drypetes gerrardii staminate flowers have four to five stamens, and like those of D. integerrima, have an intrastaminal disk which is dilated at the center of the flower. On the other hand, in Drypetes arguta staminate and pistillate flowers are similar to those of D. gerrardinioides. The staminate flowers have 14 to 17 stamens and a longitudinally folded disk, and the pistillate flowers have a tubular disk.

In contrast, the nectariferous disk is completely lacking in both staminate and pistillate flowers of Putranjiva formosana (Figs. 13, 16, 18) and P. matsumurae (Fig. 17). We expected that the nectary might be present somewhere within the flower as an embedded tissue instead of the distinct tubular disk. If it is present, the nectary would be present as a group of small, densely stained cells as in many insect-pollinated flowers of dicotyledons (e.g. Graham et al., 1986, Lythraceae). However, Putranjiva formosana and P. matsumurae do not have such a nectariferous tissue, either (Figs. 13, 17). The staminate flowers have three or four sepals and...
Figs. 1–6. Flowers of *Drypetes integerrima*. 1. Top view of staminate flower. 2. Longitudinal section (LS) of staminate flower. 3. Top view of pistillate flower. 4. LS of pistillate flower. 5. LS of basal part of sepal and pistil junction, showing tubular disk. 6. Scanning electron micrograph of the disk on adaxial surface of pistillate flower, showing the presence of stomata-like pores (arrowheads). Abbreviations: d, disk; pl, pistil; se, sepal; st, stamen; stg, stigma; stl, style; ov, ovary wall. Scale bars equal 1 mm, 1 mm, 1 mm, 1 mm, 200 μm, and 100 μm, respectively.
Figs. 7–12. Flowers of Drypetes gerrardinioides. 7. Lateral view of staminate flower, with one sepal and several stamens removed. 8. Transverse section of staminate flower. Arrowheads indicate tips of two styles of a rudimentary pistil. 9. Lateral view of pistillate flower, with a half of it removed. 10. Longitudinal section of the basal part of sepal and pistil junction. 11. Scanning electron micrograph (SEM) of the disk on adaxial surface of pistillate flower. 12. SEM of part of the disk of pistillate flower showing the presence of stoma-like pores (arrowheads). Abbreviations: d, disk; pl, pistil; se, sepal; st, stamen; sig, stigma; stl, style; ov, ovary wall. Scale bars equal 1 mm, 1 mm, 1 mm, 200 μm, 200 μm, and 100 μm, respectively.
Figs. 13–18. Flowers of *Putranjiva*. 13, 14, 16, and 18. *Putranjiva formosana*; 15 and 17. *P. matsumurae*. 13. Longitudinal section (LS) of staminate flower. 14 and 15. Transverse sections of staminate flower. 16. LS of pistillate flower. 17. LS of basal part of sepal and pistil. 18. Scanning electron micrograph of the basal part of the sepal on adaxial side of pistillate flower, showing the lack of the disk. Abbreviations: pl, pistil; se, sepal; st, stamen; stg, stigma; stl, style; ov, ovary wall. Scale bars equal 500 μm, 500 μm, 500 μm, 500 μm, 500 μm, and 100 μm, respectively.
only two (or three) stamens (Figs. 14, 15). The pistillate flowers have three to four sepals and a single pistil (Fig. 16). A style of the pistil appears to be more or less long compared to that of the Drypetes species examined and has a dilated stigma (Fig. 16).

Discussion

The floral morphology of the species (tentatively treated as Drypetes integerrima in aforementioned descriptions) from Bonin islands, as well as of the three African species of Drypetes and two East Asian species of Putranjiva (including P. matsumuranae), was presented in detail above. Contrary to all earlier taxonomic treatment placing the two Japanese species in the same genus (Koidzumi, 1919; Keng, 1951; Hurusawa, 1954; Ohba, 1989), the species from Bonin islands greatly differs in floral morphology from Putranjiva matsumuranae, another Japanese species in Ryukyu islands. In fact, the species from Bonin islands has the nectariferous “disk” which is lacking in Putranjiva matsumuranae and has 5–8 stamens in staminate flowers in contrast to 2(–3) stamens in those of P. matsumuranae. The presence of the “disk” in flowers of the species from Bonin islands are recognizable in Figure 55A–G in Hurusawa (1954, p. 336).

Thus, following the latest system of classification of Euphorbiaceae (Webster, 1994), two Japanese species of Drypeteae are placed separately in two distinct genera, i.e., the species from Bonin islands as Drypetes integerrima and, as Webster accepted, the other from Ryukyu islands as Putranjiva matsumuranae.

We are grateful to Hiroshi Tobe for his efforts in getting materials examined in this study; to Hisashi Higa, Jon Lovett, Peter H. Raven, and, Takaya Yasui, for collecting materials or their arrangement to collect the materials; and to Tokushiro Takaso for taking some photographs of flowers.

References

摘 要

徳岡 徹1・Ching-I Peng2：小笠原諸島産ハツバキ (トウダイグサ科ハツバキ属) の花の形態
とその分類学的意味

小笠原諸島に産するハツバキの花の形態と構造はこれまで正確に理解されていなかった。そのため，ハツバキ，およびこれとの比較のためアフリカ産のハツバキ連3種とアジア産ハ
ツバキ連2種の雄花と雌花を实体顕微鏡，ミクロトーム切片，及び走査型電子顕微鏡を用い
て観察した。その結果，ハツバキは日本産ハツバキ連のもう一種である琉球列島のツゲモド
キ属ツゲモドキ (Putranjiva matsumurae) とは，これまで知られていた雄しべの本数の違い
のほかに花盤の有無でも異なることがわかった。すなわち，ツゲモドキは花盤がないのに対
し，ハツバキは花盤を持っていた。ハツバキとツゲモドキはこれまで常に同属と扱われてき
た。しかし，花の形態が大きく異なるため，現在利用されているWebster の分類システム
に従ってハツバキをツゲモドキとは別属 (ハツバキ属 Drypetes) の Drypetes integerrima とし
て扱うべきである。また，ハツバキ属 (Drypetes) の花盤は解剖学的に見れば，細胞質に富
んだ，良く染まる小さな細胞から作られ，その向軸側には気孔に似た孔が散在している。こ
れらのことから，花盤は蜜腺であることが分かった。

(1 〒606-8501 京都市左京区吉田二本松町 京都大学人間・環境学研究科；2 台湾台中市 国
立自然科学博物館)