Studies in the floral anatomy and morphology of Rubiaceae*

III. Hedyotideae (Ophiorrhiza and Pentas)

Nobuyuki FUKUOKA**

** Continued from this Acta 29: 185, 1978.

Ophiorrhiza—The flower of Ophiorrhiza is usually 5-merous. The calyx-lobes are small and persistent. The corolla-tube is densely covered with pilose hairs at the throat inside in O. japonica and O. pumila. The filament fuses a corolla-tube at its entire length in O. japonica, and only at its base in O. pumila. An ovary has two loculi and is compressed loculicidally. Each ellipsoidal or ovoid placenta bears many ovules all over the surface (Fig. 11-C, 13-A, C). The short and thick stalk of placenta attaches to the middle portion of septum. The disc is developed as high as calyx-lobes and splits into two parts loculicidally (Fig. 13-E), or in O. japonica rarely into four parts loculicidally and septicidally (Fig. 11-G). An elongate style branches two oblong lobes. There are many raphides in ovary of this genus, except in O. japonica whose placenta contains very small raphides.

Table 3. The species and the voucher specimens examined.

<table>
<thead>
<tr>
<th>Species</th>
<th>Voucher Specimens</th>
</tr>
</thead>
</table>

Two species of Ophiorrhiza are here observed for the floral anatomy. O. japonica will be described first. In a receptacle, a vascular cylinder divides radially ten bundles in 5-merous flower (Fig. 11-A, 13-B) and eight in 4-merous one. These bundles run up in the periphery of an ovary giving off the disc bundles at various levels (Fig. 11-A–D, 13-C, D). Each of the alternate five among the ten peripheral bundles forks at the upper half of an ovary (Fig. 11-E, 13-A, D). The outer bundles enter into calyx. Inner ones supply stamens, but sometimes branch and supply the disc. The other five bundles are corolla ones. A calyx bundle branches near the apex of a lobe (Fig. 13-E). A corolla bundle runs up in the corolla-tube without branching to a little above the throat of a corolla-tube.


** Shoei Junior College, Nakayamate-dori, Ikuta-ku, Kobe 650.
The disc bundles are branched off from peripheral bundles at the levels between the base and near the uppermost level of an ovary (Fig. 11-B-D) as in Anotis subitiana and Hedyotis diffusa as described in the previous reports, though four, rarely three to one, peripheral bundles near the dorsal portions of loculi do not branch any disc bundle. These disc bundles running up into the inner portion of periphery vary in number even within a species (Fig. 11-F, H). In case having many disc bundles, these bundles divide and fuse to each other repeatedly in the periphery of ovary at the positions near the radii of septa. At the upper limit of ovary, the disc bundles arrange loculicidally in two rows. The disc is supplied by eight to nineteen bundles (Fig. 11-F–H). The bundles in disc do not branch as in the disc bundles of Hedyotis and others, but sometimes fork.

Each of four thicker disc bundles near the radii of septa gives off centripetally a short bundle at the top of ovary or the base of disc (Fig. 11-E, 13-A), as in the ventral bundle of Hedyotis scabra. These four bundles move to the inner portion and run up in the center of disc (or the sterile neck of ovary) (Fig. 11-F, H), though the bundles do not run up in style but end at the level where disc splits into two pieces but is still connected by a style, or the level slightly lower than that (Fig. 11-G). These four bundles are similar to the ventral bundles in the disc of Hedyotis scabra.

The dorsal bundle is separated from the peripheral one near the dorsal portion of loculus at the level between the base and the apex of loculus (Fig. 11-D, E, 13-A, D). These two peripheral bundles in an ovary are corolla and calyx—stamen bundles, or rarely two corolla ones. The dorsal bundle moves to the center along the shoulder of ovary between the discs and supplies a style (Fig. 11-F, 13-A).

The traces entering into the center of a receptacle become one or rarely two bundles (Fig. 13-B). In the former, the two xylems never fuse together and a bundle forks into two at a slightly upper level. Both of the two bundles supply placenta and each of them branches into many ovular bundles (Fig. 11-C, 13-A, C).

The vascularization of O. pumila is similar to that of O. japonica. In O. pumila, the bundles supplying calyx, corolla, and stamen, are surrounded by the larger vacuolate cells at abaxial side (Fig. 11-A–D). Each calyx—stamen bundle begins to divide at the middle level of ovary (Fig. 11-C). In O. pumila, is not observed the bundle which runs up into the inner portion of the apex of ovary as in the ventral bundle of O. japonica.

Pentas—In the flower of Pentas lanceolata, there are five corolla-lobes and stamens, rarely four or six, though the calyx-lobes are four to eight in number and irregular both in size and shape; larger ones are lanceolate and 1.3 cm long, and smaller ones hair-like and less than 1 mm long. At the basal portion of corolla-tube, there are narrow gaps of a length of some 0.5 mm between the adjacent corolla-lobes and the gaps are filled with the filaments (Fig. 12-F). An ovary consists of two carpels. The swollen placenta attaches to the center of septum and bears many small ovules all over the surface (Fig. 12-C, 14). The disc is distinctly developed to form a ring at the apex of ovary (Fig. 14). There are many raphides in every part of a flower including placenta.
In a receptacle a vascular ring divides radially into eight to ten bundles which run up in the periphery of ovary (Fig. 12-A). These bundles count nine to eleven at the base of an ovary and ten to fifteen at its middle level (Fig. 12-C). The bundles in periphery are derived by the fusion of a median calyx bundle and stamen one and also of lateral calyx bundle and corolla one. It is expected to be, therefore, ten bundles in periphery in 5-merous flower and twelve in 6-merous one. However, such a case is observed neither in serial sections of six flowers nor in any of the five cleared ones. In many cases, one
Fig. 12. Flowers of *Pentas lanceolata*. A. Cross section at base of ovary (×40). B. At lower half, where there are eleven bundles in periphery of ovary (×50). C. At middle level, showing thirteen bundles (×40). D. At upper half, where calyx bundles begin to become distinct (×30). E. At uppermost level, showing separation of disc bundles (×30). F. At very base of corolla, where gaps are found and filaments are free from corolla (×40).

median calyx—stamen bundle fuses to one lateral calyx—corolla one at the lower half of ovary. In all the materials observed, one or more of calyx, rarely corolla and stamen bundles become distinct at the middle level or even at the base of ovary. As a result of the separation of these bundles, the bundles in periphery gradually increase in number, taking an upward course from receptacle to the upper level of an ovary (Fig. 12-A–D). Each of the bundles in periphery divides periclinally into two at the highest level (Fig. 12-D, E); outer ones supplying calyx and inner ones alternately corolla and stamens, though distinct calyx, stamen, and corolla bundles do not fork. Disc bundles are centri-
petally given off from corolla bundles, stamen ones, and a few of calyx ones in still higher levels (Fig. 12-E).

The dorsal bundles of carpel are given off from the peripheral bundles, calyx—corolla—stamen one and calyx—corolla one, at the dorsal portion of loculus at the upper half of ovary, where corolla—stamen bundle does not become distinct (Fig. 12-C, D, 14). The dorsal bundle runs up into a style (Fig. 14).

On the other hand, the strands remaining at the center of receptacle fuse together to form a broad bundle (Fig. 12-A, B). At a level little above that, this bundle divides into two, both of which supply placentae. There is no ventral bundle which runs up in the outer portion of septum.

Conclusive remarks on the tribe Hedyotideae—In the tribe in question, the placenta
is spherical or ellipsoidal in outline, and the stalk of it is much narrow comparing with the size of placenta. A loculus is occupied by a larger placenta bearing many ovules all over the surface, except in a case of Anotis whitiana. Such a placenta may be considered as specialized form. This speculation seems to be supported by the fusion of the bundles in the periphery of ovary and valvate corolla-lobes. The increase in the number of ovules within an ovary seems to be correlated with the enlargement of placenta and the decrease in the size of ovules.

The bundles in the periphery of ovary show a tendency to fuse together. The calyx, corolla, and stamen bundles become distinct at the uppermost level, though the dorsal bundles of carpel and/or disc one are sometimes separated at the lower half as in Clarkella, Ophiorrhiza, and some of Hedyotis. Each of calyx-lobes is supplied by a bundle in Anotis, Hedyotis, and Ophiorrhiza, and by three bundles in Argostemma, Clarkella, and Pentas. In general the smaller sepals are one-traced and the larger ones three-traced in this tribe.

There are various forms of bundles supplying the disc. These bundles are given off from the bundles in the periphery of an ovary at the uppermost level in Anotis, Pentas, and in most of Hedyotis, and at the levels between the lower half and the uppermost level in some of Hedyotis and in Ophiorrhiza. In Clarkella, the disc is supplied only by the bundles running up in the outer portion of septum. The disc bundles branch into a number of small strands and are scattered in disc in Anotis, Clarkella, Hedyotis, and Pentas. In Ophiorrhiza, on the contrary, the disc bundles do not scatter, but run up vertically. In Argostemma, there is no bundle supplying disc.

There is observed the bundle which runs up either in the outer portion of septum or the inner portion of the periphery of ovary near the radius of septum in Clarkella, Hedyotis coreana, H. grayi, H. lindleyana, and some of H. scabra. This bundle is called as the septum bundle or ventral one. The derivation of the septum bundle is variable even in a species especially in Hedyotis. In any case this bundle is separated from the placenta bundle and/or the peripheral bundle. The septum bundle forks into two at the upper half of ovary and is scattered in the disc or the top of ovary.

It is rather common that the ventral bundle runs up in the wall of ovary near the radius of septum and the bundle supplying placenta or ovule in the center of ovary (Lindsey, 1940). Judging from the various derivation of the septum bundle at the base of ovary especially in Hedyotis, the septum bundle seems to be the ventral bundle of the carpel. The ventral bundle is not observed for most species of this tribe, though this is observed in Clarkella, and in some species of Hedyotis as if it is derived from the peripheral
bundle, and the apparent relation between the ventral and peripheral bundles may be caused by the irregular division of these as well as placenta bundles at the lower levels. In *Ophiorrhiza japonica*, the four disc bundles near the radii of septa give off centripetally four short bundles which run up in the inner portion of disc. These bundles seem to be the ventral ones of two carpels. In this case the ventral bundle fuses the disc bundle in the periphery of ovary. In the examples where no ventral bundle is observed, the ventral bundle may have fused the peripheral bundle as in the cases of some of *Hedyotis*, in which only one ventral bundle is found, or the disc bundle as in the case of *Ophiorrhiza pumila*.

Taxonomical comments—**Schumann** (1897) considered the tribe Hedyotideae as the most primitive and he highly evaluated the number of ovules in a loculus. However, the tribe seems to be rather specialized in the Rubiaceae by the following reasons: the specialized placenta, the fusion of the bundles in the periphery of ovary, valvate corolla-lobes, and the presence of one-traced sepal.

**Lewis** (1966) distinguished Asian species from American ones of *Anotis* and ascribed them to *Neanotis*. He emphasized the differences in the morphology of the pollen as for the delimitation between *Hedyotis* and *Neanotis*. On the basis of his conclusion, many species of *Hedyotis* were transferred to *Neanotis*. **Bakhuizen v.d. Brink** (1975) reduced *Neanotis* to a synonym of *Hedyotis*. As noted by him (1965), these two genera are difficult to separate, but *Anotis* (*Neanotis*) *whitiana*, at least, is characterized by the ball-like placenta bearing only two ovules at the base and apex, compressed ovary, the number of floral parts in a capitulate flowers, distinctly compressed capsule, and larger plan-convex seed. Among these features, the disposition of ovules on a placenta is remarkable. According to Hooker's (1880) delimitation, the number of ovules is numerous in *Hedyotis* and few in *Anotis*, but there are found one- to six-seeded capsule in the species ascribed to *Hedyotis* and contrarily many-seeded capsule in *Anotis*. As reexamined in previous report, the number of seeds is much larger than that ever estimated in three species of *Hedyotis* regarded as few-seeded capsule. Both the globose and compressed capsules are found in *Anotis* and *Hedyotis*, though the difference in the shape of fruit is most important key character to distinguish allied genera from each other. We should reexamine the circumscription between *Anotis* and *Hedyotis* from the standpoint of these respects.

**Bakhuizen v.d. Brink** (1975) noted that *Clarkella* and *Ophiorrhiza* might be merged together. *Clarkella* is characterized by short stamen and style inserted near the bottom of hypocrateriform corolla, globose ovary, larger calyx, slightly swollen disc, and sub-globose fruit gradually tapering to the base, and contrarily *Ophiorrhiza* by longer stamen exserted or inserted at the level upper than the middle of corolla-tube, filiform style, smaller calyx, strongly developed disc, and obtriangular, distinctly compressed capsule. In the floral anatomical features, both genera differ from each other in the respects as follows: the placenta elongates longitudinally in *Clarkella* and tangentially in *Ophiorrhiza*; a calyx-lobe is supplied by three bundles in the former and by one bundle in the latter; and in *Clarkella* the disc bundle is not observed but ventral bundles scatter in the disc, and in
Ophiorrhiza the disc bundles become distinct even at the base of ovary and do not scatter in the disc. In these respects, Clarkella is separable generically from Ophiorrhiza.

References


